Official Journal of the
Malaysian Medical Association

The Medical Journal of Malaysia

Malaysian Orthopaedic Association

Orthopaedic Supplement

Volume: 61

Supplement A

February 2006

ISSN 0300-5283 PP 2121/12/06 MITA(P) 124/1/91

MJM

Official Journal of the Malaysian Medical Association

Volume 61 Supplement A February 2006

EDITORIAL BOARD

PP 2121/12/06 MCI (P) 124/1/91 ISSN 0300-5283

The Medical Journal of Malaysia is published four times a year
i.e. March, June, August, October and December.

Advertisement Rates:
Enquiries to be directed to the Secretariat.

Subscription Rates:
Price per copy is RM70.00 or RM300.00 per annum, for all subscribers.

Secretariat Address:
Malaysian Medical Association
4th Floor, MMA House, 124, Jalan Pahang, 53000 Kuala Lumpur.
P.O. Box S-20, 51700 Kuala Lumpur.
Tel: (03) 4042 0617, 4041 8972, 4041 1375 Fax: (03) 4041 8187
E-mail: mma@tm.net.my Website: www.mma.org.my

Publishing Consultant and Printer: New Voyager Corporation Sdn. Bhd. (514424 U)
37 Jalan Gangsa SD 5/3D, Bandar Sri Damansara, 52200 Kuala Lumpur. Tel: 03-6272 2097, 6273 2900 Fax: 03-6272 2380

MJM

NOTICE TO CONTRIBUTORS

The *Medical Journal of Malaysia* welcomes articles of interest on all aspects of medicine in the form of original papers, research notes, communications and correspondence. The MJM also welcomes brief abstracts, of not more than 50 words, of original papers published elsewhere, concerning medicine in Malaysia. Articles are accepted for publication on condition that they are contributed solely to *The Medical Journal of Malaysia*. Neither the Editorial Board nor the Publishers accept responsibility for the views and statements of authors expressed in their contributions. The Editorial Board further reserves the right to reject papers read before a society. To avoid delays in publication, authors are advised to adhere closely to the instructions given below.

Manuscripts: All manuscripts should be submitted in triplicate to:

Hon Editor
Medical Journal of Malaysia
Malaysian Medical Association
4th Floor, MMA House, 124, Jalan Pahang
53000 Kuala Lumpur

Manuscripts should be typed on one side of A4 paper and double-spaced throughout (including tables, legends and references), with wide margins.

An electric typewriter, letter quality or laser printer should be used. Do not use dot-matrix printer. 'San Serif' typefaces/fonts such as Helvetica are preferred.

The title page should state the title of the paper, initials and name(s) of the author(s), degrees (limited to one degree or diploma) and address(es). The name and address of the author for correspondence should be clearly indicated.

Names of authors should be written in style of initials followed by the surname or preferred name e.g., K G Lim for Lim Kean Ghee or B S Gendeh for Balwant Singh Gendeh. For those without surnames, the MJM would like to suggest that authors use their given name in place of their surname e.g. M Z Azhar for Azhar bin Md Zain, K Suresh for Suresh Kumarasamy or S Harwant for Harwant Singh. Authors however, who have previously published should try as much as possible to keep the abbreviation of their name consistent.

Summary, Introduction, Materials and Methods, Results, Discussion, Acknowledgment and References should follow each section beginning on a fresh page.

Papers may be submitted in Bahasa Malaysia but must be accompanied by a short summary in English.

Scientific names, foreign words and Greek symbols should be clearly indicated and underlined.

Reviewers: Authors may submit the names of two possible reviewers whom they feel are qualified and suitable to review their paper, who are not involved in the work presented, and from another institution. This may hasten the process of peer review. Authors need not obtain the premission of these possible reviewers' as it is both the responsibility and perogative of the MJM to approach them.

Case Reports: Papers on case reports (one to five cases) must follow these rules: maximum of 1,000 words; only one table is allowed; maximum of two photographs; only up to five references quoted.

Having a unique lesson in the diagnosis, pathology or management of the case is more valuable than mere finding a rare entity. Being able to report the outcome and length of survival of a rare problem is more valuable than merely describing what treatment was rendered at the time of diagnosis.

Short Communications: Short communications should not exceed 1,000 words and shall consist of a Summary and the Main Text. The number of figures and tables should be limited to three and the number of references to five.

Letters to the Editor: Such correspondence must not exceed 450 words.

Summary and Key Words: A summary of not more than 100 words should be provided immediately after the title page. Below the summary, provide and identify 3 to 10 key words or short phrases that will assist indexers in cross-indexing your article. Use terms from the medical subject headings list from *Index Medicus* where possible.

Introduction: Clearly state the purpose of the article. Summarise the rationale for the study or observation. Give only strictly pertinent references, and do not review the subject extensively.

Materials and Methods: Describe your selection of the observational or experimental subjects (patients or experimental animals, including controls) clearly, identify the methods, apparatus (manufacturer's name and address in parenthesis), and procedures in sufficient detail to allow other workers to reproduce the results. Give references to established methods, including statistical methods; provide references and brief descriptions of methods that have been published but are not well-known; describe new or substantially modified methods, give reasons for using them and evaluate their limitations.

Identify precisely all drugs and chemicals used, including generic name(s), dosage(s) and route(s) of administration. Do not use patients' names, initials or hospital numbers. Include numbers of observation and the statistical significance of the findings when appropriate.

When appropriate, particularly in the case of clinical trials, state clearly that the experimental design has received the approval of the relevant ethical committee.

Results: Present your results in logical sequence in the text, tables and illustrations. Do not repeat in the text all the data in the tables or illustrations, or both: emphasise or summarise only important observations.

Discussion: Emphasise the new and important aspects of the study and conclusions that follow from them. Do no repeat in detail data given in the Results section. Include in the Discussion the implications of the findings and their limitations and relate the observations to other relevant studies.

Conclusion: Link the conclusions with the goals of the study but avoid unqualified statements and conclusions not completely supported by your data. Avoid claiming priority and alluding to work that has not been completed. State new hypotheses when warranted, but clearly label them as such. Recommendations, when appropriate, may be included.

Acknowledgements: Acknowledge grants awarded in aid of the study (state the number of the grant, name and location of the institution or organisation), as well as persons who have contributed significantly to the study.

Authors are responsible for obtaining written permission from everyone acknowledged by name, as readers may infer their endorsement of the data.

References: Number references consecutively in the order in which they are first mentioned in the text. Identify references in text, tables and legends by Arabic numerals (in parenthesis). References cited only in tables or legends to figures should be numbered in accordance with a sequence established by the first identification in the text of the particular table or illustration.
Use the form of references adopted by the US National Library of Medicine and used in the *Index Medicus*. Use the style of the examples cited at the end of this section, which have been approved by the National Library of Medicine.
The titles of journals should be abbreviated according to the style used in the ***Index Medicus.***
Try to avoid using abstracts as references; "unpublished observations" and "personal communications" may not be used as references, although references to written, not verbal, communication may be inserted (in parenthesis) in the text. Include among the references manuscripts accepted but not yet published; designate the journal followed by "in press" (in parenthesis). Information from manuscripts should be cited in the text as "unpublished observations" (in parenthesis).
The references must be verified by the author(s) against the original documents. List all authors when six or less; when seven or more list only first three and add *et al*. Examples of correct forms of references are given below:

Journals

1. Standard Journal Article
   Soter NA, Wasserman SI, Austen KF *et al*. Cold uticaria: release into the circulation of histamine and eosinophil chemotaxic factor of anaphylaxis during cold challenge. New Engl J Med 1976;294 : 687 - 90.

2. Corporate Author
   The Committee on Enzymes of the Scandinavian Society of Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36 : 119 -125

Books and Other Monographs

3. Personal Author(s)
   Osler AG. Complement: mechanisms and functions. Englewood Cliffs: Prentice-Hall, 1976.

4. Corporate Author
   American Medical Association Department of Drugs. AMA drug evaluation (3rd ed.) Littleton: Publishing Sciences Group, 1977.

5. Editor, Compiler, Chairman as Author
   Rhodes AJ, Van Rooyen CE (comps). Textbook of virology: For students and practitioners of medicine and the other health sciences (5th ed). Baltimore: Williams & Wilkins, 1968.

6. Chapter in Book
   Weinstein L, Swartz MN. Pathogenic properties of invading micro-organisms. In: Sodeman WAJr, Sodeman WA (eds). Pathologic physiology: mechanisms of disease. Philadelphia: WB Saunders, 1974: 457 - 72.

7. Agency Publication
   National Care for Health Statistics. Acute conditions: incidence and associated disability, United States, July1968 - June 1969. Rockville, Me: National Centre for Health Statistics, 1972. (Vital and health statistics). Series 10: data from the National Health Survey, No 69). (DHEW Publication No (HSM) 72 - 1036).

Other Articles

8. Newspaper Article
   Shaffer RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help cure alcoholism and insomnia, explain mental illness. However, the messengers work. Wall Street Journal 1977; Aug 12: 1(col 1), 10 (col 1).

9. Magazine Article
   Roucehe B. Annals of medicine: the Santa Claus culture. The New Yorker 1971; Sep 4: 66 - 81).

Tables and illustrations: Roman numerals should be used for numbering tables. Arabic numerals should be used when numbering illustrations and diagrams. Illustrations and tables should be kept to a minimum.
All tables, illustrations and diagrams should be fully labelled so that each is comprehensible without reference to the text. All measurements should be reported using the metric system.
Each table should be typed on a separate sheet of paper, double-spaced and numbered consecutively. Omit internal horizontal and vertical rules. The contents of all tables should be carefully checked to ensure that all totals and subtotals tally.
All illustrations and diagrams should be in Indian ink on separate sheets of thick, smooth, white paper of Bristol board or in the form of photographs printed on glossy paper and should be 12.7cm x 17.3cm but not larger than 20.3cm x 25.4cm. They should bear, on the reverse side, the author's name, short title of the paper, the figure number and an arrow indicating the top of each illustration.
All illustrations and diagrams should be referred to as "Figures" and numbered consecutively. Their approximate position in the text should be indicated. Legends and captions should be typed on separate sheets and numbered correspondingly.
Whenever possible, please include all data used for construction of graphs in order to ensure clarity or reproduction.

Colour reproduction: Illustrations and diagrams are normally reproduced in black and white only. Colour reproductions can be included if so required and upon request. However, a nominal charge must be paid by the authors for this additional service; the charges to be determined as and when on a per article basis.

Colour illustrations and diagrams should be supplied in the form of colour positive photographic prints or slides. All other specifications should be as for normal illustrations and diagrams, as noted above.

Abbreviations: Use only standard abbreviations. The full term for which an abbreviation stands should precede its first use in the text, unless it is a standard unit of measurement.

Reprints: 25 copies of the article will be supplied free of charge to the leading author. Requests for additional reprints should be made to the MMA Secretariat. A nominal charge will be levied for each additional reprint.

CONTENTS

EDITORIAL

ORIGINAL ARTICLES

CASE REPORTS

ORTHOPAEDIC SUPPLEMENT

EDITORIAL BOARD

Publishing Consultant and Printer: New Voyager Corporation Sdn. Bhd. (514424 U)
37 Jalan Gangsa SD 5/3D, Bandar Sri Damansara, 52200 Kuala Lumpur. Tel: 03-6272 2097, 6273 2900 Fax: 03-6272 2380

EDITORIAL

The Two Faces of Capital Femoral Epiphyseal Injury – New Treatment Paradigms against the Perceived Myths

M Hassan Shukur

Department of Orthopaedics and Trauma Surgery, Faculty of Medicine, UKM, Cheras, Kuala Lumpur, Malaysia

In this issue of the Journal, there are two articles addressing relevant clinical problems that we may encounter in our practice. The main issue is related to the occurrence or inevitability of avascular necrosis (AVN) following treatment of two different types of capital femoral epiphyseal 'injury'.

Kamarulzaman et al. (pages 71-78) and Aminuddin *et al.* (pages 94-96) present two look-alike pediatric hip injuries: slipped capital femoral epiphysis and transphyseal fracture separation of the capital femoral epiphysis. Traumatic fracture separation of capital femoral epiphysis is a rare injury inflicted by a very violent trauma, typically occurring through a 'healthy' physis between the hypertrophic and provisional calcification zone of the cartilage. In contrast, the slipped capital femoral epiphysis (SCFE) is not uncommon. It is typically inflicted by a trivial injury to a 'sick' physis in an overweight adolescent with predisposed preexisting epiphysiolysis and retroverted femoral neck. It represents an abrupt slippage of the femoral neck from the head due to separation between the proliferative and hypertrophic zones of the growth plate.

Transphyseal fracture separation of the capital femoral epiphysis (Delbet type-I injury) represents an exceptional Salter-Harris I physeal injury as regards to the necessity for accurate anatomical reduction and stable internal fixation. A non-anatomical reduction will cause formation of bony bridge leading to growth arrest and subsequent progressive angular deformity. If the fracture is accurately reduced so that there is coaptation of the growth plate, a resultant small scar will not be sufficient to disturb growth. The risk of AVN may reach 100%. It may result from complete disruption of vessels supplying the femoral head, kinking of the remaining uninjured vessels or tamponade effect of hemarthrosis. This depends on the pattern of blood supply to the femoral head which is predetermined by the age and sex of the child, and the severity of the injury. When the physis is still open, blood supply depends solely on the epiphyseal artery as the metaphyseal arteries do not cross the physis.

Delbet type-IA injury has similar radiographic features to SCFE. An urgent timing of reduction may relief kinking of the remaining intact vessels. This allows revascularization of the femoral head by recanalization and the process is probably enhanced by arthrocentesis or anterior capsulotomy to relief tamponade effects of hemarthrosis on the retinacular vessels. A delayed reduction will lead to revascularization of the femoral head via neovascularization, a prolonged course of new blood vessels formation. It is in this type of revascularization pathway that severe AVN with collapse of the head tends to occur. Delbet type-IB injury (the femoral head is dislocated) has the worst prognosis as the key blood supply from epiphyseal artery is totally disrupted and 100% chance of AVN is inevitable. However, with the patient's age approaching the timing for physeal closure, there is a possible avenue for revascularization through the intraosseous metaphyseal arteries if the vessels had started crossing the physis. This can be enhanced by providing an absolute stable internal fixation of an anatomically reduced fracture. Both of these were not featured in the operative treatment of the case reported by Aminudin *et al.* Delayed non-anatomical reduction and unstable fixation were the underlying causes of subsequent AVN in their patient. The surgical treatment should aim at obtaining early stable epiphysiodesis. Most surgeons express a preference for screw fixation, and the use of a single cannulated 6.5mm cancellous screw provides sufficient stability to facilitate early epiphysiodesis. Delaying weight bearing is necessary to prevent collapse during the revascularization phase.

The phrase *primum non nocere* continues to be a reminder whenever we are involved in the treatment of SCFE. The treating surgeon remains at fault for his part in doing non-gentle reduction or placing too many pins allowing a greater risk of joint penetration and subsequent AVN. But when studies looking for the outcome of surgical treatment of SCFE continue to duplicate the same rate of AVN, we should ponder whether we have missed something that is crucial to dispel the perceived myth pertaining to the underlying cause of AVN. The traditional classification of SCFE: acute, acute-on-chronic and chronic, has recently been modified into stable and unstable acute or chronic slip. An acute unstable slip is determined based on clinical feature of inability to bear weight (Loder et al.1993). The presence of effusion in the absence of metaphyseal remodeling on sonographic evaluation of the affected hip was considered as additional features of acute unstable slip (Kallio *et al.* 1993). The patients categorized to have an acute unstable slip are found to be at the highest risk to develop AVN exceeding 50%. Despite these modifications, the perceived traditional concept of treatment emphasizing stabilization of the head by percutaneous pinning or screwing *in-situ* without attempt at anatomic reduction remains unchanged for fear of reduction further contributing to the risk of AVN.

Maeda *et al.*2001 took us into the new millennium by providing new promising evidences to dispel uncertainties of yesteryears. In their study on 12 patients with SCFE who had pre-reduction selective angiography of the medial circumflex femoral artery, all seven hips with stable slip showed good filling of the superior retinacular artery (SRA). However, the SRA was not visualized in three out of five hips with acute unstable slip and interestingly, the SRA reappeared after reduction in one patient. These results appear to suggest that even in some unstable slips, vascular compromise is secondary to kinking of the retinacular arteries caused by a displaced femoral neck and possibly tamponade effect of hip effusion at the time of injury, and that the reduction does not necessarily contribute to the risk of AVN. If we consider the presence of effusion in acute unstable slip as potential attribute to the development of AVN, arthrocentesis or anterior capsulotomy may play an adjunctive role to early reduction by gentle reduction and screw fixation. Perhaps emergency hip athrocentesis, gentle reduction and percutaneous screw epiphysiodesis should be declared as evidence-based modern treatment for acute unstable slip.

Pre-operative magnetic resonance angiography (MRA) should be considered as an indispensable evaluative tool to determine the need for reduction and post-operative MRA to predict the likelihood of AVN. This is probably the best way to dispel the existing controversy on the need for reduction and perhaps to explain AVN after percutaneous in situ pinning or screw fixation. Hips with good vascular filling are treatable with *in situ* screwing but hips with poor or absent vascular filling are probably best treated by gentle reduction and percutaneous screwing followed by post-treatment MRA to detect vascular refilling as good prognostic indicator against the likelihood of AVN. Further studies of multicenter basis are necessary to support the task for changing the unchanging face of the management of SCFE.

References

1. Kamarulzaman MA, Abdul Halim AR, Ibrahim S. Slipped capital femoral epiphysis (SCFE): A 12-year review. Med J Malaysia. 2006; 61(Suppl A): 71-8.
2. Aminudin CA, Suhail A, Shukur MH, Yeap JK. Transphyseal fracture separation of the femoral capital epiphysis: A true SCFE of traumatic origin. Med J Malaysia. 2006; 61(Suppl. A): 94-6.
3. Loder RT, Richards BS, Shapiro PS *et al.* Acute slipped capital femoral epiphysis. The importance of physeal stability. J Bone Joint Surg. 1993; 75-A: 1134-40.
4. Kallio PE, Peterson DC, Foster BK, Lequesne GW. Classification of slipped upper femoral epiphysis. Sonographic assessment of stability and remodeling Clin Orthop. 1993; 294: 196-203.
5. Maeda S, Kita A, Funayama K, Kokubun S. Vascular supply to Slipped Capital Femoral Epiphysis. J Pediatr Orthp. 2001; 21(5); 664-7.

ORIGINAL ARTICLE

Functional Outcome After Major Lower Extremity Amputation: A Survey on Lower Extremity Amputees

C H Wan Hazmy, MS (Orth)*, W Y E Chia, Adv Dip Med Sc, T S Fong, Adv Dip Med Sc**, P Ganendra, Adv Dip Med Sc****

*Department of Orthopaedics and Traumatology, Seremban Hospital, **International Medical University, Seremban, Negeri Sembilan, Malaysia

Summary

The post-operative course of amputees is poorly documented. This cross-sectional survey was undertaken to determine functional outcomes of 213 patients who had undergone either a below-knee or above-knee amputation from 2000 to 2002 in a state-hospital setting. The study comprises a self-constructed questionnaire and interview conducted by phone. Of the 213 amputees, 41 out of 61 documented telephone numbers of the patients were useful for contact. Only 30 amputees were available for the study as the remaining 11 had passed away. Included in the questionnaire was the modified Barthel Index, a measurement to assess the amputees' ability to carry out activities of daily living (ADL). It contains ten questions pertaining to ADL with a total score of 20 points. Two-thirds of the respondents (67%) use their prosthesis for less than six hours per day. The Barthel Index of 30 patients ranged from 9-20 (mean 17.7). However, the mean Barthel Index in those with and without prosthesis was 18.4 and 15.2 respectively, but this difference was not significant. Half of the respondents were unable to maintain their pre-amputation jobs, while the remaining 50% were still able to work. Forty seven percent of amputees took less than a year to return to their activities, while 33% took between one to two years. Regarding the adequacy of pre-amputation information provided by the doctors, 73% amputees responded in the affirmative, while 27% felt otherwise. Amputees were still facing substantial disabilities following major amputation of the lower limb. Although 80% of respondents surveyed own prosthesis, the full use of prosthesis is suboptimal due to prosthetic-related problems. Most amputees had a good functional outcome based on the modified Barthel Index. Some amputees were unhappy as they felt that they were insufficiently informed regarding post-amputation expectation prior to the amputation. Despite good support from family, the community support for amputees is still lacking.

Key Words: Lower extremity amputation, Functional outcomes

Introduction

Lower extremity amputation (LEA) is an ablative operative procedure carried out for variable indications including diabetic-related problems: gangrene, critical limb ischaemia, uncontrolled sepsis; severe limb injuries: major arterial injuries, crush injury and type-IIIC open fractures; and non-salvageable aggressive and malignant tumours.

Regardless whether the amputation is performed as a life-saving procedure or for palliative reason, it is a major life event that may change the patient's activities of daily living (ADL). Proper rehabilitation is necessary to improve the quality of life of the amputees. An earlier epidemiological study on major lower limb amputations carried out in our institution from 1997 to 1999 has failed to provide in-sights into the outcome following amputations[1]. Such amputation-related outcome studies have not been conducted in Malaysian population. This study was undertaken to assess post-amputation functional outcome of the patients who have undergone amputation in our institution.

Materials and Methods

This cross sectional survey was based on amputations carried out during a three years period beginning from January 2000 to December 2002 in a level-one hospital setting.

Data of all patients who had major lower limb amputation were obtained from the patients' medical records traced from the orthopaedic rehabilitation unit. The demographic profiles include race, age and gender. The data relevant to the date, level and cause of amputation were recorded. Excluded from the study were patients with trans-metatarsal, tarsal, Syme and bilateral amputations. Of 213 patients who met the inclusion criteria, only 61 patients were under post-operative follow-up and rehabilitation. Forty-one patients were successfully 'contacted' by telephone.

The assessments include their personal and occupational functioning; the use of prostheses focusing on the time spent each day using the prosthetic limb, and the reasons if any, for not using it optimally. We hypothesise that optimal use of prosthesis will improve post-amputation functional outcome in term of the ability to carry out activities of daily living (ADL). By considering the predominant role of the male as the breadwinner of the family, we also hypothesise that following major lower limb amputation; the financial independence will be more adversely affected in male than in female amputees.

A self-constructed questionnaire was designed to obtain pertinent information on patients' perceptions and problems related to their prostheses and lives as amputee. Data and information regarding marital status, social support, current status of income and employment were ascertained from the questionnaire. The questionnaire was prepared in two languages, English and Malay.

However, taking into consideration the multi-ethnic and multi-lingual diversity among the amputees, most of the interviews were conducted in the amputee's own mother tongue. All patients were required to answer completely the questionnaire.

The duration following the amputation was based on the date of the most recent amputation regardless whether it was a primary definitive or a revision of the previous amputation. Reasons for amputation, mobility status and the walking aid or devices were also determined.

The modified Barthel Index of activities of daily living (ADL) was included in the questionnaire and used to gauge functional outcome. The index cousisted ten questions pertaining to ADL, such as mobility, bathing, dressing, and toilet use, and was scored out of a total of 20 points with the lower the score, the worse the disability (Table I) The data were obtained by telephone interviews with the patients or their family members.

Information on self-rating of the supports given to the patient (by the family, friends, community or organizations) and post-hospitalization self-efficacy in their ability to resume ADL were recorded. Additionally, this study was designed to retrospectively evaluate the amputees' opinion on the informed consent given, leading to the decision for amputation. The assessments included the adequacy of information given prior to the surgery, and the quality of pre- and post-amputation medical care given to them.

Results

A total of 213 lower limb amputations were performed from January 2000 to December 2002. Only 41 out of 61 amputees who had their telephone number recorded in the medical records of the orthopaedic rehabilitation department were 'contactable'. Eleven of the remaining 41 'contactable' patients had passed away leaving only 30 patients (53% males; 47% females) available for the study. There were 40% Indian, 33% Malay and 27% Chinese. The mean age of amputees was 53 years. Of the total number of amputees, 68% were between 30-60 years of age, 27% above 60 years and 7% below 30 years. (Fig. 1)

Below-the knee amputees account for 73% of the series constituting 75% and 71% male and female amputees respectively. The remaining 27% were above-the knee amputees. Seventy-seven percent of lower limb amputations were indicated for diabetic-related complications while traumatic amputation constituted 23% of the amputations.

Eighty percent of the amputees (79% males and 81% females) had prosthesis fitted onto the stumps. Among the amputees who had the prosthesis, 79% claimed to use their prosthesis but 42% found their prosthesis uncomfortable, and had some difficulty adjusting to it. About 21% of them complained of allergy or itchiness with the use of the prosthesis. Having prosthesis was a burden in 13% of amputees as it was difficult to

maintain. Loosely fitted prosthesis was a problem in 17% amputees. In general, 17% had more than one complaint in relation to the prosthetic usage (Fig. 2). Financial constraint was the only reason for 20% amputees who did not own prosthesis.

Two-thirds (67%) of amputees including all above-the knee amputees and 56% below-the knee amputees used their prosthesis for less than six hours per day. The remaining one-third (33%) which include 44% below-the knee amputees used it more than six hours.

When compared in relation to gender, 62% of male amputees and 73% of female amputees used the prosthesis for less than six hours a day. Among those who used prosthesis less than six hours per day were all amputees below the age of 30 years, 69% amputees between 30 to 60 years, and 50% elderly amputees above 60 years of age (Fig. 3).

The modified Barthel Index scores of 30 amputees ranged from 9-20 (mean 17.7±2.5). The mean Barthel Index scores in those with and without prosthesis was 18.4 and 15.2 respectively. The t-test comparing the difference in Barthel Index for those with and without prosthesis was not statistically significant (t=2.094, p=0.085).

With regard financial independence, 50% of the amputees were unable to return to work. Out of the remaining 50% amputees, 40% held the same job as before with unaffected income, while the other 10% were working in a low- paid job category. A half of female amputees had retained their job with unaffected income and the remaining 50% were unable to return to work. Among the male amputees, 31% had retained their job with unaffected income, 19% working with a low-paid job while 50% were unable to work. Thus, the financial independence of male amputees was more adversely affected (69%), as compared to females (50%). However, the difference between genders and their affected financial independence was not statistically significant (p=0.296).

In general, family support was rated as good, fair and poor by 63%, 30% and 7% amputees respectively. The majority of amputees were living at home and well supported physically, financially and emotionally (Fig. 4). Supports from friends in forms of social, emotional and physical supports were good, fair and poor in 20%, 43% and 37% of amputees (Fig. 5). Community support was rated as good by only 7% of amputees, fair in 33% amputees and poor in the majority (60%) of amputees. Financial support was the main form of support given by the community.

The duration taken by the amputees to accept their status and return to their daily activities varied among the amputees interviewed with 43% took less than a year, 40% took one to two years and 17% took more than two years to accept their status, while. Forty-seven percent of amputees took less than a year to return to their daily activities, while 33% took between one to two years and 20% took more than two years.

Retrospectively, only 63% of amputees would still have agreed to go for the amputation, while 37% felt that they would like to have refused the amputation. Nearly three-quarters (73%) of amputees thought that it was wise to undergo an amputation, while 27% of amputees thought otherwise. All these were attributed to the amount of pre-amputation information received by the patients. In term of adequacy of information given, 73% amputees responded in the affirmative, while the remaining 27% felt that information was lacking. Among the amputees who felt they were given insufficient information, there were more males (27%), compared to females (14%). Eighty-six percent of females claimed that they were given adequate information on their amputation. Only 63% of male amputees felt the same.

Pre-amputation medical care given at Seremban Hospital was rated as good, fair and poor in 30%, 57% and 13% of amputees respectively. Post-amputation care was considered as good, fair and poor by 40%, 47% and 13% of amputees respectively. Out of the 30 amputees, 83% of them had the same rating for quality of medical care before and after the amputation. Thirteen percent of amputees rated the quality of post-amputation medical care as better than pre-amputation care. Only four percent of amputees felt that the quality of post-amputation medical care was worse.

Table I: The Modified 10-Item Barthel Index

Parameter	Finding	Point
Bowel (preceding week)	Continent	2
	Occasional incontinent (once a week)	1
	Incontinent (needs enema)	0
Bladder (preceding week)	Continent	2
	Occasional incontinent (once a day)	1
	Incontinent (needs catheterization)	0
Grooming (preceding 24-48 hours)	Independent	1
	Needs help	2
Toilet Use	Independent	2
	Needs some help	1
	Dependent	0
Feeding	Independent	2
	Needs help	1
	Unable	0
Transfer (from bed to chair and back)	Independent	3
	Little help (verbal or physical)	2
	More help (one or two persons physical), Can sit	1
	Unable (no sitting balance), Needs two people to lift	0
Mobility	Independent (may use walking aid)	3
	Walks with the help of a person (verbal or physical)	2
	Wheelchair independent	1
	Immobile	0
Dressing	Independent	2
	Needs help but can do some unaided	1
	Dependent	0
Stairs	Independent, must carry any walking	2
	Needs help (verbal, physical carrying aid)	1
	Unable	0
Bathing	Independent; unsupervised and wash self.	1
	Dependent	0

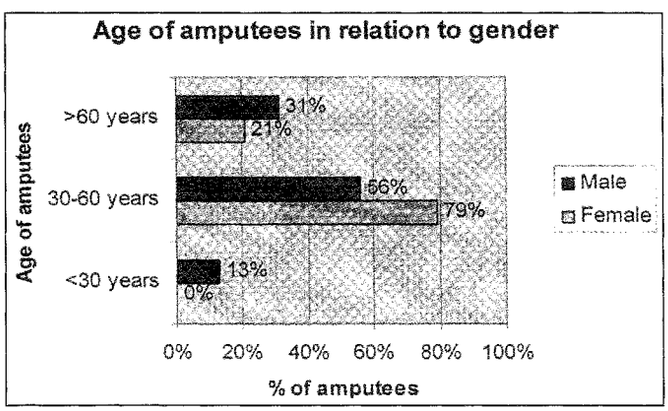


Fig. 1

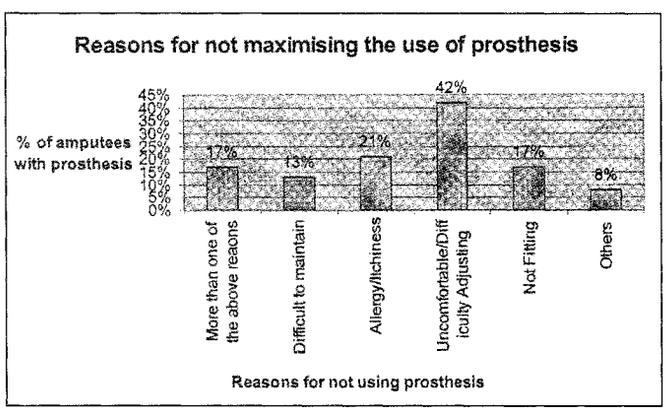


Fig. 2

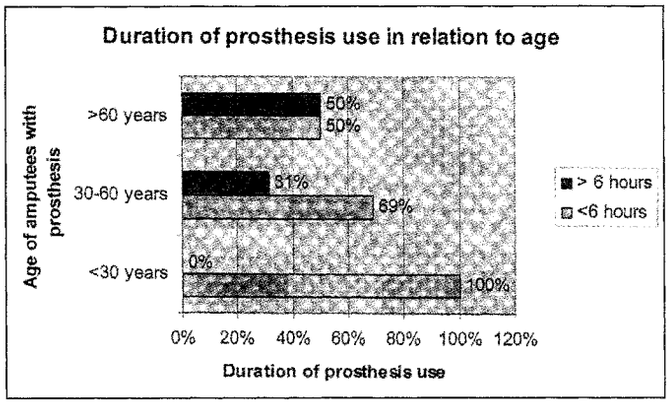


Fig. 3

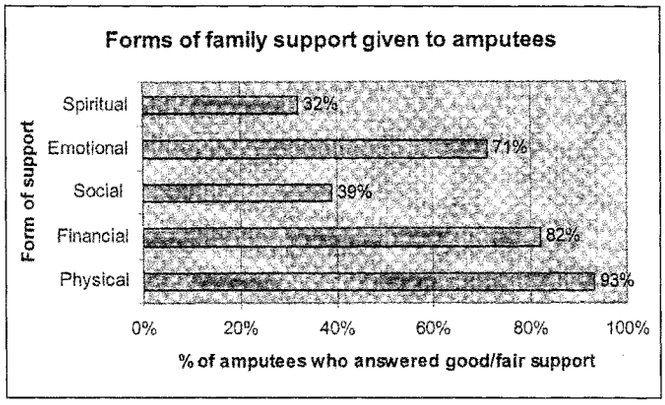


Fig. 4

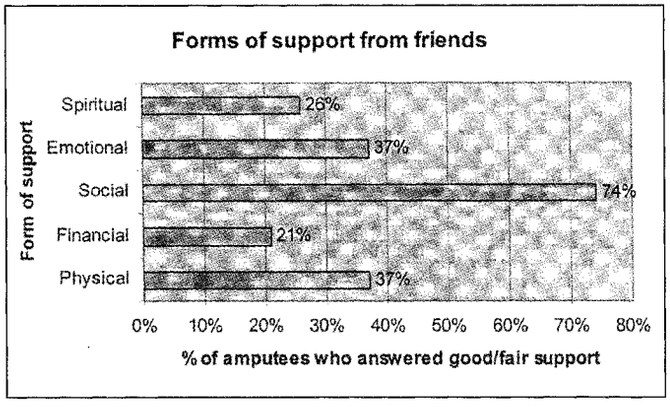


Fig. 5

Discussion

Over 80% of the amputations were indicated for diabetic foot related complications. This is in agreement with our earlier series[1] and other series reported in the literature[2, 3]. Limb trauma was the second most common cause for amputation.

The use of prosthesis has extensively been studied among traumatic amputees. In a study on 109 amputees with a mean age of 51 years, Neilsen *et al* noted that 67% of patients used their prosthesis longer than nine hours a day[4]. Purry and Hannon reported 84% of amputees use prosthesis longer than 13 hours a day in a series of 25 amputees[6]. A study by Burger *et al* on 223 traumatic amputees also showed that 85% of amputees used their prosthesis for over seven hours a day[6]. In a large series of 626 amputees aged between 16 and 60 years, Schoppen *et al* showed that 92% of patients wore their prosthesis for more than 8 hours a day, and 84% judged their wearing comfort as sufficient[7].

The majority of amputees (67%) in our series used their prostheses less than six hours a day and one-third of patients used the prosthesis for longer than six hours. It can be considered that the full use of prosthesis among amputees surveyed is suboptimal. Amputees in the younger group tended to have shorter duration of prosthesis use. All amputees below 30 years of age used prosthesis less than six hours a day, compared to 69% and 50% for those in the age groups of 30 to 60 years and over 60 years respectively. However, since the sample size of our series is too small, no conclusion can be made about this apparent trend.

In a survey on prosthetic-related problems which include prosthetic fitting, mechanical functioning and non-mechanical quality of the prosthesis, advice about life adaptation with prosthesis and ancillary supports, Legro *et al*[8] reported ill-fitting prosthesis as the main reason for suboptimal use of the prosthesis with all amputees having complaints regarding their prosthesis. Lack of product monitoring or quality control may lead to inconsistency in the quality of prosthesis. In Malaysia, rehabilitation medicine is progressing at a slow pace and the lack of rehabilitation specialists makes it difficult for amputees to get a proper prescription for their prosthesis. Our study concurs with the conclusion of the survey by Legro *et al* that future research is recommended to adjust aspects of the fit of the prosthesis with the residual limb among lower limb amputees[8].

The presence of diabetes-related co-morbidities and its systemic complications often lead to sub-optimal use of the prosthesis among the amputees. The compounding factors were not surveyed in our study. Further studies will be necessary to address these issues.

The Barthel Index is a reliable way to measure disabilities in Activities of Daily Living (ADL) and mobility[9]. DeHaan *et al.* in their study noted that most patients had a good functional outcome in term of their ability to carry out ADL based on the modified Barthel Index[10]. The Barthel Index scores of the 30 amputees surveyed ranged from 9-20, with a mean of 17.7±2.5. The main impairment in most amputees was the inability to climb stairs. This did not appear to be a problem if the amputees' homes were either single-storey houses, or they slept on the ground floor. Most patients adapted to their situation, and were able to attend to personal hygiene without assistance, as reflected by the Barthel Index. However, it should be noted that in another study, the Barthel Index lacked sensitivity and was less suitable as measurement for a functional outcome for amputees[11].

The first hypothesis of this study was that the optimal usage of prosthesis will significantly improve the functional outcome of amputees following major lower limb amputation in terms of their ability to carry out ADL. The mean Barthel Index scores of amputees with prosthesis (18.4) was slightly higher than those without prosthesis (15.2). However, it was statistically insignificant due to the small sample of the series.

Half of the amputees were unable to return to work. Almost all the male amputees in our series were working prior to the amputation, whereas half of the female amputees were non-working housewives. This may account for the high percentage of female amputees (50%) who had their income unaffected. The situation was different for the male amputees as most of them were working prior to the amputation. In the context of an Asian society, the male is usually the breadwinner of the family. Nearly one-third of the male amputees (31%) returned to the same pre-amputation job with unaffected income. Some of them had already retired and continued to receive their pension. This explains the relatively high rate of male amputees whose income seemed to be unaffected. The remaining 69% of male amputees had their income adversely affected while some were totally unable to return to work.

Another hypothesis of this study was that financial independence of males would be affected more than females. Although the financial independence of male amputees was affected (69%) slightly higher than female amputees (50%), the difference was not statistically significant as size of the study sample was small.

Re-integration of amputee back to the workplace requires job adaptation to the limitations presented by individual amputee[12]. Adjustments should be made to prevent highly demanding workload. Most amputees have limited walking and standing ability, and for above-the knee amputees, sitting comfort also needs attention. Flexibility in time scheduling may prevent problems in jobs where the amputee is hindered in his or her working speed because of the amputation. Additional research is necessary to give a more detailed advice about adequate workplace adjustments for lower limb amputees[12].

The supports received by the amputees showed a declining rating, with the best from family, fair from friends, to poor community support. This reflects the important role of family supports in the rehabilitation of amputees. However, in Malaysia, support groups or organizations for amputees are either inactive or non-existing, and this makes it more difficult for amputees and their families to obtain information regarding amputation or prosthesis. In most developed countries, however, many support groups are operating in their local communities. Low public awareness on amputation exists in Malaysia. A greater community awareness and participation in the rehabilitation of amputees is prudent to assist re-integration of amputees into the society.

One-third of amputees were unhappy with their amputation to the extent that 37% of them would have changed their mind to defer amputation. A notable finding was that 27% of amputees felt that they were inadequately informed regarding the whole purpose of amputation and its potential consequences in the rehabilitation phase. Some of the amputees had low educational level to understand the actual concept of amputation. Communication difficulty in obtaining informed consent was a problem in our multi-ethnic community. Perhaps a multi-lingual booklet with information regarding amputation and prosthetics should be made available. Interpreters could also be called in when obtaining informed consent from patients who are only fluent in their mother tongue.

This study has its own limitation as the sample size was too small to validate some of apparent significant results. The key weakness of this study lies in our inability to enrol enough patients because of failure to document the patients' telephone numbers in the admission or discharge form. To have only 28% of 213 patients' take telephone numbers documented is

probably an unacceptable recording practice as owning a telephone is norm nowadays. Interview methods and interviewers just represent minor variables that can be standardized to reduce differences.

Conclusion

Complications arising from diabetes mellitus remains a major cause of lower limb amputation. Although 80% of amputees surveyed own prosthesis, the full use of prosthesis is suboptimal due to prosthetic-related problems. Most amputees had good functional outcome. One-third of the amputees were unhappy and felt that they were insufficiently informed regarding the post-amputation course. Despite good family supports, community support for amputees is still lacking.

Acknowledgement

We thank Dr P. Theva Raj and Dr Teng Cheong Lieng for their help and support during the preparation of this article.

References

1. Wan Hazmy CH, Mahamud M, Ashikin N, et al. Major limb amputations in Scremban Hospital: a review of 204 cases from 1997-1999. Med J Malaysia. 2001; 56 (Suppl C): 3-7.
2. Rommers GM, Vos LD, Groothoff JW, et al. Epidemiology of lower limb amputees in the north of The Netherlands: Aetiology, discharge destination and prosthetic use. Prosthet Orthot Int 1997; 21(2): 92-9.
2. Pohjolainen T; Alaranta H. Epidemiology of lower limb amputees in Southern Finland in 1995 and trends since 1984. Prosthet Orthot Int 1999; 23(2): 88-92.
3. Nielsen CC. A survey of amputees: functional level and life satisfaction, information needs and the prosthetist's role. J Prosthet Orthot 1990; 3: 125-9.
4. Purry NA, Hannon MA. How successful is below-knee amputation for injury? Injury. 1989; 20(1): 32-6.
5. Burger H; Marincek C; Isakov E. Mobility of persons after traumatic lower limb amputation. Disabil Rehabil 1997; 19(7): 272-7.
6. Schoppen T, Boonstra A, Groothoff JW, et al. Epidemiologic characteristics and quality of life of lower limb amputations in adulthood in the Netherlands. Thesis University of Groningen, the Netherlands. 2002.
7. Legro MW, Reiber G, del Aguila M, et al. Issues of importance reported by persons with lower limb amputations and prostheses. J Rehabil Res Dev. 1999; 36(3): 155-63.
8. De Haan R, Limburg M, Schuling J, et al. Clinimetric evaluation of the Barthel Index, a measure of limitations in dailly activities. Ned Tijdschr Geneeskd. 1993; 137(18); 917-21.
9. Mahoney FL, Barthel DW. Functional evaluation: the Barthel index. Maryland State Med J. 1965; 14: 61-5.
10. Treweek SP, Condie ME. Three measures of functional outcome for lower limb amputees: a retrospective review. Prosthet Orthot Int. 1998; 22(3): 178-85.
11. Schoppen T. Functional outcome after a lower limb amputation. Thesis University of Groningen, the Netherlands. 2002.

ORIGINAL ARTICLE

Alteration of Foot Temperature in Diabetic Neuropathy: Is it Another Piece of Puzzle?

A S Naicker, MMed (Rehab), S A Roohi, FRCS, C S Lee*, W H Chan*, L S Tay*, X J Din*, L H Eow*

Department of Orthopaedics and Traumatology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia, *Medical Student

Summary

Poor glycaemic control and the duration of diabetes mellitus are known to accelerate development and progression of neuropathy. Diabetic co-morbidities: hypertension and hyperlipidaemia, have been postulated to associate with development of neuropathy. A diabetic foot with low temperature and frequent exposure to low temperature environment has recently been hypothesized to be at higher risk to develop early neuropathy. This cross-sectional study is undertaken to identify risk factors for diabetic neuropathy and the association between foot temperature and development of diabetic neuropathy by using simple clinical examination in the outpatient setting. From April 18, to April 30, 2005, universal sampling method was used to select 134 diabetic patients (type 1 or type 2 for > 1 year) with peripheral neuropathy. Excluded are those with chronic alcoholism, drug-induced neuropathy, dietary history of vitamin B deficiency and family history of porphyria and hereditary sensorimotor neuropathy. The patient's duration of diabetes, glycaemic control status and the presence of co-morbids: hypertension and hyperlipidemia, were recorded. The temperature of the foot was measured by using thermo buddy. Of 134 patients representing Malaysian ethnic distribution with an equal number of males and females, 20.1% were in the age group of 61 to 65 years and, 85.1% and 67.9% belonged to lower socioeconomic and educational groups respectively. Associations between diabetic neuropathy and glycaemic control ($p = 0.018$) and duration of diabetes ($p < 0.05$) were significant. However, hypertension, hyperlipidaemia and low foot temperature were not significantly associated with development of diabetic neuropathy. Poor glycaemic control is significantly associated with diabetic neuropathy. Foot temperature alteration is merely an effect of autonomic neuropathy with a cold foot is attributed to co-existing peripheral arterial disease.

Key Words: Diabetic Neuropathy, Foot temperature, Glycaemic Control

Introduction

Diabetic peripheral neuropathy (DPN) is simply defined as 'the presence of symptoms and/or signs of peripheral nerve dysfunction in people with diabetes after exclusion of other causes' (International Consensus Meeting for the Outpatient Management of Neuropathy, 1998). It has been estimated that 10-65% of diabetics have some form of peripheral neuropathy but only 7.5% were recognized at the time of diagnosis of diabetes. However, geographical variation in the prevalence of DPN is largely attributed to non-standardization of the diagnostic criteria, patient selection, and methods of assessment.

Similarity between the mechanisms for the development of DPN and cold-induced nerve injury has been observed. Cooling of the distal extremity seems to enhance microcirculatory-induced neuronal damage. Patients with DPN commonly present with foot symptoms related to temperature change secondary to autonomic dysfunction. Autonomic denervation of peripheral arteries may occur early in the course of DPN. It has significant effects on regional blood flow and vascular responses. Diabetic autonomic neuropathy (DAN) may cause severe loss of cutaneous thermoregulation in the form of excessively warm skin, bounding pulse and marked venous dilatation due to

increased nutritive capillary blood flow secondary to arteriovenous shunting or cool extremity due to tunica media calcification of the arteries of the foot and leg. Blood flow responses to various stimuli are also abnormal. Normal vasodilatation response to heat is reduced partly due to effect of hyperglycaemia in the microvasculature and failure of nitric oxide dependent smooth muscle vasodilatation in DPN.

It has been postulated that temperature-related neuronal damage started to occur in the presence of cooling in the range of 5° 10°C or below to what the feet are typically exposed to in everyday life[2]. Nonetheless, it is possible that early impairment of normal neurovascular function may occur in the setting of diabetes, and early neuropathy could be accelerated by even modest temperature reduction in the range of 15 20°C without the need for extreme temperature reduction to produce such injury[1].

If cooling enhances the development and progression of DAN, an effect of geographical location might be anticipated. The prevalence of DPN in Mauritius is only 8%, much lower than in most European countries[2]. In a case-controlled study comparing the incidence of amputation of people who live in South Asia as compared with those in England, South Asians were found to have a lower likelihood of DPN than those who live in England[3]. The fact that even in warm climate, such as in Mauritius, DPN does occur supports the hypothesis that cooling plays a possible role in hastening the progress of the disorder and making it clinically apparent rather than being necessary for its development[4].

The aims of the present study are to determine the association between foot temperature alteration and development of DPN; and to identify risk factors associated with DPN.

Materials and Methods

The Population Studied

A total of 134 diabetic patients (age range from 19 to 70 years) who came to Pusat Perubatan Primer Bandar Tasik Selatan were enrolled into the study. Those with type -1 or type -2 diabetes for more than a year were included. Major exclusion criteria were chronic alcoholism, drug-induced neuropathy, positive history of vitamin B deficiency in the diet and family history of porphyria and hereditary sensorimotor neuropathy.

Study Design

This was a cross-sectional study on risk factors of DPN of patients in Pusat Perubatan Primer Bandar Tasik Selatan. Patients were assessed by questionnaire, physical examination and biochemical parameters. The physical examination included vibration sense, pinprick, Achilles tendon reflex and foot temperature. The instruments used were a 128Hz tuning fork, sharp and blunt orange sticks, tendon hammer and Thermo Buddy. Biochemical markers included fasting blood sugar (FBS) or HbA1c and lipid profile, which were done within one year, were traced from patient's report. Data was analyzed by using SPSS 13.0.

Case Definition

A diabetic patient with symmetrical distal sensory-motor neuropathy with exclusion of other causes of neuropathy such as alcoholism, prescription of drugs, diet, use of supplements, toxic exposures and family history is defined as a case.

DPN is diagnosed based on new minimal abnormal criteria in two evaluations: neuropathic symptom score (NSS) and neuropathic disability score (NDS). Parameters assessed in the NSS are paraesthesia, numbness, pain and an unsteady gait. The NDS assesses muscle strength, sensation of the index finger and big toe, and Achilles tendon reflex.

The association between duration of diabetes, control of diabetes, hypertension, hyperlipidaemia and DPN is also included in the study.

Statistical Analysis

Parametric data were analyzed using t-student test; whereas non-parametric data by chi-square. SPSS 13.0 programme was used.

Results

A total number of 134 patients (76 females and 58 males) with age ranging from 35 to 70 years were recruited into this study. The majority of patients (n = 112) fell in the age range of 51-70 years (mean 57.7 years). The racial distribution of the patients was in keeping with the Malaysian population (Malays 50.0%, Chinese 32.8%, Indians 15.7%, others 1.5%). Most patients (85.1%) had monthly income of less than RM 2000 and 67.9% were of lower educational group. Nearly half of the patients (47.8%) had DPN. Among the five risk factors, glycaemic control ($p=0.018$) and duration of diabetes ($p<0.05$) were significantly

associated with DPN. This is in agreement with the literature which indicated that the longer the duration of the disease, the higher the risk of getting diabetic neuropathy[5]. Hypertension and hyperlipidaemia have been linked as potential risk factors of DPN[6]. In our study, however, these were not found to be significant. This non-concordance was probably due inadequate patient numbers, insufficient long term records and patient data. Some of the tests were not done routinely in every patient. For example, in the assessment and management of glycaemic control, not all patients had both HbA1c and fasting blood sugar (FBS) values.

Diabetic patients with neuropathy recorded higher average foot temperature of 30.2°C, whereas those without neuropathy recorded an average of 29.7°C. Therefore, low foot temperature did not show significant correlation to the presence of diabetic neuropathy (p=0.174) in our study (Table I).

Discussion

In this cross sectional study, 47.8% diabetics were found to have neuropathy. This is comparable to the prevalence of DPN in the US where an estimated 10-65% of patients with diabetes had some form of peripheral neuropathy.

The pathophysiology of DPN remains unclear but is postulated to be a multifactorial process. The metabolic theory proposes hyperglycaemic-induced axonal transport impairment and nerve structure damage caused by intracellular accumulation of sorbitol and fructose in peripheral nerves secondary to increased levels of intracellular glucose. The vascular theory of ischemic-hypoxia suggests that increased endoneural vascular resistance secondary to hyperglycaemic blood, causing endoneural ischaemia and axonal degeneration. The neurotrophic theory suggests that alteration of production and transport of nerve growth factors (NGF) in diabetes affects maintenance and regeneration potential of the axon.

Interestingly, DPN has been observed to be associated with alteration of foot temperature. The two most common mechanisms: direct vascular effect and reactive oxygen species formation were postulated. In diabetics, lowering of the temperature induces physiological changes that could lead to nerve ischaemia. The changes: plasma hyperviscosity, increased red cell rigidity and volume, reduction in leucocyte mobility, will lead to a decreased regional blood flow, slowing oxygen delivery and elimination of toxic metabolites. In animal models, cooling and excess temperature fluctuations have been shown to enhance production of reactive oxygen species in otherwise healthy nerves. Reactive oxygen species are product of auto-oxidation of glucose, the advanced glycation process, lipid oxidation, inefficient mitochondrial function, and inflammatory processes[7]. They may play important roles in the development of neuropathy by interfering with cellular signalling via changes in protein kinase C activity or direct and indirect injury to the endothelium. Hence, cold temperatures, in combination with these diabetes-related effects, could work in concert to exacerbate reactive oxygen species-induced endothelial damage[7, 8, 9].

Association between lowering of foot temperatures and development of DPN is insignificant in our study. This

Table I: Association of various factors in the development of diabetic neuropathy

	Diabetic Neuropathy		Total	X^2 / T	p
	Yes	No			
Glycaemic Control					
Good	7	19	26	X^2=5.614	0.018
Poor	57	51	108		
Duration of diabetes (years)	10.45	5.83		T=3.634	<0.05
Hyperlipidaemia					
Yes	43	51	94	X^2=0.513	0.474
No	21	19	40		
Hypertension					
Yes	51	50	101	X^2=1.229	0.268
No	13	20	33		
Mean temperature of the foot (°C)	30.15	29.74		T=1.367	0.174

probably represents poor thermal autoregulation in the neuropathic group rather than an absolute temperature value. However, temperature elevation is expected to occur in patients with subclinical diabetic autonomic neuropathy and significant increase up to 2°C has been observed in patients with acute Charcot's foot.

Limitations of the Study

This study has several limitations. The exclusion criteria for diabetics with vitamin B1, B6 and B12 deficiency and family history of neuropathy like porphyria are purely based on history taking. The diagnosis of neuropathy was simply made on clinical grounds to accommodate the study in an outpatient setting. Specific investigations for hard evidences including nerve conduction study (NCS) and computer-assisted sensory examination (CASE) were not done. The minimal Dyck's diagnostic criteria of neuropathy[10]: abnormalities in at least two of neuropathic symptom score (NSS), neuropathy disability score (NDS), nerve conduction study and computer-assisted sensory examination (CASE) were not adopted. The patient factor is also a minor limitation in our study. The symptoms may vary subjectively from one patient to another. Some patients may perceive mechanical discomfort as paraesthesia or pin-prick sensation. Furthermore, recall bias was also a limiting factor.

The missing links in this study are salient clinical signs of autonomic neuropathy: bounding peripheral pulse and dilatation of skin veins in the foot. These signs typically occur early in the course of DPN before other signs of neuropathy manifest.

Conclusion

Neuropathy is a known complication of diabetes mellitus. Lowering of foot temperature may play yet an undetermined role in the development of symptomatic DPN. The risk of developing neuropathy in diabetic patients who are constantly or frequently exposed to colder environment is probably high but whether 0.5°C temperature change or fluctuation of lower temperatures has a significant effect on DPN remained unclear. Further researches to explore this jigsaw puzzle may lead to early identification and diagnosis of DPN. This may in turn, crucial to prevent complications such as chronic foot ulcers and lower limb amputation in diabetics.

References

1. Kang PB, Hoffman SN, Krismitsos E, Rutkove SB. Ambulatory foot temperature measurement: a new technique in poly-neuropathy evaluation. Muscl Nerve.2003; 27: 737-42.
2. Shaw JE, Hodge AM, de Courten M, et al. Diabetic neuropathy in Mauritius: prevalence and risk factors. Diabetes Res Clin Pract. 1998; 42: 131-9.
3. Chaturvedi N, Abbott CA, Whalley A, et al. Risk of diabetes-related amputation in South Asians vs. Europeans in the UK. Diabet Med. 2002; 19: 99-104.
4. Tesfaye S, Stevens LK, Stephenson JM, et al. Prevalence of diabetic peripheral neuropathy and its relation to glycaemic control and potential risk factors: the EURODIAB IDDM Complications Study. Diabetologia. 1996; 39: 1377-84.
5. Young MJ, Breddy JL, Veves A, Boulton AJM. The prediction of diabetic neuropathic foot ulceration using vibration perception thresholds. A prospective study. Diabetes Care. 1994; 17: 557-60.
6. Shaw JE, Zimmet PZ, Gries FA, Zigler D. Epidemiology of diabetic neuropathy. In. Gries FA, Cameron NE, Low PA, Zigler D (Eds). Textbook of Diabetic Neuropathy. Stuggart. Thieme. 2003; 64-82.
7. Cameron NE, Eaton SE, Cotter MA, Tesfaye S. Vascular factors and metabolic interactions in the pathogenesis of diabetic neuropathy. Diabetologia. 2001; 44: 1973-88.
8. Low PA, Nickander KK. Oxygen free radical effects in sciatic nerve in experimental diabetes. Diabetes. 1991; 40: 873-7.
9. Hunt JV, Dean RT, Wolff SP. Hydroxyl radical production and autoxidative glycosylation. Glucose autoxidation as the cause of protein damage in the experimental glycation model of diabetes mellitus and ageing. Biochem J. 1988; 256: 205-12.
10. Dyck PJ. Detection, characterization and staging of polyneuropathy; assessed in diabetics. Muscle Nerve. 1988: 11: 21-32.

ORIGINAL ARTICLE

Bacteriology of Diabetic Foot Lesions

R Yoga, MS(Orth), A Khairul, MD, K Sunita, MPCR, C Suresh, MS(Orth)

Department of Orthopaedic Surgery, Hospital Alor Star, Alor Star, Kedah, Malaysia

Summary

Infection plays a pivotal role in enhancing a diabetic foot at risk toward amputation. Effective antibiotic therapy against the offending pathogens is an important component of treatment of diabetic foot infections. Recognition of the pathogen is always difficult as the representative deep tissue sample for culture is surrounded by ulcer surface harbouring colonies of organisms frequently labelled as skin commensals. The emergent of resistant strains represents a compounding problem standing against efforts to prevent amputation. This study was undertaken to identify the pathogens associated with diabetic foot infection in terms of their frequency and sensitivity against certain commonly used antibiotics. Forty-four consecutive patients with open diabetic foot infections had wound swab taken for culture and sensitivity testing. Cultures positive were observed in 89% of the cases with *Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeroginosa* encountered in 20%, 14% and 14% of cases respectively. Mixed growths were isolated in 6% of cultures. All *Staphylcoccus aureus* isolates were resistant to Penicillin but 80% were sensitive to Erythromycin and Co-trimoxazole. *Klebsiella pneumoniae* isolates were sensitive to Methicillin and Gentamycin in 80% and 60% of cases respectively, and resistant to Ampicillin and Ceftazidime in 83% and 50% respectively. All *Pseudomonas aeroginosa* isolates were sensitive to Amikacin and Ciprofloxacin but 50% were resistant to Gentamycin. There was no single antibiotic possessing good coverage for all common organisms isolated from diabetic foot lesions. *Staphylococcus aureus* remains the predominant cause of diabetic foot infections followed by *Klebsiela pneumonia* and *Pseudomonas aeroginosa.* Most infections are monomicrobial. The emergence of multiresistant organisms is a worrying feature in diabetic foot infections.

Key Words: Bacteriology, Diabetic foot, Infection

Introduction

Diabetic foot related lesions represent a major public health problem. The trio of problem leading to the diabetic foot: neuropathy, peripheral arterial disease and infections constitute the so-called diabetic foot syndrome. Infection complicates the pathological pictures of diabetic foot and plays a pivotal role in the development of moist gangrene leading to major amputation. The infection accelerates early development of tissue necrosis and gangrene even after a trivial trauma. As the disease progresses, it will become recalcitrant to antibiotic therapy. It is essential to assess the magnitude of bacterial infection of the lesions to avoid further complications and save the foot. Early diagnosis of microbial infections helps in the administration of appropriate antibacterial therapy following the initial empirical antibiotic therapy. This study was undertaken to identify patterns of diabetic foot infections in terms of the underlying offending organism(s) and their sensitivity to antibiotics.

Materials and Methods

A total of 44 patients with diabetic foot ulcer admitted to the orthopaedic unit of Alor Star Hospital from January 2005 to June 2005 had swabs taken from the foot ulcers. All patients were admitted because the ulcers were seriously infected and not amenable to be treated on an outpatient basis. Sterile swabs were used to swab the floor of the ulcer. These were then put in suitable transport media and sent to the microbiology laboratory for processing. The specimens were

cultured on blood agar and MacConkey agar. The bacterial isolates were identified by conventional biochemical tests. The antibacterial susceptibility testing was carried out according to Kirby-Bauer method.

Results

There were 44 patients in this series. The mean age of the patients was 58.6 years. *Staphylococcus aureus* was the most common organism accounting for 20.5% of all infections. This was followed by *Klebsiella pneumoniae* and *Pseudomonas aeroginosa* in 13.6% each. Proteous mirabilis and *Enterobacter sp* were encountered in three and four specimens respectively. The remaining organisms were in the gram-negative group (11.4%) and gram-positive group (6.8%). There were no growth in 5 (11.4%) specimens and only 3(6.4%) had a mixed growth.

Sensitivity testing showed 88% of the *Staphylococcus aureus* were sensitive to Erythromycin, Gentamycin and Co-trimoxazole. Almost all organisms were resistant to Penicillin and 10% were resistant to Erythromycin.

Almost 83% *Klebsiella pneumoniae* were sensitive to Gentamycin and Amikacin, and 66% were sensitive to Cefuroxime, Cefoperazone, Ceftazidime and Co-trimoxazole. However, 83% were resistant to Ampicillin and 30% resistant to Cefuroxime.

Nearly 80% *Pseudomonas aeroginosa* were sensitive to Amikacin and 66% were sensitive to Imipanem, Ceftazidime and Ciprofloxacin. Although half of the cultures were sensitive to Cefoperazone, the remaining 50% were Gentamycin and 20% were also resistant to Cefoperazone, Ceftazidine, Netilmycin and Piperacillin.

Cultures which grew *Enterobacter sp.* were all sensitive to Cefoperazone and Ceforoxime but 60% were sensitive to Gentamycin, Netilmycin and Co-trimoxazole. All Proteus mirabilis isolates were sensitive to Cefoperazone but sensitivity to Cefuroxime, Gentamycin and Bactrim was demonstrated in 60% isolates.

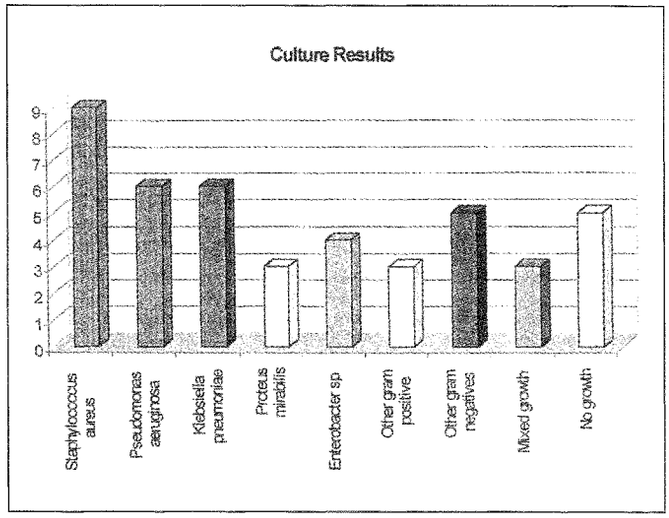


Fig. 1: Culture Results in 44 Samples

Discussion

Aerobic and anaerobic infections in diabetic foot lesions have been extensively studied. Most patients presented with trophic ulcers over the heel of the foot with characteristic punched out edges and surrounded by area of inflammation and swelling. Monomicrobial infections were encountered in 38 patients and 3 patients had polymicrobial infections. *Staphylococcus aureus* was the commonest organism and isolates of *Staphylococcus aureus* were resistant to Penicillin. This finding is not surprising as Penicillin is an old antibiotic and many organisms have already developed resistance to it. Sensitivity to Gentamycin was encountered in half to two-thirds of the cases. This is an interesting finding because Gentamycin has been the preferred choice of antibiotic for diabetic foot infections. Most Gentamycin resistant strains were hospital-acquired infection and they were in fact multiresistant organisms. There is no single antibiotic which is adequate coverage for all organisms. For empirical treatment of diabetic foot infections, a combination of antibiotics will give a better coverage against the possible offending organisms. Proper culture and sensitivity testing is required to ensure that the prescribed antibiotics correspond to the organisms isolated.

References

1. Frykberg RG. Diabetic foot ulcers. Current Concept. J Foot Ankle Surg. 1996; 37(5): 440-6.
2. Blazer K, Heidrich M. Diabetic gangrene of the foot. Chirug. 1999; 70(7): 831-44.
3. LoGerfo FW, Coffman JD. Current Concepts: Vascular and microvascular diseases of the foot in diabetes. New Engl J Med. 1978; 311: 1615-9.
4. Shea KW. Antimicrobial therapy for diabetic foot infections. A practical approach. Postgrad Med. 1999; 106(1): 85-6, 89-94.
5. Smith JMB, Payne JE, Berue TV. Diabetic foot lesions of the skin and soft tissue infections of surgical importance. In The Surgeons Guide to Antimicrobial Chemotherapy. 2002; 218-21.
6. Meade JW, Muller CB. Major infections of the foot. Med Times. 1968; 96: 154-65.
7. Bailey TS, Yu HM, Rayfield EJ. Patterns of foot examination in a diabetic clinic. Am J Med. 1985; 78: 371-4.
8. Miller RS, Amyes SGB. Laboratory control of antimicrobial therapy. In. Collee JG, Fraser AG, Marmion BP, Simmons (eds) Mackie and McCartney Practical Medical Microbiology.14th ed. London, Churchill Livingston. 1996; 151-78.
9. Forbes BF, Sahn DF, Weisf AS. Anaerobic Bacteriology. Laboratory Consideration. In Bailey and Scott's Diagnostic Bacteriology. 10th ed. New York, Mosby. 1998; 696-710.
10. Pittet D, Wyssa B, Herter-Clevel C et al. Outcome of diabetic foot infections treated conservatively: A retrospective cohort study with long-term follow-up. Arch Intern Med.1999; 159(8): 851-6.

ORIGINAL ARTICLE

Necrotizing Fasciitis of the Lower Limb: An Outcome Study of Surgical Treatment

M K Kwan, MS(Orth), A Saw, FRCS, E K Chee, MD, C S Lee*, C H Lim*, N A Zulkifle*, N H Saarey*, M N Mohamad Hussien*

Department of Orthopaedic Surgery, University of Malaya Medical Centre, Kuala Lumpur, Malaysia, *Medical Student

Summary

Necrotizing fasciitis is a limb- and life-threatening rapidly spreading infection affecting the deep fascia with secondary necrosis of the subcutaneous tissue. It requires immediate medical attention and emergency surgery to prevent morbidity and death. This study was undertaken to determine its co-morbidity and risk factors affecting the outcome of its surgical treatment. This is a retrospective review of 36 cases of necrotizing fasciitis of the lower limb treated in our center between 1998 and 2002. Only 19% of the cases were correctly diagnosed upon admission and 48.6% were initially diagnosed as 'cellulitis'. Diabetes mellitus was the most common co-morbid. Pseudomonas, Staphylococcus, Streptococcus and Enterobactericae were the common pathogens isolated. Ten patients (27.8%) had major amputation as part of radical debridement. The overall mortality rate was 36% with laboratory parameters: high serum urea and creatinine, and low haemoglobin levels were predictors for higher mortality. Poor white cell response which is common in diabetic patients and a delay in surgical debridement were notable attributes to a higher mortality. Necrotizing fasciitis is a serious infection associated with significant morbidity and mortality. A poor white blood cell response, high serum urea and creatinine, and low haemoglobin level were the predictors for mortality. Early diagnosis and prompt treatment are of paramount importance in the treatment of this infection.

Key Words: Necrotizing fasciitis, Lower limb, Surgical treatment

Introduction

Necrotizing fasciitis has existed as a clinical entity since the time of Hippocrates[1,2] and the first documentation in modern surgical literature was recorded by Joseph Jones in 1871[3]. It is a form of necrotizing soft tissue infection encompassing various clinical entities previously known as hospital gangrene[3], phagdena gangrenosum, progressive bacterial synergistic gangrene, hemolytic streptococcal gangrene, Meleney gangrene and Fournier gangrene[4]. The term necrotizing fasciitis which maybe more accurate in describing the disease process, was first suggested by Wilson in 1952[5].

It is a limb- and life-threatening infection characterized by rapidly spreading deep fascia and subcutaneous tissue. The cumulative mortality rate was high ranging from 6% to 76% as reported as McHenry *et al*[6]. Recent endemic of this infection in the United States in the 1990's has been hyped by the media as 'flesh-eating bacterial infection'[7]. Approximately 500-1000 cases were reported annualy[8]. However, its mortality rate has remained unchanged over the past few decades.

Surgical treatment in form of early radical debridement of the necrotic infected tissue has remained the key to a successful treatment. The purpose of this study is to evaluate the surgical outcome in patients with necrotizing fasciitis treated in our institution by specifically looking into its epidemiological pattern, diagnostic issue, microbial characteristics, existing co-morbidities, major amputation rate and mortality predictors.

Materials and Methods

This cross-sectional retrospective study was a review of medical records of all the patients diagnosed as necrotizing fasciitis of the lower limb and treated in our institution between January 1998 and December 2002.

Confirmation of the diagnosis was solely based on the clinical and operative findings: the presence of infected necrotic fascia, foul smelling purulent discharge, lack of fascial bleeding or deep fascia resistance to intra-operative blunt probing.

The following variables were recorded: age, race, gender, date of the first symptom or injury, duration of symptom, date of admission, diagnosis on admission and date of diagnosis, co-morbid medical disease, type of surgery, organism isolated and final outcome. Laboratory parameters including serum urea, creatinine and albumin levels, white cell count and haemoglobin levels were used to determine the prognosis.

The data was recorded, tabulated and analyzed by using SPSS statistic software (Version 11 SPSS, Chicago, Illinois).

Results

Demographic data

Of 38 cases of necrotizing fasciitis treated during the period of the study, two cases were excluded because of incomplete records. There were 27 male and nine female patients (male to female ratio of 3:1) with a mean age of 53 years (range 30-73 years). Malay patients constituted 38.8% of all patients with the remaining equally distributed for Chinese and Indian.

Clinical Profiles

Only seven cases (19%) were initially diagnosed as necrotizing fasciitis. The remaining majority (81%) were preliminarily misdiagnosed as cellulitis in 17 patients (48.6%), ulcer four (13.8%), abscess three (10.3%) and gangrene two (6.9%). Majority of the patients had some form of co-morbidities with 69% (25 patients) diabetics and two patients (5.5%) HIV-positive.

Microbiological Profiles

Monomicrobial infection accounted for eight cases (22.2%) and polymicrobial infections were encountered in 25 patients (69.4%). Three patients had negative culture. The pathogens isolated were Pseudomonas (17 cases), Staphylococcus (13 cases), Streptococcus (10 cases) and Enterobactericae (7 cases).

Treatment and Outcome

Systemic antibiotic cover and early aggressive surgical debridement constitute the most important parts of the management. Twenty one patients (58.3%) had to undergo two or more surgical procedures and 15 patients (41.7%) had at least one surgery. Of the total 77 surgical procedures, 48 (62.3%) were primary debridements and the remaining 29 (37.7%) were secondary procedures including three immediate re-exploration for uncontrolled bleeding from the wounds, 10 major amputations, 16 wound closure with split skin graft (Fig. 1). Thirteen patients died, which translated to a mortality rate of 36%. Four variables: low white cell count ($p<0.01$), high blood urea level ($p<0.01$), high serum creatinine ($p<0.05$) and low haemoglobin level ($p<0.05$) were significant risk factors of mortality (see Table I). Delay in surgical intervention was a notable significant predictor of mortality.

Table I: Predictors of High Mortality Risk

Parameters	Survive	Dead	t-test
White Cell Count ($X10^3$/dL)	18.9± 7.9	11.1± 5.5	P<0.01
Blood Urea (mmol/L)	6.3± 3.9	13.2± 10.4	P<0.01
Serum Creatinine (umol/L)	97 ±30	173 ±157	P<0.025
Surgical Delay (days)	9.9± 3.9	14.3± 6.9	P<0.025
Haemoglobin (g/dL)	11.4± 2.1	9.8± 2.8	P<0.05
Serum Albumin (g/L)	17.2± 6.6	16.1± 5.3	P>0.05
Age (years)	52.4±10.0	53.9± 12.1	P>0.05
Initial Temperature (°C)	37.4± 0.7	37.5± 0.7	P>0.05

Discussion

Necrotizing fasciitis is a limb- and life-threatening infection which requires immediate medical attention. It is a progressive rapidly spreading infection predominantly affecting the deep fascia and further necrosis of the overlying skin and subcutaneous tissue is attributed to septic thrombosis of the vessels penetrating the fascia. Paucity of cutaneous findings early in the course of the infection makes the diagnosis difficult. Only 19.9% of our cases were correctly diagnosed on admission. This is comparable to a 14.6% admission diagnostic rate in a series reported by Wong *et al.*(2003). Necrotizing fasciitis is commonly misdiagnosed as cellulitis and to a less frequent extent as ulcer or abscess. Differentiation of necrotizing fasciitis from these conditions is crucial as its progression is always rapid and the prognosis depends largely on immediate prompt interventions including rapid optimization of medical co-morbid, appropriate antibiotic cover and aggressive surgical debridement of necrotic and infected tissue.

In the usual circumstances, the diagnosis was made later when clinical symptoms and signs: fever, exquisite pain, swelling, erythematous skin and finally bullae formation with skin necrosis, had become more obvious. Previous or pre-admission antibiotic therapy often changes the initial clinical picture and masks the severity of the underlying infection. A high index of suspicion is required to recognize necrotizing fasciitis. Plain radiographs may show soft tissue thickening and gas formation. However, gas in the soft tissue is seen only in 16.9% of patients[4]. Frozen section biopsy and imaging studies including ultrasonography, CT-scans and MRI were reported to be more helpful in establishing early diagnosis[9-12]. Most of these imaging studies are done as semi-urgent procedures. Sometimes, the diagnosis is only made during the surgery. The findings of grayish necrotic fascia with loss the normal resistance of its adherence to myofascial layer during blunt dissection, lack of fascial bleeding and foul smelling 'dishwater' discharge are characteristics of necrotizing fasciitis. Histological features of necrosed fascia with polymorphonuclear leukocyte infiltration of deep dermis and fascia are typical. Septic thrombosis of cutaneous vessels occurred late when full thickness skin necrosis manifestated[13].

The pathogenesis of necrotizing fasciitis involved interaction between bacterial virulence and host immunity[14]. The host immunity plays an important role against skin infection. Seventy percent of our patients were diabetics. Similar findings of 70.8% and 56.4% diabetic patients were reported in Wong *et al.*(2003) and Elliot *et al.* (2000) series. The infection is typically polymicrobial[5,7,13] involving up to nine organisms synergistically[15]. In our series, polymicrobial synergistic infections involving Pseudomonas, Staphylococcus, Streptococcus and Enterobactericae were encountered in 69.4% of the cases.

Early recognition, immediate antibiotic therapy and aggressive radical debridement are crucial to improve survival rate. All necrotic tissue should be excised until healthy tissue encountered as evidenced by the skin and subcutaneous tissue not being elevated off from the deep fascia by gentle separation. A second look debridement may be necessary. In severe cases with extensive infection, major amputation is the only means of removing the infected tissue completely. The amputation rate in our series was 27.8%. Antibiotic therapy should be adjusted based on culture and sensitivity result. The use of hyperbaric oxygen (HBO) has not been well supported by clinical evidences. Brown *et al.*(1994) in their multicentric study of treatment of necrotizing fasciitis showed that the use of HBO failed to reduce the number of surgical debridement or mortality. Elliot *et al.*(1996) in their series found that HBO was helpful to shorten post-debridement wound closure timing.

The mortality rate in our series of necrotizing fasciitis was 36%. Predictors for high mortality risk were extensively studied[17]. Diabetic co-morbid alone did not correlate well with an increase in mortality. Wong *et al.*(2003) reported that the 20% mortality rate in their series was significantly associated with the patients' advanced age, the presence of two or more co-morbidities and delay in surgical debridement. Childer *et al.*(2002) reputed the correlation between advanced age and mortality rate. In our series, low white cell count and haemoglobin level, high blood urea and serum creatinine levels and delay in surgical intervention were strong predictors of high mortality risk. These parameters indicate the presence of systemic inflammatory response syndrome (SIRS) with eventual prolongation of multiple organ failure prior to a delayed surgical debridement.

Conclusion

Necrotizing fasciitis of the lower limb is a serious infection associated with a high morbidity and

mortality. More than a quarter of the patients require major amputation with the overall mortality exceeding one third. Poor optimization of the patients as indicated by high serum urea and creatinine, low haemoglobin and poor white cell response, was the predictor for higher mortality rate. Early diagnosis and adequate treatment are of paramount importance.

Acknowledgement

We thank Mr Teh Ah Huat, Miss Hermaya Suparman and Miss Norazura Sahbudin of the Medical Record Department of the Univesity Malaya Medical Center for their help in the course of this study.

References

1. Trent JT, Kirsner RS. Diagnosing necrotizing fasciitis. Adv Skin Wound Care. 2002; 15: 135-8.
2. Kotrappa KS, Bansal RS, Amin NM. Necrotizing fasciitis. Am. Fam Physician. 1996; 53(5): 1691-7.
3. Brandt MM, Corpron CA, Wahl WL. Necrotizing soft tissue infections: a surgical disease. Am. Surgeon. 2000; 66(10): 967-70.
4. Wong CH, Chang HC, Pasupathy S et al. Necrotizing fasciitis: clinical presentation, microbiology, and determinants of mortality. J Bone Joint Surgery. 2003; 85-A: 1454-60.
5. Wilson B. Necrotising fasciitis. Am Surg 1952; 18: 416-31.
6. McHenry CR, Plotrowski JJ, Petrinic D, Malangoni MA. Determinants of mortality for necrotizing soft tissue infections. Ann Surg. 1995; 221: 558-63.
7. Childers BJ, Potyondy LD, Nachreiner R et al. Necrotizing fasciitis: a fourteen-year retrospective study of 163 consecutive patients. Am Surgeon. 2002; 68(2): 109-16.
8. World Health Organization. Necrotizing Fasciitis. Weekly Epidemiological Record. 1994; 69: 165-6.
9. Stamenkovic I, Lew PD. Early recognition of potentially fatal necrotizing fasciitis. The use of frozen section. New Engl J Med. 1984; 310: 1689-93.
10. Yen ZS, Wang HP, Ma HM et al. Ultrasonographic screening of clinically suspected necrotizing fasciitis. Acad Emergency Med. 2002; 9(12): 1448-51.
11. Wyoski MG, Santora TA, Shah RM, Friedman AC. Necrotizing fasciitis. CT-scans characteristics. Radiology. 1997; 203: 859-63.
12. Schmid MR, Kossmann T, Duewell S. Differentiation of necrotizing fasciitis and cellulitis using MRI. Am J Radiol. 1998; 170: 615-20.
13. Elliot D, Kufera JA, Myers RA. The microbiology of necrotizing soft tissue infections. Am J Surg. 2000; 179(5): 361-6.
14. Low DE, McGeer A. Skin and soft tissue infections: Necrotizing fasciitis. Curr Opinion Infec Dis. 1998; 11(2): 119-23.
15. Singh G, Ray P, Sinha SK et al. Bacteriology of necrotizing infections of soft tissue. Aust NZ J Surg. 1996; 66: 747-50.
16. Brown DR, Davis NL, Lepawsky M et al. A multicenter review of the treatment of major truncal necrotizing infections with and without hyperbaric oxygen therapy. Am J Surg. 1994; 167: 485-9.
17. Elliot DC, Kufera JA, Myers RA. Necrotizing soft tissue infections: Risk factors for mortality and strategies for management. Ann Surg. 1996; 224: 672-83.
18. Bosshardt TL, Handerson VJ, Organ CH Jr. Necrotizing Soft Tissue infections. Arch Surg. 1996; 13(8); 846-54.
19. Tang WM, Ho PL, Fung KK et al. Necrotizing fasciitis of a limb. J Bone Joint Surg. 2001; 83-B: 709-14.

ORIGINAL ARTICLE

Antimicrobial Properties of Erythromycin and Colistin Impregnated Bone Cement. An *In vitro* Analysis

M Y Ruzaimi, MS(Orth)*, Y Shahril MS(Orth)*, O Masbah MS(Orth), H Salasawati, MMed (Microbiol)***

*Department of Orthopaedics and Traumatology;**Department of Microbiology and Medical Immunology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia

Summary

Deep surgical site infection is a devastating consequence of total joint arthroplasty. The use of antibiotic impregnated bone cement is a well-accepted adjunct for treatment of established infection and prevention of deep orthopaedic infection. It allows local delivery of the antibiotic at the cement-bone interface and sustained release of antibiotic provides adequate antibiotic coverage after the wound closure. Preclinical testing, randomised and clinical trials indicate that the use of antibiotic-impregnated bone cement is a potentially effective strategy in reducing the risk of deep surgical site infection following total joint arthroplasty. The purpose of this study was to assess antibacterial activity of erythromycin and colistin impregnated bone cement against strains of organisms' representative of orthopaedic infections including Gram-positive and Gram-negative aerobic organisms: *Staphylococcus aureus, coagulase-negative Staphylococci, Enterococcus sp., Proteus sp., Klebsiella sp., Pseudomonas sp., and Escherichia coli*. Pre-blended Simplex® P bone cement with the addition of erythromycin and colistin (Howemedica Inc) was mixed thoroughly with 20ml liquid under sterile conditions to produce uniform cylindrical discs with a diameter of 14mm and thickness of 2mm. 24-48 hour agar cultures of Staphylococcus aureus, coagulase-negative *Staphylococci, Enterococcus sp.,Proteus sp., Klebsiella sp.,Pseudomonas sp., and Escherichia coli* were used for the agar diffusion tests. The agar plates were streaked for confluent growth followed by application of erythromycin and colistin impregnated bone cement disc to each agar plate. The plates were incubated at 30°C and examined at 24, 48, 72 hours, and four and five days after the preparation of the impregnated cement. The susceptibility of *Staphylococcus aureus* to the control discs was most clearly demonstrated showing a distinct zone of inhibition. The zone observed around c*oagulase-negative Staphylococci, Klebsiella sp.,Pseudomonas sp., and Escherichia coli* were also significant. However, there was no zone of inhibition or signs of antibacterial activity at the cemented surface were detected around discs with *Enterococcus sp.* and *Proteus sp.* The results showed that Simplex® P bone cement with the addition of erythromycin and colistin was effective against most of the broad spectrum organisms encountered during total joint arthroplasty. The activity of Simplex® P bone cement impregnated with erythromycin and colistin is mainly during the first 72 hours.

Key Words: Total joint arthroplasty, Erythromycin, Colistin, Bone cement

Introduction

Since the mid-1960's, total hip replacement has become one of the most popular and successful procedures performed by orthopaedists. However, devastating consequences may result if infection occurs. Numerous treatment methods have been proposed. The results of attempts to retain the prosthesis, in cases of infection, have been unpredictable.

The primary advantage of antibiotic-loaded bone cement for prophylaxis is the potential for further

reduction of an already low rate of deep periprosthetic infection[1]. The potential disadvantages of routine use of antibiotic-loaded bone cement include increased emergence of antibiotic-resistant organisms, increased potential for the occurrence of an allergic reaction, the potential for systemic toxicity and the effect of adding antibiotics on the mechanical properties of bone cement.

Gentamicin is a naturally-occurring antibiotic produced by the bacterial strain *Micromonospora purpurea* and was considered to be the antibiotic of choice because of its wide spectrum of antimicrobial activity, excellent water solubility, thermal stability and low allergenicity. As an aminoglycoside, it has a concentration-dependent antibacterial activity[2].

Apart from gentamicin, other antibiotics have also been used as additives to bone cement[3]. Erythromycin and colistin are examples of those that made it to a commercial product.

However, due to emerging antibiotic resistance, there is now a renewed interest for the addition of other antibiotics to bone cement, such as tobramycin, vancomycin, clindamycin and fusidic acid. Combinations of these antibiotics are also added to bone cements[4]. Certain antibiotics such as lincomycin and tetracycline, are heat labile and are deactivated by the polymerisation process[5].

An antibiotic which is incorporated into bone cement must be stable to the exothermic polymerisation, be eluted in therapeutic concentrations and have an appropriate spectrum of antibacterial coverage against the diverse range of causative pathogens in deep sepsis[6]. Aminoglycosides are a class of antibiotics which possess these qualities. A combination of two antibiotics improves the elution of both agents.

Erythromycin and colistin were reported to demonstrate a non-antagonistic ability to inhibit the growth of a wide variety of aerobic and anaerobic bacterial isolates[7]. When incorporated in Surgical Simplex® P radiopaque bone cement, fabricated cement pellets were effective in inhibiting 98% of all anaerobic and aerobic test isolates. Separate experiments indicate that each antibiotic can diffuse from polymerized cement, and that the concentration of each antibiotic is consistently above the minimum inhibitory concentration of 96% of the isolates. It is concluded that erythromycin/colistin Surgical Simplex® P radiopaque bone cement is a worthy candidate for clinical investigation.

This study aims to evaluate the *in vitro* antimicrobial activity of bone cement impregnated with erythromycin and colistin against bacteria common to infected arthroplasty cases.

Materials and Methods

The diffusion of erythromycin and colistin when impregnated in bone cement was studied using an agar diffusion assay. Pre-blended Simplex® P bone cement with erythromycin and colistin (Howmedica Inc) was mixed thoroughly with 20ml liquid under sterile conditions to produce uniform cylindrical discs with a diameter of 14mm and thickness of 2mm. The mixture was placed in aluminium moulds to make disc specimens of a designated size. The moulds were sandwiched between two solid polytetrafluoroethylene slabs to pressurize the cement. After curing, the discs were tamped free and immediately used for assay.

A 24 – 48 hour agar culture of *Staphylococcus aureus, coagulase-negative Staphylococcus, Enterococcus sp., Proteus sp., Klebsiella sp., Pseudomonas sp.*, and *Escherichia coli* were used for the agar diffusion tests. Test organisms were propagated and handled in accordance with American Type Culture Collection (ATCC) recommendations for broth media, agar, and incubation specifications. The selection included Gram-positive and Gram-negative aerobic organisms. The distribution of the strains of each organism was chosen to depict their frequency of occurrence in clinical situations. Thus, multiple strains of more frequently encountered bacteria such as *Staphylococcus aureus* and *Pseudomonas aeruginosa* were used.

The agar plates were streaked for confluent growth followed by application of erythromycin and colistin impregnated bone cement disc to each agar plate. The plates were incubated at 30°C and examined at 24, 48, 72 hours, 4 and 5 days after the preparation of the impregnated cement. Zone of growth inhibition around each disc were measured at four different sites and average reading were taken as the activity of the bone cement.

The zone of inhibition was defined as the distance between the edge of the test disc and the edge of bacterial growth. Susceptible strains may be defined as those which have a zone of inhibition greater than

2mm and resistance was defined as absence of a zone of inhibition with no growth at the cement surface, as seen about most of the control discs[6]. Control strain organisms also were prepared and analysed.

Results

From the study, *Klebsiella sp.* showed the most total zone of inhibition (12 mm) followed by the other micro-organisms (Table I). However, no zone of inhibition or signs of antibacterial activity at the cemented surface were detected around discs containing *Enterococcus* sp. and *Proteus sp.*

This study also clearly demonstrated that the antimicrobial activity of erythromycin and colistin bone cement was mainly on day one (35%) followed by reducing trend of activity and very minimal activity noted on day five (2%) (Table II).

Discussion

In the early days of joint replacement surgery, the incidence of infection was high. With the advent of clean air surgical rooms, systemic and topical antibiotic use, impermeable drapes and gowns, and antibiotic bone cement, the rate of infection has decreased considerably. Still, today up to 5% of implanted prostheses become infected, indicating that infection is still an important problem in orthopaedic surgery. Nearly all orthopaedic infections are due to bacteria.

Treatment of an infected prosthesis usually means additional surgery and additional risk to the patient. Prosthesis removal may also result in large skeletal defects, shortening of the extremity and severe functional impairment. Since prevention is better than cure, antibiotic bone cement is an excellent way to minimise the risk of orthopaedic infection.

Currently, antibiotics are an essential ingredient in bone cement in many areas of the world. In some cases, the cement is already pre-blended with an anti-biotic, whilst in other instances; the surgeon adds an anti-biotic of choice to the bone cement during the mixing process. There are many issues surrounding the use of antibiotics in bone cement. These issues range from the prevalence of infection in orthopaedic surgery and how these infections affect implant performance, to choosing an appropriate antibiotic.

Table I: The five days total zone of inhibition (mm) in test discs for the strains of organisms tested

Organisms	Zone of Inhibition (mm)
Klebsiella sp.	12
Escherichia coli	11
Pseudomonas sp.	8
Coagulase-negative Staphylococcus.	7
Staphylococcus aureus	6
Enterococcus sp.	0
Proteus sp.	0

Table II: The zones of inhibition recorded around bone-cement discs containing erythromycin and colistin against various micro-organisms

Organisms	Zone of Inhibition (mm)				
	24 hours	48 hours	72 hours	4 days	5 days
Staph. aureus	3	1	1	1	-
Staph. coagulase-negative	-	2	4	1	-
Enterococcus sp.	-	-	-	-	-
Proteus sp.	-	-	-	-	-
Klebsiella sp.	5	3	3	1	-
Pseudomonas sp.	3	2	2	1	-
Escherichia coli	4	3	2	1	1
Percentage	35%	25%	27%	11%	2%

Table III: Summary of Antibiotics Used for Impregnating Bone Cement

Antibiotic	Antibiotic Dose/Cement Amount (Simplex®)	Comments
AMINOGLYCOSIDES		
Tobramycin	0.5 grams/40 grams 3 grams/40 grams (Palacos®)*	High water solubility; heat stability; bactericidal at low concentrations; effective against some gentamicin resistant pseudomonas species
Gentamicin	0.5-2 grams/40 grams 0.5-2 grams/60 grams 3 grams/40 grams (Palacos®)	High water solubility; heat stability; bactericidal at low concentrations
VANCOMYCIN		
Vancomycin	2-8 grams/40 grams	Elution characteristics similar to tobramycin; no significant activity against gram negative bacteria
PENICILLINS		
Ticarcillin	6-13 grams/40 grams 7 grams/40 grams (Palacos®)	Not recommended due to a large ratio of powdered antibiotic to cement – causes difficulties in maintaining bead coherency; high sensitivity reactions
Nafcillin	4-8 grams/40 grams 6 grams/40 grams (Palacos®)	
CEPHALOSPORINS		
Cefalothin	1 gram/40 grams	Diminished heat stability compared to aminoglycosides; increased incidence of allergic reactions
Cefazolin	4-8 grams/40 grams 4-8 grams/60 grams	
Cefotaxime	4-8 grams/40 grams 6 grams/40 grams (Palacos®)	
Cefamandole	2 grams/40 grams 6 grams/40 grams (Palacos®)	
OTHER		
Erythromycin	6 grams/40 grams (Palacos®)	Alternative for penicillin allergic patients; bacteriostatic agent
Clindamycin	4-8 grams/40 grams 6 grams/40 grams (Palacos®)	Effective in treatment of infection in patients with poor vascular supply to the extremities; effective in mixed infections with anaerobic organisms

*Palacos® is the brand name of bone cement sold in Europe. It has different elution characteristics when compared to PMMA.

Orthopaedic infections typically occur at the bone and cement interface and in the immediate surrounding bone and soft tissue. As the infection progresses, prosthetic loosening can occur. Subsequent prosthetic failure necessitates revision surgery.

There are many criteria surgeons must consider when choosing an antibiotic to mix with bone cement. One important criterion is its spectrum of activity – the variety of organisms against which the antibiotic is effective. There is no single antibiotic that is effective against all organisms. In addition, the antibiotic must not cause an allergic reaction in the patient. The remaining considerations pertain to the interaction between the antibiotic and the bone cement. First, the antibiotic must elute from the cement for an extended period of time to provide prolonged antibacterial protection. Second, the antibiotic must not compromise the mechanical properties of the cement. Third, the antibiotic must not loose its effectiveness as a result of the heat generated by polymerisation.

The most commonly-used bone cement is powdered polymethylmethacrylate polymer (PMMA); sold under

the brand name of Simplex® in the United States. This cement needs to be mixed with liquid methylmethacrylate to form an adhesive material. The adhesive will form in 5-10 minutes after the two ingredients are mixed. Antibiotic powder is added to the powdered bone cement prior to the addition of the methylmethacrylate.

Most commonly used antibiotics for impregnating bone cement are described in Table III. The antibiotic doses may vary based on the type of bone cement used. All antibiotic doses listed in the table are based on Simplex® bone cement unless otherwise specified.

In this current study, susceptible strains may be defined as those which have a zone of inhibition greater than 2mm. Resistance was defined as absence of a zone of inhibition with no growth at the cement surface. Based on this definition, Simplex® P with erythromycin and colistin had some antibacterial activity against majority of all strains tested in this study. Only *Enterococcus sp.* and *Proteus sp.* were not susceptible.

Bacteria resistant to systemic erythromycin and colistin at typical concentrations, such as *coagulase-negative Staphylococcus*, showed some susceptibility to the concentrations of antibiotic released from the bone-cement discs containing erythromycin and colistin. The inhibition of all strains at the surface of the bone-cement disc containing antibiotics is significant. It is important to prevent bacterial colonisation on the surface of an implant material because it is the key to the establishment of infection. The combination of erythromycin and colistin, two tried and tested drugs in the study, effectively combat deep wound infecting organisms during the vital time, within 72 hours of the operation. Any subsequent infection risks can then be identified and treated by the surgeon with an appropriate specific antibiotic. After this period the release of erythromycin and colistin are minimal. This further supports the continued mechanical integrity of Antibiotic Simplex® cement. The small amount of colistin in the cement combined with both the short release time and localised delivery minimises the possibility of any toxic effects.

In this application, erythromycin has been shown to be a non-toxic drug and lacks the tendency to produce hypersensitivity.

The difficulty of drawing conclusive correlations between *in vitro* results and clinical performance has been recognised. An *in vitro* model of the diffusion of antibiotic from bone cement into the surrounding bone is difficult to produce since diffusion begins while the cement is in a liquid or dough stage and continues as it polymerises within the surrounding bone, which has been partly devascularised. Studies of the release of antibiotics into solution, or diffusion through agar media, are helpful, but measured concentrations and zones of inhibition cannot be directly correlated with values of the systemic minimum inhibitory concentration. Although direct correlation between *in vitro* and *in vivo* results is difficult, the study showed that erythromycin and colistin are stable to the exothermic polymerisation of the cement, and that they are released from the surface of the cement at concentrations high enough to inhibit the growth of most organisms which may be encountered after joint arthroplasty.

The range of zones of inhibition reported for the various organisms in this study provides a relative comparison of the effectiveness of cement containing erythromycin against the broad spectrum of bacteria which may be expected during joint arthroplasty. Its success in inhibiting bacterial growth at the surface of the disc can be interpreted directly since the application of the discs on to a seeded agar surface eliminates the problems related to diffusion. The result of this study is supported in an experimental rabbit model by Rodeheaver *et al*[8]. In their study, the efficacy in preventing osteomyelitis was investigated for Simplex® P bone cement, containing 0.73g of erythromycin and 0.24 g of colistin per unit of bone cement.

Taking into account the level of 10^5 CFU/g of bone as definition of infection, the authors demonstrated that this antibiotic bone cement was fully effective against *Staphylococcus aureus*, and prevented infection in 87% of the femora inoculated with the highest dose of Escherichia coli.

Another animal study by Wininger[9] also demonstrated the potential for antibiotic-impregnated cement to prevent bone and joint infections. When bacteria were inoculated into bone just prior to filling surgical defects with antibiotic-impregnated cement, infection was reduced. Erythromycin and colistin impregnated cement also prevented *Staphylococcus aureus* and Escherichia coli infections in rabbit femurs.

Erythromycin and colistin (or other thermostable antibiotics) may be added to polymethylmethacrylate (PMMA) for use in the fixation of prostheses to bone.

The antibiotics are leached or rapidly released from the combination in bactericidal concentrations. They do not reduce the strength characteristics of the cement below acceptable standards, nor do they change its handling characteristics.

In a study by Murray, erythromycin alone was used in 1112 total hip arthroplasties between 1971 and 1976, with an infection rate of 0.98%. Erythromycin-colistin bone cement was used in 786 total hip arthroplasties from July 1976 to December 1980, with a deep-wound infection rate of 0.4%. Erythromycin-colistin bone cement is safe and effective in treatment of and prophylaxis against deep wound infection in total joint arthroplasty[10].

Conclusion

This in vitro study shows that Simplex® P bone cement impregnated with erythromycin and colistin is effective against *Staphylococcus aureus* (4th most effective) with 14% of the activity. Simplex® P bone cement impregnated with erythromycin and colistin is also effective against the following organisms (in decreasing order of the activity) *Klebsiella sp.* (27%), *Escherichia coli* (25%), *Pseudomonas sp.* (18%) and *Staphylococcus coagulase-negative* (16%). Simplex® P bone cement impregnated with erythromycin and colistin showed no activity against *Enterococcus sp.* and *Proteus sp.* The activity of Simplex® P bone cement impregnated with erythromycin and colistin is mainly during first 72 hours.

The theoretical advantages of antibiotic-impregnated cement in the treatment and prophylaxis of orthopaedic infections are supported by the results of this study. Evidences of their efficacy, particularly in comparison with those of systemic antibiotics or with those of antibiotic-impregnated cement in combination with systemic antibiotics, have not been firmly established.

References

1. Hansen AD. Prophylactic use of antibiotic bone cement. An emerging standard in opposition. J Arthroplasty. 2004; 19: 73-7.
2. Lacy MK, Nicolau DP, Nightingale CH, Quintiliani R. The pharmacodynamic of aminoglycosides. Clin Infect Dis. 1998; 27: 23-7.
3. Bayston R, Milner RD. The sustained release of antimicrobial drugs from bone cement. An appraisal of laboratory investigations and their significance. J Bone Joint Surg. 1982; 64-B: 460-4.
4. Khoo KH, Yang JW, Cho SH. Impregnation of vancomycin, gentamicin and cefotaxime in a cement spacer for two-stage cementless reconstruction in infected total hip arthroplasty. J Arthroplasty. 2001; 16: 882-92.
5. Hansen AD, Osmond DR. The use of prophylactic antimicrobial agents during and after hip arthroplasty. Clin Orthop. 1999; 369: 124-38.
6. Scott CP, Hingham PA, Dumbleton JH. Effectiveness of bone cement containing tobramycin. An in vitro susceptibility study of 99 organisms found in infected joint arthroplasty. J Bone Joint Surg. 1999; 81-B(3): 440-3.
7. Rosenthal AL, Rovell JM, Girard AE. Polyacrylic bone cement containing erythromycin and colistin.In vitro bacteriological activity and diffusion properties of erythromycin, colistin and erythromycin/colistin combination. J Int Med Res. 1976; 4(5): 296-304.
8. Rodeheaver GT, Rukstalis D, Bono M, Bellamy W. A new model of bone infection used to evaluate the efficacy of antibiotic-impregnated polymethylmetha-crylate cement. Clin Orthop. 1983; 178: 303-11.
9. Winiger DA, Fass RJ. Antibiotic-impregnated cement and beads for orthopaedic infections. J Antimicrobial Chemotherapy. 1996; 38: 2675-9.
10. Murray WR. Use of antibiotic-containing bone cement. Clin Orthop. 1984; 190: 89-93.

ORIGINAL ARTICLE

Biomechanical Properties of Bone Cement with Addition of Cefuroxime Antibiotic

D Mohd Fuad, MS(Orth)*, O Masbah, MS(Orth)*, Y Shahril, MS(Orth)*, S Jamari, MS(Orth)*, M Y Norhamdan, MS(Orth)*, S H Sahrim, PhD**

*Department of Orthopaedics and Traumatology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, **Department Of Material Science Programme, Faculty Science and Technology, UKM, Bangi, Selangor, Malaysia

Summary

Antibiotic-loaded bone cement has been used as prophylaxis against infection in total joint replacement surgery. Its effect on the mechanical strength of cement is a major concern as high dose of antibiotic was associated with a significant reduction in mechanical strength of bone cement. However, the cut-off antibiotic that weakens the mechanical strength of cement remains to be determined. This study was undertaken to observe the changes in the mechanical properties of bone cement with gradual increments of Cefuroxime antibiotic. Cefuroxime at different doses: 0, 1.5, 3.0 and 4.5gm were added to a packet of 40gm bone cement (Simplex P) and study samples were prepared by using third generation cementing technique. Mechanical impact, flexural and tensile strength were tested on each sample. Significant impact and tensile strength reduction were observed after addition of 4.5gm of Cefuroxime. However, flexural strength was significantly reduced at a lower dose of 3.0gm. The maximum dose of Cefuroxime to be safely added to 40mg Surgical Simplex P is 1.5gm when third generation cementing technique is used. Further study is needed to determine whether it is an effective dose as regards to microbiological parameters.

Key Words: Antibiotic, Bone cement, Mechanical strength

Introduction

Infection is one of the most feared complications of total hip replacement. The use of antibiotic- loaded bone cement has significantly reduced the incidence of post primary total hip replacement infection. Alteration of the mechanical strength of bone cement has been proven if high dose of antibiotic was added but addition of small amounts of antibiotics did not seem to substantially weaken the cement. The purpose of this study is to observe the changes in mechanical properties of plain bone cement with addition of different antibiotic doses in terms of its impact, flexural and tensile strength.

Materials and Methods

In an experimental design, four powder form Cefuroxime doses: 0, 1.5, 3.0 and 4.5gm were added to a packet of 40gm Surgical Simplex P bone cement. Specimens were prepared using the third generation cementing technique (Vacuum) to determine the impact, flexural and tensile strength according to ASTM and ISO standards, respectively. For each concentration, five samples were prepared. Mechanical tests were performed after 24 hours. Samples with zero gm Cefuroxime served as controls. Mechanical strengths for each antibiotic concentration were compared. All the results were then analyzed using SPSS (Mann-Whitney U) statistic analysis program.

Results

In impact tests, samples showed significant reduction of strength after addition of 4.5g of antibiotic. Both transverse and bending modulus components of flexural strength were significantly reduced with

addition of 3.0 gram or more antibiotic into the cement. As for Tensile strength, its component of Young modulus and stress at break showed significant reduction of strength after addition of 4.5 gram of antibiotic.

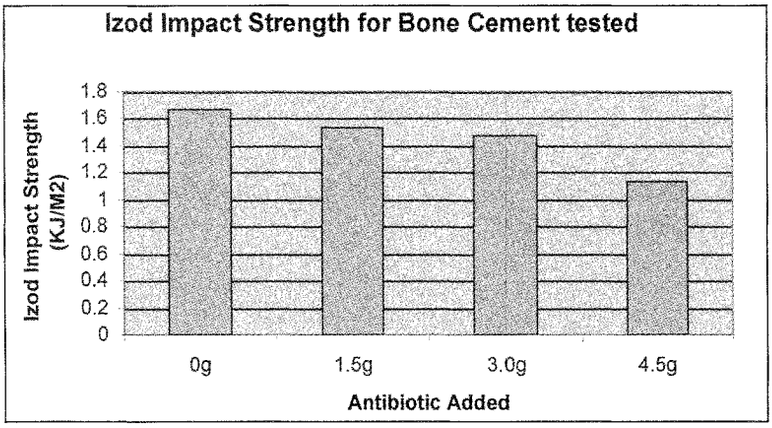
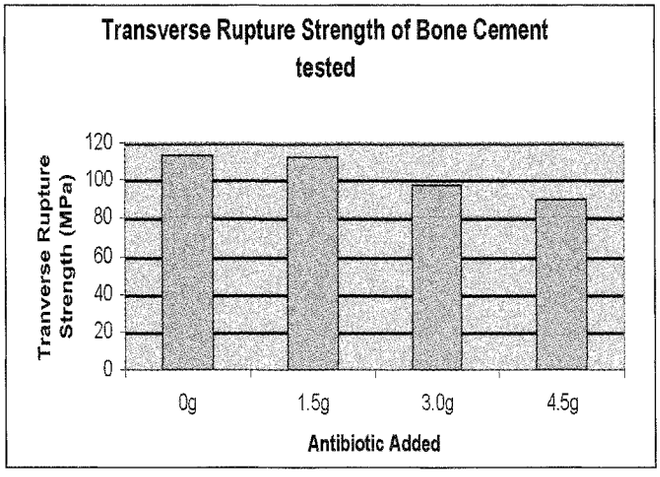


Fig. 1: Mean Izod Impact Strength (KJ/M2) changes with antibiotic added



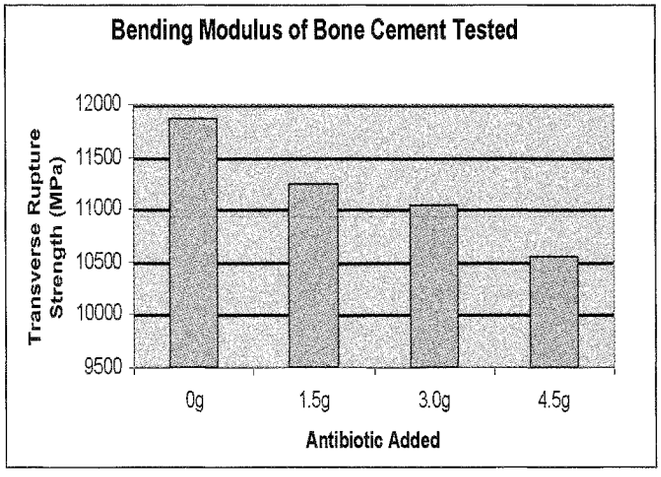
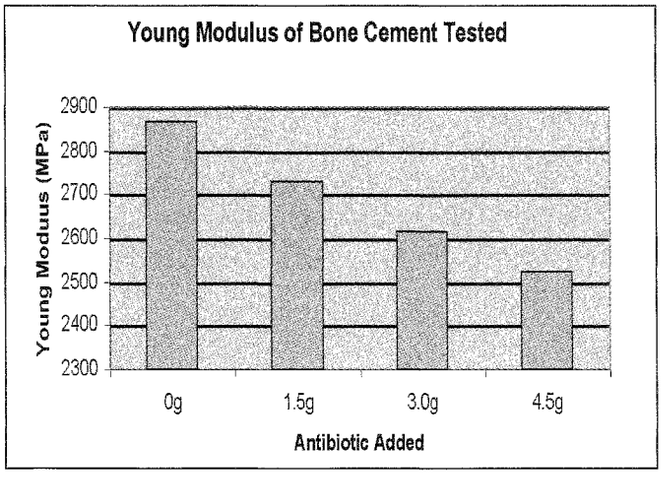


Fig. 2: Mean Flexural Strength (MPa) consists of Transverse and BendingModulus changes with antibiotic added



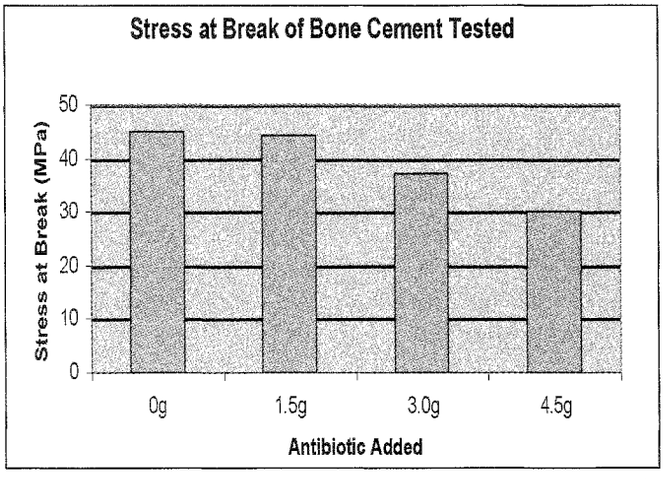


Fig. 3: Mean Tensile Strength (MPa) consists of Young Modulus and Stress at Break changes with antibiotic added

Table I: Results of Impact, Flexural and Tensile Strength with addition of antibiotic

Antibiotic Added (Gram)	Impact	Flexural		Tensile	
		Transverse Rupture	Bending Modulus	Young Modulus	Stress at Break
1.5	√	√	√	√	√
3.0	√	√	√	X	X
4.5	X	X	X	X	X

√ - Non Significant Reduction of Strength. X - Significant Reduction of Strength

Discussion

The results (Table I) showed that by adding the antibiotic there was a gradual change in the mechanical strength of the bone cement. It is clearly demonstrated that the overall strength is significantly reduced after addition of 4.5 gram (11.25% of total volume) to the 40 gram of bone cement. Regarding Impact Strength (Fig. 1), the bone cement strength was still preserved until up to an addition of 3.0 gram of antibiotic but was significantly reduced after addition of 4.5 gram of antibiotic. In Tensile Strength (Fig. 2), the bone cement strength was also still preserved up to addition of 3.0 gram of antibiotic in both Young Modulus and stress at break but was significantly reduced after addition of 4.5 gram of antibiotic.

The amount of antibiotic added that can reduce the strength, however, changes in Flexural (3 point) bending tests (Fig. 3). The strength was significantly reduced when 3.0 gram of antibiotic were added to the plain bone cement. Transverse rupture and bending modulus were both significantly reduced compared to the control (plain bone cement) after 3.0 grams of antibiotic were added.

Conclusion

Our results suggest that the maximum amount of Cefuroxime dose to be safely added to 40gm of Surgical Simplex P is 1.5gm when third generation cement mixing and application techniques are employed. Further study is needed to determine whether it is an effective dose with regards to microbiological parameters.

References

1. Chiu FY, Chen CM, Lin CFJ. Cefuroxime impregnated cement in primary total knee arthroplasty. J Bone Joint Surg. 2002; 84-A: 759-62.
2. Chiu FY, Lin CF, Chen CM. Cefuroxime-impregnated cement at primary total knee arthroplasty in diabetes mellitus. A prospective, randomized study. J Bone Joint Surg. 2001; 83-B: 691-5.
3. Dunne N.J, Orr J.F. Influence of mixing techniques on the physical properties of Acrylic bone cement. Biomaterials. 2001; 22: 1819-26.
4. McQueen MM, Hughes SP, May P, Verity L. Cefuroxime in total joint arthroplasty. Intravenous or in bone cement. J Arthroplasty. 1990; 5(2): 169-72.

ORIGINAL ARTICLE

Spinal Injuries in a Level-One Trauma Centre: A Demographic Study

S A Roohi, FRCS, A S Naicker, MMed(Rehab), M H Shukur, MS(Orth), A R Mohammad, MS(Orth)

Department of Orthopaedics and Traumatology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia

Summary

The incidence of spinal injuries in Malaysia is on the rise following similar trend of rapid development and increasing number of building constructions sites, and motor vehicles. This epidemiological study was aimed at compiling local data with a view to identifying target areas for preventive measures as well as improvement strategies in the management of these potentially devastating injuries. Seventy eight patients admitted with spine trauma in 1998 in a level-one trauma centre were retrospectively reviewed. All records were traced from the admission and discharge books of the orthopaedic wards, accident and emergency wards, operative registration book, spinal rehabilitation ward and orthopaedic registration data of the Department of Orthopaedics, Hospital Kuala Lumpur. Details on pre-treatment neurological and radiological level of injury and post-treatment outcomes were recorded according to the American Spinal Injury Association (ASIA) inpairment scale. Most patients (61.5%) were in the productive ages of less than 34 years with a 4:1 male to female ratio. Majority were due to motor vehicle accidents (57.7%) and fall from a height (28.3%). The thoraco-lumbar junction was the most common site of injury followed by the lower cervical region with 62.5% of which associated with neurological deficit. Neurological deficits: 11 ASIA-A, 1 ASIA-B, 6 ASIA-C, and 3 ASIA-D were detected in 21 (27%) patients with fall from height (50%) particularly landing on the feet (50%) and recreational sports (100%) were the risk factors. Less than 10% of patients were treated surgically and this explains an average 39.4 days of hospitalization (5 times longer in patients treated non-operatively). On discharge, four patients with incomplete neurology recovered to ASIA-E status and the remaining improved to ASIA-C and –D in one and five patients respectively. Only one patient with complete neurology improved to ASIA-B status following surgical treatment. The demographic profiles of our patients were comparable to other series in the literature but still inadequate to provide enough epidemiological data. A multicenter study to provide a larger pool of patients is needed.

Key Words: Epidemiology, Spinal trauma, Cord injury

Introduction

The last decade has witnessed a considerable increase in the incidence of spinal trauma in Malaysia. This is attributable to overgrowth of construction sector with increasing number of work-site related accidents, and increasing number of vehicles with collateral increase in high-speed motor vehicle crashes. With better living lifestyle come recreational accidents contributing to an increased incidence of spinal trauma. Most of these injuries are preventable.

Spinal trauma most commonly affects the productive age group of predominantly male population with motor vehicle accidents taking the biggest share of the aetiology. This is followed by fall at work-site, recreational activities and assaults[1-3]. The site of traumatic spinal cord injury shows predilection to cervical spine followed by thoraco-lumbar region[4]. Remarkably, anatomical location may also be closely related to the aetiology[5]. Studies on cervical and thoraco-lumbar injuries had previously been undertaken[6,7]. However, there has been no local

comprehensive study conducted, to date, of spinal injuries involving the whole vertebral column.

The aim of this study, besides the collection and analysis of epidemiological data, is to develop effective methods of surveillance and data collection in the future by designating spinal cord injuries as a reportable health condition. The compilation of this raw data has the modest aim of providing the basis of further studies in related aspects such as assessment of pharmacological treatment of spinal cord injuries.

Materials and Methods

This is a retrospective study conducted on all spinal injury cases seen at Kuala Lumpur Hospital in the year of 1998. It includes all patients admitted to or through the Accident and Emergency Department who had sustained traumatic injury to the spinal column or cord. All records were traced from the admission and discharge books of the orthopaedic wards, accident and emergency wards, operative registration book, spinal rehabilitation ward and orthopaedic registration data of the Department of Orthopaedics, Hospital Kuala Lumpur.

A total of 207 cases involving 124 male and 83 female patients were admitted for various spinal disorders over a period of one year (1998). Only 78 patients fulfilled inclusion criteria of having sustained a traumatic vertebral and/or cord injury. The remaining 129 patients were excluded for various reasons including osteoporotic fracture in elderly, pathological fracture and inflammatory disease of the spine. Also excluded were those who were brought in dead or died while in Accident and Emergency department for undetermined cause of death. There were 12 case records that could not be traced.

Records of the patients' particulars as well as their addresses, date of admission and discharge were noted. The date, time, cause and the mechanism of injury, and the presence of associated injuries and medical problems were included in the data collection. Details on neurological and radiological level of injury were recorded according to the American Spinal Injury Association (ASIA) chart. The neurological level of injury (NLI) is defined as the most caudal segment that tests as normal or intact for both sensory and motor function, on both sides of the body[8]. A complete injury indicates no preservation of sensory and motor function in the lowest sacral segments whereas an incomplete injury indicates partial preservation of sensory and/or motor function below the neurological level and includes the lowest sacral segment.

The treatment offered was categorized as conservative or operative. Conservative options include analgesics, extension pillow or traction followed by immobilization by body cast or Halovest/Philadelphia collar. Patients were evaluated for a minimum of one year for changes in the neurological status and any associated complication of spinal cord injury.

Results

A total of 78 patients with traumatic injury to the spine were admitted through the Accident and Emergency Department of HKL in 1998 was available for evaluation. Of these, 16 (21%) were females and 62 (79%) were males. There were 69 Malaysian (43 Malay, 19 Chinese, six Indian and one Sabahan) and nine foreigners (seven Indonesian, one Burmese and one Bangladeshi).

The patients' ages ranged from 12 to 83 years (average 34.8 years). The majority of patients were in the productive age groups: 27 in the age group of 12-24 years and 21 in the age group of 25-34 years. The figures then tapered off (Table II). There was a decreasing trend in number of patients as the age was increasing in both sexes.

Motor vehicle accidents and fall from heights constituted 58% and 28% of causes of spinal injuries respectively (Table III). Of interest to note is that of the 22 patients who fell from height, nine (41%) did so at work and of the five who were hit by an object, four (80%) sustained injury at work site. As for the motor vehicle accidents, the type of vehicle involved was not adequately documented. We found no cases of gunshot wounds in our series. It was interesting to note that mode of landing ensuing the fall had contributed to the development of neurological deficit (Table IV).

Neurological deficit developed in 50% of eight patients who landed on their feet and none of those who landed on their buttocks or backs had any deficit. This may be explained by the fact that the impact of the force was distributed over a larger surface area in the latter. There was no documentation of the mode of landing in the remaining five patients with three of them being under the influence of alcohol (two patients) and of drug (one patient).

Thoraco-lumbar injuries constituted 61.5% of all spinal injuries and other areas: upper cervical (C1-C2), sub-axial (C3-C7), thoracic (T1-T10) and lower lumbar (L3-L5) showed almost equal distribution of 7.7%, 10.3%, 9.0% and 11.5% respectively. Two patients had multilevel injury involving combination of thoraco-lumbar and thoracic and coccygeal fractures

The length of hospital stay ranged from one day to 151 days. The average length of stay for patients with neurological deficit was 39.4 days, five times longer than those without neurological deficit who averaged a stay of 7.7 days (range 1-42 days). Of the two patients with neurological deficit who stayed less than nine days, one took at-own-risk discharge at day two while the other had full neurological recovery at day four.

In the present series, it was noted that 21 patients (26.9%) who had neurological deficit with recreational injuries and fall from height seem to have a greater risk. Although motor vehicle accidents form the main aetiology contributing to the total number of spinal trauma cases (57.7%), recreational injuries and fall from height were at greater risk of causing neurological deficit associated with spinal trauma. Of 13 patients with work-related injuries (16.7%), only one had neurological deficit.

The lower cervical spine injuries have higher likelihood of causing neurological deficit and this is attributed to narrow canal-cord ratio. The thoracic spine has smaller cord-canal ratio attributed to cord enlargement and therefore susceptible to cord injury.

There were 11 motor useless and 10 incomplete but motor useful neurological deficits on admission. All motor useless lesions involved nine patients with ASIA-A and two patients with ASIA-C. One of these complete lesions improved from ASIA-A to -B status after a delayed decompression surgery. The incomplete lesions ranged from ASIA-B to -D status and most attained two levels neurological improvement on recovery. A full spectrum of neurological recovery observed from admission and on discharge is summarized in table VII. There were 11 patients with ASIA-A, one ASIA-B, six ASIA-C and three ASIA-D on admission. Ten patients were unavailable for follow up for various reasons: one died, three took at-own-risk discharge and six defaulted follow-up

Associated Injuries

The associated injuries were mainly noted in those who had motor vehicle accidents and fall from height. The injuries were broadly classified into fractures (36%), head and maxillofacial injuries (11%), chest trauma (28%), intra-abdominal injuries (8%) and miscellaneous (17%). Most fractures were confined to the distal extremities: four each around the ankle and the wrist. Those who sustained sub-axial cervical injuries typically had facial trauma and those with lower cervical injuries tended to have brachial plexus injury.

Complications

Patients with neurological deficit were at risk to develop complications throughout their paraplegic life. More than a half (11 out of 21 patients) of those with neurological deficit and only two of those without neurological deficit developed complications. Risk factors associated with development of complications included long follow-up intervals, defaulting follow-up for financial and social reasons, transfer of follow up to a non-specialized institution, and under-recognition of complication during follow-up review.

Treatment

Conservative treatment which included analgesia and resting on extension pillow, was the primary treatment in 40 patients and subsequent fracture stabilization with body cast in 20 patients. Primary skull traction followed by Halovest or Philadelphia collar was used in ten patients. Three patients underwent delayed or secondary operation; one each for kyphosis after casting, C2 non-union and unifacetal C5-C6 dislocation. Operative treatment was initially proposed to 11 patients. However, two of three patients who deferred surgery defaulted follow-up. One patient took at-own–risk discharge to seek treatment from a private hospital. One patient developed pre-operative respiratory insufficiency and was treated by closed manipulative reduction instead.

Discharge

At the time of discharge from hospital, 61 patients were ambulating either independently or aided by orthosis or walking aid. Fourteen patients needed wheelchair for ambulation. Three patients were not categorized as discharged: at-own-risk discharge in two and death in one.

Table I: American Spinal Injury Association (ASIA) Impairment Scale

Scale	Injury Subtype	Motor/Sensory
A	Complete	No motor and sensory preservation
B	Incomplete	No motor but incomplete sensory preservation
C	Incomplete	More than one half of key muscles caudal to injury have strength graded < 3 (motor useless)
D	Incomplete	More than one half of key muscles caudal to injury have strength graded > 3 (motor useful)
E	Normal	Normal or radicular loss

Table II: Spinal Injuries According to Age Groups

Age Group	12-24	25-34	35-44	45-54	55-64	65-74	75-84	Total
Patients (n)	27	21	13	7	3	5	2	78

Table III: Causes of Injury

Cause	Work-Related	Other	n (%)
MVA	0	45	45 (58%)
Fall From Height	9	13	22 (28%)
Fall at Home	0	4	4 (5.0%)
Hit by Object	4	1	5 (6.4%)
Sports/Recreational	0	2	2 (3.0%)
Grand total	13	65	78 (100%)

Table IV: Mode of Landing and Neurological Deficit

Vertebral Level	Fracture (%)	Neurology (%)
C1-C2 Sub-axial	6 (7.7%)	0 (0%)
C3-C7 Lower Cervical	8 (10.3%)	5 (62.5%)
T1-T10 Thoracic	7 (9.0%)	3 (42.9%)
T11-L2 Thoraco-lumbar	48 (61.5%)	13 (27.1%)
L3-L5 Lumbar	9 (11.5%)	0 (0%)
Total	78	21

Table VI: Causes of Neurology

Cause	Trauma (N)	Neurology (n)	%
MVA	45	11	24.4
Fall From Height	22	7	31.8
Fall at Home	4	1	25
Hit by Object	5	0	0
Sports/Recreational	2	2	100
Total	78	21	26.9

Table VII: Recovery of Neurological Status

ASIA Scale	On Admission		On Discharge	
	Incomplete	Complete	Incomplete	Complete
A	0	11	0	8
B	1	0	2	0
C	6	0	1	0
D	3	0	5	0
E	0	0	4	0

Table VIII: Complications

Complication	n
Urinary Tract Infection	8
Pressure Sore	4
Respiratory Infection	2
Septicaemia	1
Death	1

Discussion

The total of 78 patients compiled reflected the cross-section of the Malaysian population with some interesting findings. The distribution of foreigners particularly Indonesians, reflects the input of foreign labor into the construction industry. The 4:1 male-to-female ratio was similar to many other studies worldwide which ranged from 3:1 to 5.8:1 [2,4,10-12]. The subset of population of less than 35 years of age was affected in 61.5% of cases and this figure was in agreement with other series.

Motor vehicle accidents represent 58% of the etiology in this series but the data were indiscriminate to indicate the proportion of motorcyclists involved as they were lumped together as motor vehicle accidents and not as motorbike accidents. Data from Taiwan indicate 62% of cases were attributed to motorbike accidents[2,12]. Work-related injuries accounted for 16.7% of cases in the present study. Most of them occurred at the work place and were either fall from height (69.7%) or being hit by an object (30.3%). The reported incidence of work-related injuries ranged from 17%[3] to 20%[14]. Sports-related injuries were rare, accounting for three percent of cases but all had neurological deficit. This was in concordance with the findings of Fife and Kraus (1986).

The incidence of associated injuries in our series was 40%. It was also found that associated injuries were higher in those who fell from a height (50%) rather than motor vehicle accidents (42%). Although associated chest injuries were apparently common, mortality of patients with spinal trauma was commonly associated with severe head injuries. Associated fractures were encountered in more than one-third of cases. Saboe *et al.* (1991) reported 47% incidence of associated injuries with almost similar distribution of head injuries (26%), chest trauma (24%) and long bones fracture (23%).

Thoraco-lumbar injuries occurred in 61.3% of cases but neurological deficit was the highest (62.5%) in the C4-C6 region. This is attributable to narrow canal dimension in this segment. The thoracic spine had 42.9% while the mobile thoraco-lumbar junction only had 26.5% incidence of neurological deficit. The highest percentage of neurological deficit was attributed to sports or recreational activities (100%) followed by fall from a height (31.8%), fall a home (25%) and motor vehicle accidents (24.4%). Comparative figures could not be obtained as most studies were done on spinal cord injuries alone without vertebral trauma.

In contrast to Western figures of higher number of patients undergoing surgery[14], only nine percent of our patients had surgery. The majority of our patients were managed conservatively. The ASIA status showed an overall improvement. On admission, 11 patients had ASIA-A status while there were only eight on discharge. ASIA-E patients meanwhile increased to four on discharge. The follow-up was very poor for those with neurological deficit. Only 11 of 21 patients were regularly seen at the follow-up clinic. The complication rate would thus be inaccurate. Only four patients with ASIA-A remained unchanged at one year follow-up.

Conclusion

Our epidemiological data were comparable to other series. An extensive compilation of records on multi-center level-one trauma center setting.

References

1. Thurmann DJ, Burnett CL, Jeppson L, et al. Surveillance of spinal cord injury in Utah, USA. Paraplegia. 1994; 32: 665-9.
2. Lai C, Lai JS, Chang KH, et al. Traumatic spinal cord injuries in the rural region of Taiwan. An epidemiological study in Hualien County between 1986-1990. Paraplegia. 1993; 31(6): 398-403.
3. Saboe LA, Reid DC, Davis LA, et al. Spinal trauma and associated injuries. JTrauma 1991; 31(1): 43-8.
4. Karamehmetoglu SS. Traumatic spinal cord injury in Istanbul, Turkey. Paraplegia. 1995; 33(8): 469-71.
5. Fife D, Klaus J. Anatomic location of spinal cord injury. Relationship to the cause of injury. Spine. 1980; 11(1): 2-5.
6. Jamaludin M, Cervical spine injury. Dissertation submitted for Master of Surgery (Orthopaedics), Universiti Kebangsaan Malaysia. 1986.
7. Moses T, Thoraco-lumbar injuries. Dissertation submitted for Master of Surgery (Orthopaedics), Universiti Kebangsaan Malaysia. 1993.
8. Waters RL, Adkins RH, Yakura JS. Definition of complete spinal cord injury. Paraplegia. 1991; 29: 573-81.
9. American Spinal Cord Injury Association. Standard for Neurological and Functional Classification of Spinal Cord Injury. Revised. Chicago,IL, American Spinal Cord Injury Association. 1992.
10. Karamehmetoglu SS. Traumatic spinal cord injury in South East Turkey. Spinal Cord. 1997; 1997; 35(8): 531-3.
11. Pajareya K. Traumatic spinal cord injuries in Thailand. An epidemiological study in Siriraj Hospital 1989-1994. Spinal Cord. 1996; 34(10): 608-10.
12. Chen HY, Chiu WT, Chen SS et al. A nationwide epidemiological study of spinal cord injury in Taiwan from July 1992 to June 1996. Neurol Research. 1997; 19(6): 617-22.
13. Biering-Sorensen E, Pederson V, Clausen S. Epidemiology of spinal cord injury in Denmark. Paraplegia. 1990; 28(2): 105-18.
14. Capaul M, Zollinger H, Satz N, et al. Analysis of 94 consecutive spinal cord injury patients using ASIA definition and modified Frankel score classification. Paraplegia. 1994; 32: 583-7.

ORIGINAL ARTICLE

Sliding Compression Screw Fixation for Delayed Union/Non-Union of Femoral Neck Fracture: Is it a Viable Option?

W I Faisham, MMed (Orth), A R Sulaiman, MMed (Orth), W Zulmi, MS (Orth)

Department of Orthopaedics, School of Medical Science, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

Summary

Femoral neck fracture non-unions often present with significant difficult treatment decision as regards to surgical options and the risk of complication. We present three cases of femoral neck non-union treated with double screw stabilization technique using sliding compression hip screw and anti-rotational screw. The rationale for opting to these simple implants in our setting is discussed.

Key Words: Femoral neck fracture, Non-union, Sliding compression screw

Introduction

Non-union and osteonecrosis after femoral neck fracture have been well documented complications[1,2]. Surgical intervention to achieve union and to salvage of the femoral head is desirable in young adults. Surgical options include realignment osteotomy and stabilisation, muscle pedicle graft, and vascularised fibular graft are designed to address both mechanical and biological factors to enhance healing and prevent complication. However, most of these technically demanding procedures require expert assistance from plastic reconstructive surgeon or vascular surgeon. We opt for a simpler technique of using ordinary implants, which are applicable for an average orthopaedic surgeon to perform the operation. Three cases of femoral neck non-unions were presented to illustrate our simple approach in dealing with such potentially complicated non-unions.

Case Report 1

A 19 year-old boy who has had his fractured hip fixated with screws 3-month earlier presented with persistent right hip pain on regular follow-ups. Radiograph of the affected hip showed the previous unreduced transcervical fracture displaced into a varus position with evidence of cannulated screw pullout (Fig. 1a). A revision surgery was carried out for which the screws were removed and the fracture was reduced by closed technique under fluoroscopic guidance. Two threaded guide wires were inserted into the upper and lower halves of the femoral neck and head as provisional stabilization to minimize 'helicopter effect' while reaming the track for sliding compression screw. A third threaded guide wire was inserted in centro-central position in both anteroposterior and lateral radiographs. This wire was used to guide cannulated reamer for creating track for sliding compression screw. The distalmost guide wire was removed prior to placement of a four-hole 8cm sliding hip screw system. The side-plate was fixed with four cortical screws. The uppermost guide wire was used to guide a cannulated reamer for insertion of anti-rotation screw (Fig. 1b). His post-operative progress with an initial regime of 3-month period of touch-down weight bearing ambulation has resulted in radiological union at three months.

He returned to full function after 6 months and there was no significant limb length discrepancy noted on follow-up.

Case Report 2

A 26 year-old man sustained ipsilateral neck and diaphyseal fracture of the right femur following a high velocity road traffic accident. The diagnosis of femoral neck fracture was initially missed and the femoral shaft fracture was stabilized by using a standard first generation locked nail. However, his rehabilitation was delayed due to persistent hip pain even after completing two months post-operative period. Radiograph of the affected femur depicted severe coxa vara indicating a displaced fracture neck of femur. The fracture was reduced and fixed with two cannulated screws inserted by using miss the nail technique. He presented with non-resolving severe hip pain and 2.5cm shortening of the right lower limb. Radiographs showed severe coax vara due to redisplaced fracture and implant failure in form of screw cut-out through the femoral head (Fig. 2a). Revision surgery by removing the initial implants was performed. Open reduction of neck fracture was carried out following unsuccessful attempts to correct varus deformity by closed reduction technique. The diaphyseal fracture was restabilized by using locked compression plate (LCP). Similar technique was used to insert sliding compression screw fixation system. However, post-operative radiographs showed a non-ideal placement of sliding hip screw in supero-central position on antero-posterior and lateral views. A strict non-weight bearing ambulation for four months was prescribed in anticipation of a higher risk for sliding screw cut-out. At five months follow-up, radiographic evidence of union was noted. The right femur was shortened by 1.5cm. He was allowed to return to selected normal function after six months.

Case Report 3

A 33 year-old lady with two month history of unexpected persistent left hip pain following the initial treatment of proximal third diaphyseal fracture of the left femur for which stabilization with a locked nail was performed. Radiographs of the left hip showed a displaced basal neck fracture. As the morphology of the neck was estimated to be relatively small to allow insertion of two cannulated screws using missed the nail technique, a decision to utilize sliding compression screw system was made as alternative option. Following removal of locked nail, the incision was extended distally to allow anterolateral access to the hip for basal neck fracture reduction. The same technique of sliding compression screw fixation as described in Case 1 was used. Post-operative radiographs showed near anatomic reduction and alignment of neck fracture. Her rehabilitation consisted of three months touch-down weight bearing ambulation followed by full weight bearing mobilization. She was able to return to full function after six months.

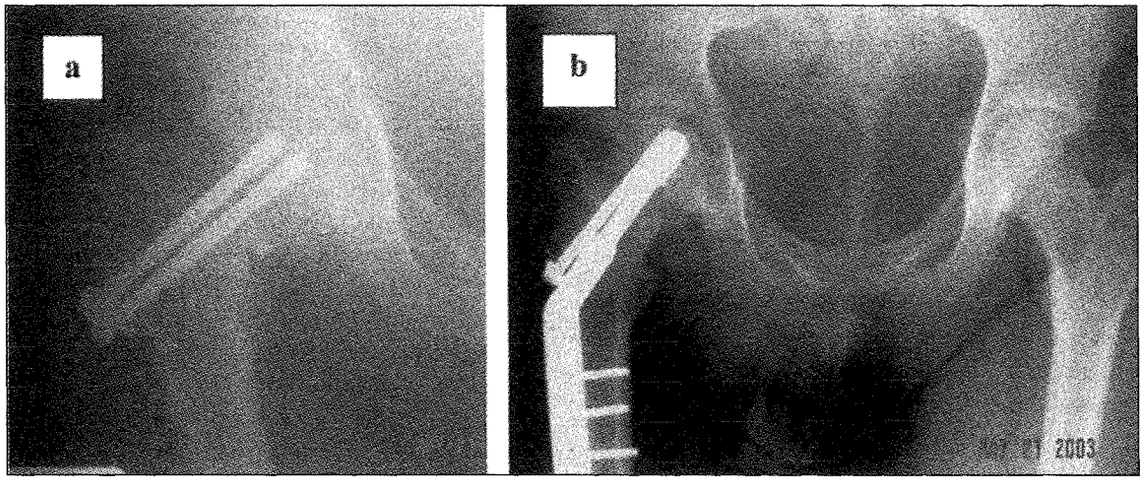


Fig. 1: a - Radiograph of the affected hip showing the proximal fracture fragment in varus and the fracture was unreduced (indicated by screw pull-out without evidences of peri-implant bone resorption and implant bending). b - Post-revision radiograph showing better alignment of the proximal fragment and stabilization option using sliding compression screw and anti-rotation screw.

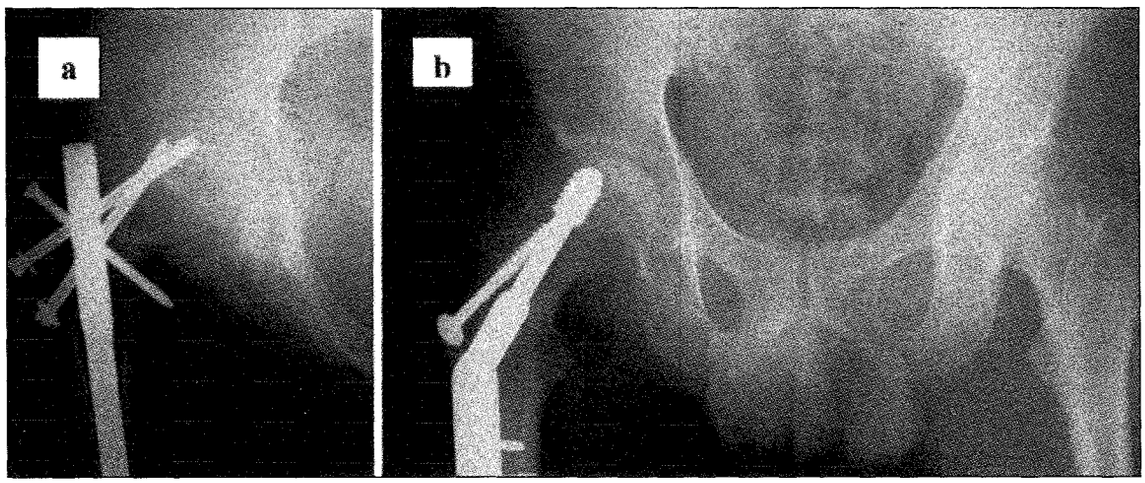


Fig. 2: a- Pre-revision radiograph showing severe coxa vara and screw cut-out. b- Post-revision radiograph showing non-ideal position of sliding compression screw in the supero-lateral segment of the femoral head.

Discussion

Fixation of femoral neck fracture is associated with a higher incidence of complication than any other fracture. The rate of non-union associated with open reduction and internal fixation has been reported to be 10% to 33%[1,2]. The most common causes for failure of internal fixation are inadequate reduction as illustrated in Case 1 and inadequate fixation as in Cases 1 and 2. The incidences of non-union were 18% in adequately reduced fractures compared to 70% in inadequately reduced fractures[1]. In Case 1, the fracture was unstable due to high shear force fracture pattern (Pauwels type-III) and a stable fixation frequently requires placement of three screws in a triangular divergence pattern. High energy trauma especially concomitant femoral shaft fracture may complicate reduction and fixation. Technical error made during internal fixation may also contribute to non-union, avascular necrosis and ultimately fixation failure[1,2]. In Case 2, reconstruction nail (instead of the standard first generation locking nail) plus two missed the nail screws is a better stabilization option. Patient compliance to rehabilitation can also cause failure of an excellent reduction and fixation.

The aim of treatment of femoral neck non-union in young patients is to preserve a viable head while attempting to achieve union. This is achievable if a stable fracture reduction is maintained in correct anatomical axis. The options include subtrochanteric valgus osteotomy, compression stabilisation, muscle pedicle grafting and fibular graft. Realignment osteotomy remains a standard procedure especially in patients with shortening[3]. The rationale for the procedure is to convert shearing force into compressive force. However, this will cause distortion of proximal femur alignment and morphology. These changes have relevant bearing to technical difficulty for future hip replacement.

Stabilisation with sliding hip screw in femoral neck non-union was recommended in the absence of mal-alignment, shortening or deformity[3]. Augmentation with anti-rotational screw is necessary to prevent rotation and should be done before reaming for sliding hip screw. Reaming of the head may provide internal autogenous grafting of the fracture site to augment healing. Wu *et al.*(1999) reported satisfactory outcome using sliding compression screw without subtrochanteric valgus osteotomy and recommended the technique as a standard treatment. However, this procedure cannot correct a short femoral neck, which can be worsened by telescoping effect. The three cases presented herein highlighted our ability to achieve union and good functional outcome with this technique.

The diagnosis of undisplaced femoral neck fracture following nailing is difficult and possibly delayed such

as in our Case 3. A patient presenting with significant groin pain, particularly when the nail entry point placement is medial, should be suspected of having this problem. CT scan can help in early diagnosis for institution of treatment[4]. Revision surgery for this complicated problem requires hardware removal and both shaft and neck fractures require a proper choice of implants for simultaneous stabilization[5]. Femoral neck non-union can be treated successfully with intertrochanteric osteotomy or sliding compression screw. Femoral shaft fracture is best treated with retrograde nail or plate with bone graft[5]. Both cases in our series were successfully treated with sliding compression screw and anti-rotational screw even after failure of missed the nail technique (Case 2).

Conclusion

A simple technique of double screw system using sliding compression screw with anti-rotation screw provides an alternative option in treating femoral neck fracture delayed union or non-union. The surgery can easily be performed without assistance from plastic reconstructive or vascular surgeons.

References

1. Lowell JD. Results and complications of femoral neck fracture. J Bone Joint Surg. 1980; 62-A: 1308-12
2. Banks HH. Non-union in fracture of the femoral neck. Orthop. Clin. North Am. 1974; 5: 865-85.
3. Wu CC, Shih CH, Chen WJ, Tai CL. Treatment of femoral neck non-union with a sliding compression screw: comparison with and without subtrochanteric valgus osteotomy. J Trauma 1999; 46(2): 312-7.
4. Yang KH, Han DY, Park HW. Fracture of the ipsilateral neck of the femur in shaft nailing. The role of CT diagnosis. J Bone Joint Surg 1998; 80-B: 673-8.
5. Watson JT, Berton RM. Ipsilateral femoral neck and shaft fracture, complication and their treatment. Clin.Orthop. 2002; 399: 78-86.

ORIGINAL ARTICLE

Screw Osteosynthesis of Displaced Lateral Humeral Condyle Fractures in Children: A Mid-Term Review

W P Loke, MS (Orth)*, M H Shukur, MS(Orth)*, J K Yeap, MS (Orth)**

*Department of Orthopaedics and Traumatology, Hospital Universiti Kebangsaan Malaysia, Cheras, **Tawakal Hospital, Kuala Lumpur, Malaysia

Summary

Displaced humeral condyle fractures in children are traditionally fixed with smooth Kirschner wire at the expense of a risk of secondary displacement following removal of wire. Screw fixation of such fractures has recently been advocated as it provides stable fixation. We have been using screw osteosynthesis for treatment of displaced lateral humeral condyle fractures in children in our institution since the turn of this century. This study provides a mid-term review of treatment of such injuries with special regards to growth disturbances after screw osteosynthesis and to assess rate of union with a view to formulate guidelines for screw removal.
We review the outcomes of screw osteosynthesis for displaced lateral condyle fracture of the humerus (19 Milch type-I and 15 Milch type-II) in 34 children treated in our institution from January 2000 to March 2004. The average age of the patients was 6.1 years. The average follow up was 24.5 months.
Screw osteosynthesis led to union (average 6.9 weeks) in all patients with excellent results in 28 patients. Growth disturbances in the form of lateral condyle overgrowth (2 patients), valgus deformity secondary to lateral condyle avascular necrosis (2 patients) and fishtail deformity ((3 patients) were recognized. The implants should not be removed until fracture union is established. Screw osteosynthesis of the lateral humeral condyle fracture prevents secondary fracture redisplacement and lateral condyle overgrowth is probably related to hyperemic response to metaphyseal fixation and early removal of implant before radiological union.

Key Words: Humeral condyle fracture, Screw osteosynthesis

Introduction

Lateral humeral condyle fractures account for 17% of all distal humeral fractures in children. These epiphyseal injuries are intra-articular fractures with the distal fracture fragment exhibiting metaphyseal wedge and ossification center. They must be anatomically reduced to restore the articular surface, re-align the physis and fixed with stable fixation technique to allow early mobilization of the elbow. These two principles are necessary to reduce the incidence of delayed union, non-union and malunion, and the eventual deformity and growth disturbance and tardy ulnar nerve palsy. Different treatment options have been described but most of them are based on the surgeon's preference.

For undisplaced or minimally displaced fractures of less than 2mm, immobilization in plaster cast with the elbow flexed at 90°, the forearm pronated or in natural rotation and the wrist in relaxed extension, followed by weekly radiographic review has been recommended[1]. However, the risk of secondary displacement has been reported in 11% to 42% of cases[2].

The accepted treatment of displaced fractures (>2 mm) is open reduction and internal fixation with Kirschner wires or screw[1,3]. In theory, Screw osteosynthesis should be avoided to prevent injury to the physis and to obviate reoperation for implant removal. However, it provides a stable fixation under compressive mode and allows early union and consolidation to shorten the

hyperemic response during healing. Kirschner wire fixation was preferred mainly based on the premise that further injury to the epiphysis is minimized and its removal is easily performed as an office procedure obviating a second operation. The timing of implant removal remains controversial but the recommended time between 6 to 8 weeks is associated with risk of pin-tract infection, osteomyelitis and septic arthritis if percutaneous K-wires were used. Viewing this as a serious complication, early removal of K-wires at three weeks has been preferred by many surgeons at the expense of a possibility of secondary displacement especially when elbow mobilization is permitted. However, there is no consensus as to when the implant should be removed. To date, few studies have addressed the issue of the timing for screw removal

In an earlier study at our institution, Baharuddin *et al.*(2000) reported satisfactory short-term results of screw osteosynthesis of the lateral humeral condyle fractures without significant complications. This study was undertaken to review our mid-term results of screw osteosynthesis of fractures of the lateral humeral condyle in children..

Materials and Methods

From January, 2000 to March, 2004, 34 children with acute fracture of the lateral humeral condyles were treated at our center. There were 24 boys and 10 girls with the mean age of 6.1 years (range 2.5 to 14 years). The average follow-up was 24.5 months.

Milch classification based on whether the capitellar ossification center is disrupted by the fracture line was used to classify lateral humeral condyle fractures[5]. Type-I fracture line begins in the metaphysis, crosses the physis obliquely then traverses the capitellar ossification center to exit in the articular surface. The elbow remains stable because the trochlea is intact but coronal rotation of the condylar fragment can occur if the fracture is unstable. This fracture has a higher risk of growth arrest as it represents Salter-Harris type-II injury with a disrupted ossification center.

Milch type-II fracture has the line traverses the postero-lateral metaphysis crossing the distal physis and extending to the unossified trochlea without interrupting the capitellar ossification center. This fracture is equivalent to Salter-Harris type-IV. The elbow is often unstable because the fracture line disrupts the lateral crista of the trochlea. When the forearm rotates in the coronal plane into valgus, the proximal radius and ulna tend to subluxate posterolaterally together with the lateral condyle. This mechanism of lateral translocation is an important consideration in late reconstructon of untreated fractures.

Treatment - Children who had undisplaced fractures treated with cast immobilization were excluded from this study. Standard anteroposterior (AP), lateral, internal and two oblique (internal and external) radiographs were reviewed. A displaced fracture was defined as widening of the central fracture gap of greater than 2mm in any view. All patients were treated surgically if fractures were displaced more than 2mm.

Surgical Technique – With the patient in supine position and the arm supported by an armboard, standard lateral approach in line with the lateral supracondylar ridge was used for exposure. The fracture site was entered via the inter-muscular plane between the extensor carpi radialis brevis and extensor carpi ulnaris. Careful and minimal posterior dissection was done to prevent disruption of blood supply to the lateral condyle[5]. We routinely fix the fracture with single half-threaded 4.0mm AO cancellous screw depending on the size of fracture fragment. Anatomical reduction of the fragment was preliminarily fixed with 0.062-inch Kirschner-wire and the screw was inserted in oblique direction from lateral-distal-posterior to medial-proximal-anterior positions under fluoroscopic control. We emphasize that the screw is placed proximal to the growth plate. Early active motion exercise as tolerated was allowed. Post-operative elbow immobilization with a plaster slab was not routinely used except when the operating surgeon employed it for pain relief for 10-14 days.

Evaluation - The medical records and antero-posterior, lateral, internal and external oblique radiographs were reviewed. Information from these records included the patient's age at the time of the injury and at the last follow-up, the operative technique, the type of fixation, the date of implant removal, the duration of post-operative immobilization, and complications. Range of motion of the elbow and the carrying angle between the long axis of the humerus and forearm were also reviewed. Discrepancies of less than 5° in comparison with the contra-lateral uninjured arm were tolerated as inaccuracy of the clinical measurement was negligible. A bony prominence of the lateral condyle was judged either visible or not existing.

The fracture was judged to be under 'compression' if no fracture gap could be seen in the intra-operative or immediate post-operative radiographs. The radiographic criteria for a healed fracture consisted of the presence of callus across the fracture site in the anteroposterior and lateral radiographs of the elbow. 'Consolidation' was defined as an invisible fracture gap and/or lateral periosteal callus formation. Visible fracture gap after more than four weeks post injury was used to define delayed union. A 'fishtail deformity' was defined as a visible notch between trochlea and capitellum on AP view in patients with closed or nearly closed physis of the distal humerus at review. The presence of avascular necrosis, non-union, or mal-union, the condition of the growth plate of the lateral condyle, any angular or rotational deformities, and the presence of bony spurs or heterotopic ossification were also included in the radiographic evaluation.

The outcome of the study was evaluated according to the modified Broberg and Morrey Index[6] (Table I). A total score of 95 to 100 points indicates excellent results, 80 to 94 points, a good result, 60 to 79 points, a fair result, and 0 to 59 points, poor result.

Materials and Methods

Demographic Profiles - The age of patients ranged from 2 to 14 years (mean 6.1 years) with 70% of patients less than 8 years and 55% between 5 and 8 years in age. There were 24 boys and 10 girls with 21 left- and 13 right- sided fractures. Milch type-1 fracture was encountered in 19 patients and 15 patients had Milch type-2 fracture.

Outcome - The result was rated excellent in 28 patients (82.3%), good in five patients and fair in one patient,

Table I: Modified Broberg and Morrey Index

Variable	No. of points*
Motion(total for each plane)	
Flexion(O.2 x arc)	27**
Pronation(0.1 x arc)	6**
Supination(0.1x arc)	7**
Total	40**
Strength	
normal	20
Mild loss (appreciable but not limiting, strength 80 % that of contra-lateral side)	13
Moderate loss(limits some activity, strength 50 per cent that contra-lateral side)	5
Severe loss(limits everyday tasks, disabling)	0
Stability	
Normal	5
Mild loss (perceived by patient loss, no limitations)	4
Moderate loss (limitation some activity)	2
Severe loss(limits everyday tasks)	0
Pain	
None	35
Mild ***	
With sports strenuous activity, no medication	30
With daily activity, no medication	25
Moderate (with or after activity, medication sometimes)	15
Severe (at rest, constant medication, disabling)	0

* A total score of 95 to 100 points indicates excellent result; 80 to 94 points, a good result; 60 to 79 points, a fair results; and 0 to 59 points, a poor result.

** Maximal possible score

*** Mild pain is assigned 28 points in the original rating system and is divided into categories according to activity in modified system

Table II: Complications of screw osteosynthesis for fracture lateral humeral condyle

Fish Tail Deformity	3
Lateral Condyle AVN	2
Wound Infection	1
Median Nerve Neuropraxia	1

according to modified functional index of Broberg-Morrey. This was in contrast to our previous study in this center where Baharuddin *et al.* reported 95% excellent short-term results. The average time of radiographic union was 6.9 weeks with the average time of screw removal being 16.6 weeks.

Complications - Out of the 34 patients, three 'fishtail' deformities were recognized after six months post operation. Two patients developed lateral condyle avascular necrosis and they presented with carrying angle of greater than 10°. One patient developed superficial surgical site infection which resolved after intravenous antibiotic treatment. One patient developed mild median nerve neuropraxia which recovered completely after three months. Two patients had lateral condyle prominence due to malunion following inadequate reduction and fixation, and lateral condyle overgrowth. These patients had decreased range of motion and extension lag of 10°. We also had one case of washer left over as it was embedded in the bone. The overall union rate was 100% and none of the patients needed revision surgery for inadequate primary surgery.

Discussion

Patients with displaced fractures should undergo open anatomical reduction to restore joint congruency followed by stable internal fixation to prevent secondary displacement while allowing early joint mobilization[7,8,9]. The widely used Milch classification is based on the integrity of the lateral wall of the trochlea , preserved in the transcondylar type I and the elbow joint is stable It is attached to the lateral fragment in type II, the fracture leads to a fracture-dislocation of the elbow[6]. Clear treatment guidelines are deducible from a simple differentiation between undisplaced and primary/secondary displaced fractures. In our study, we had 19 Milch type-I and 15 Milch type-II fractures. There is no significant difference in these two groups in terms of functional outcome or growth disturbance if the fracture was anatomically reduced and fixed under compression mode.

Screw osteosynthesis of displaced fractures with a metaphyseal small fragment lag screw was possible in all cases except one case of Milch type-I fracture where K- wire was used to stabilize the fracture. In our series, a perfect lag screw effect was achieved in 93.5% of the cases. A correctly placed screw may give the false impression on the AP view that it crosses the physis because the physis has an oblique extension from posterior-distal to anterior-proximal. The screw shows approximately the same direction (slightly steeper) but starts in the dorsal metaphysis proximal to the growth plate.

Open reduction and internal fixation of displaced fractures prevents malunion particularly cubitus valgus, tardy ulnar nerve palsy, radial elbow instability and cosmetic impairment. Delayed union or pseudoarthrosis is not a problem since healing is good in children. In our series, only one case with missed secondary displacement led to malunion in mild valgus. Finally, the elbows showed a slight varus deformity due to the compensatory effect of lateral condylar overgrowth

Although less than 20% of the growth of the humerus is contributed by the distal humeral physes, transphyseal screw fixation does not significantly destroy the growth potential of the physis and further growth is still possible when the screw is removed prior to physeal closure[10]. In this study, our average time of screw removal was 16.6 weeks which is 10 weeks after our average union duration (6.9 weeks). This was deemed to be an appropriate timing with reference to adequate remodeling time and growth potential. Too early removal of implants before radiological union may lead to secondary displacement. Local hyperemia at the fracture site leads to stimulation of growth during the consolidation phase of healing.

In contrast to this, premature closure of the physis affects growth as long as the physis is still active. A partial lateral growth disturbance of the distal humeral physis may gradually change the carrying angle of the elbow towards varus (stimulation) or valgus (partial arrest). In our study, screw osteosynthesis prevents growth arrest if it is inserted from metaphyseal area Despite three patients had decreased carrying angles and two patients had increased carrying angle at follow-up, they continued to have good range of motion. Clinical studies demonstrated that the extent

of condylar overgrowth is directly related to the consolidation time. Clinically, the most sensitive feature of a stimulation of the growth plate is a lateral condylar prominence which is seen radiologically as an enlarged condyle. Although there is no functional impairment, patients may complain about their marked lateral lump. Remodelling of the prominence cannot reliably be expected[11].

'Fishtail deformity' of the distal end of the humerus is caused by a notch between the trochlea and capitellum. This growth disturbance affects the central part of the physis and therefore has no influence on the carrying angle. In our study, we had three cases of fishtail deformity which appeared after 12 months of follow up. The central part of the distal humerus is cartilaginous in most of the patients at the time of injury. Therefore, this bony deformity is visible only in follow-up radiographs just before or after closure of the physis. Although malunion may play a role as a pathogenetic factor[9], the formation of this deformity seems to be more in relation to the instability of the fragment. The fact that metaphyseal screws are compressing mainly the lateral part of the fracture seems to leave some minor medial instability leading to notch forming. Avascular necrosis of the capitellum rarely complicates the course of a lateral condyle fracture. It leads to a valgization of the elbow. Excessive soft tissue dissection on the posterior part of the fragment is the main risk factor mainly in late surgery where orientation can be difficult[9,12]. Two cases of avascular necrosis were encountered in our series.

Conclusion

Screw osteosynthesis of the lateral humeral condyle in children produces good union rate. Nevertheless, long-term follow-up will entail the late sequalae. Stringent surgical techniques are essential to curtail the untoward complications. The average union rate is 6.9 weeks. The implants should not be removed until fracture healing can be demonstrated in two planes radiologically.

References

1. Bast S, Hoffer M, Aval S. Nonoperative treatment of minimally and nondisplaced lateral humeral condyle fractures in children. J Pediatr Orthop 1998; 18: 448-50.
2. Finnbogason T, Karlsson G, Lindberg L, et al. Nondisplaced and minimally displaced fractures of the lateral humeral condyle in children: a prospective radiographic investigation of fracture stability. J Pediatr Orthop 1995; 15: 422.
3. Mintzer C, Waters P, Brown D. Percutaneous pinning in the treatment of displaced lateral condyle fractures. J Pediatr Orthop 1994; 14: 462-5.
4. Cheng JC, Wing-Man K, Shen WY. A new look at the sequential development of elbow-ossification centers in children. J Pediatr Orthop 1998; 18: 161-7.
5. Brodeur AE, Silberstein JJ, Graviss ER. The basic tenets for appropriate evaluation of the elbow in pediatrics. In: Current problems in diagnostic radiology. Chicago: Year Book Medical, 1983.
6. Haraldsson S. The intraosseous vasculature of the distal end of the humerus with special reference to capitellum. Acta Orthop Scand 1957; 27: 81-93.
7. Milch HE. Fractures and fracture–dislocations of the humeral condyles. J Trauma 1964; 4: 592-607.
8. Broberg. M.A., and Morrey, B.F. Result of delayed excision of the radial head after fracture. J Bone and Joint Surg. 1986; 68(A): 669-74.
9. Bast SC, Hoffer MM, Aval S. Nonoperative treatment for minimally and nondisplaced lateral humeral condyle fractures in children. J Pediatr Orthop 1998; 18: 448-50
10. Dhillon KS, Sengupta S, Singh BJ. Delayed management of fracture of the lateral humeral condyle in children. Acta Orthop Scand 1988; 59: 419-24.
11. Rutherford A. Fractures of the lateral humeral condyle in children. J Bone Joint Surg Am 1985; 67(A): 851-6.
12. Metaizeau J P, Wong-Chun J, Bertrand H, Pasquier P. Percutaneous epiphysiodesis using transphyseal screws.J Pediat Orthop 1998; 18: 363-69.
13. Jeffery RS. Injuries of the lateral humeral condyle in children. J R Coll Surg Edin. 1989; 34: 156-9.
14. Yoo CI, Suh JT, Suh KT, Kim YJ, Kim HT, Kim YH. Avascular necrosis after fracture-separation of the distal end of the humerus in children. Orthopedics 1992; 15: 959-6.

ORIGINAL ARTICLE

Adequacy of Pain Relief in Closed Manipulative Reduction of Fracture and Dislocation

C H Wan Hazmy, MS (Orth)*, S Hana Maizuliana, Adv.Dip.Med.Sc, M T Mastura, Adv.Dip.Med.Sc**, M Norazlina, Adv.Dip.Med.Sc****

*Department of Orthopaedics and Traumatology, Seremban Hospital, **International Medical University (Clinical School), Jalan Rasah, Seremban, Negeri Sembilan, Malaysia

Summary

Adequate pain relief is a requisite for a successful closed manipulative reduction (CMR) of fractures and dislocations. This prospective study was undertaken to assess the mode and adequacy of pain relief given to patients undergoing such procedures at Seremban Hospital from the 1st April to the 31st May 2001. All patients with fractures and dislocations scheduled to undergo CMR were included in this study. The type of sedative agents and analgesia administered were recorded. Demographic data and the type of fracture or dislocation of the selected patients were documented. A visual analogue scale (VAS) for pain perception was given to both to the patients and the medical personnel who performed the procedure. All data were collected manually before entered into computerized database for analysis. Of 72 patients included in this study, 47% were Malay, 26% Indian, 21% Chinese and 6% others. There was male predominance and the patients' age ranged between 9 to 79 years (average 27.4 years). Upper limb injuries (79%) were mainly fractures of the radius and ulna (29%) and isolated fracture radius (21%). For the lower limb injuries (21%), combined tibia and fibula fractures constituted 10% of the total cases followed by isolated tibia fractures (10%) and hip dislocation (1%). The most common pain relieving agents given during the CMR were intravenous pethidine alone (43%) followed by combination of intravenous pethidine and valium (36%), intramuscular pethidine (17%) and intramuscular tramal (4%). The Visual Analogue Score (VAS) for pain perception revealed that 61% of the patients had moderate pain while 21% had severe pain during the course of the procedures. Suboptimal pain relief administered during CMR should prompt positive actions to ensure that the patient is not subjected to undue pain just for the sake of an acceptable fracture reduction.

Key Words: Fracture, Dislocation, Reduction, Manipulative, Pain relief

Introduction

Closed manipulative reduction (CMR) to achieve acceptable alignment of long bone and joint is one of the principle treatments of fractures and dislocations. Obtaining a well aligned long bone of limb is not merely for a cosmetic reason but more importantly it helps to minimize alteration of the biomechanics of the affected bone or joint that is essential for optimizing the function of the affected limb.

In order to achieve a satisfactory reduction adequate pain relief is at the utmost important. Much have been heard that despite the necessity of such a procedure, it can be a most horrible experience one can remember, sometimes more frightening than the fracture itself. Despite that not much attention has been addressed concerning this matter, partly due to the multi-factorial constraints that can only be understood by those who had long enough working in the public set-up.

The aims of this study are to identify the mode of pain relief administered during closed manipulative reduction and to assess it clinical efficacy both from the patients and the manipulators' perceptions.

Materials and Methods

A prospective cross-sectional study was conducted at Seremban Hospital from the 1st April to 31st May 2001. All patients sent to the plaster room for closed manipulative reduction of fractures and dislocations were screened prior to the procedure. They were either referred directly from the Accident and Emergency Department after initial diagnosis by the attending medical officer or sent down from the Orthopaedic wards.

Excluded from this study were children less than nine years of age, where difficulty in understanding the post-reduction questionnaires and giving self-assessment were to be expected. Those who are going for manipulative reduction under general anesthesia were also excluded. For patients who had to undergo more than one manipulative reduction, each new procedure was considered as a new case.

Demographic data of the patients were documented. This included the age, race and gender. The type of fracture or dislocation was also recorded. The estimated weight of the patients was used to calculate the dosage of the pain relief agents. The drugs were administered according to pharmaceutical instruction. Types of sedative and analgesics given, the time administered and the time the procedure took were also noted.

A visual analogue scale (VAS) for pain perception was given to the patients and the medical personnel who performed the procedure. The intention was to detect any gross discrepancy between the patients and the manipulators in order to minimize bias. The scale was from 0 (no pain) to 10 (severe pain). However for matters of simplification for the patients, the scale were classified into 0=no pain at all, 1-3= mild pain, 4-7=moderate pain, 8-10= severe pain. Interview with the individual patient was conducted within 48 hours to minimize under-evaluation of the pain. All data were collected manually before entry into computerized database for analysis.

Results

Seventy-two patients were included in this study, with male gender constituted 79% of the cases and female 21%. The age group ranged between 9 to 79 years with the average age of 27.4 years. Eighty three percent of them were below the age of 40. The distribution of age is shown in Fig. 1. Malay patients outnumbered the other races with 34(47%) followed by the Indian 19(26%), Chinese 15(21%) and others four(six percent).

Upper limb injuries represented the majority of the cases (79%) with fractures of the radius and ulna leading the list with 29% of the total cases, followed by fracture radius alone (21%), shoulder dislocations (eight percent), fracture humerus (eight percent) and isolated ulna fractures (seven percent). The lower limb injuries contributed 21% of the cases with combined tibia and fibula fractures in 10% of the total, isolated tibia fractures (10%) and hip dislocation (one percent).

The most common pain relieving agents given during the closed manipulative reduction were intravenous pethidine alone (43%) followed by combination of intravenous pethidine and valium (36%), intramuscular pethidine (17%) and intramuscular tramal injections (four percent) (Fig. 2).

The Visual Analogue Score (VAS) for pain perception, both by the patients and the manipulators were displayed in Fig. 3. Both groups have the peak interval score between 4 to 7. No obvious discrepancy detected based on the comparative graphic presentation from both groups. Fig. 4 demonstrated the patient's VAS based on the severity subgroups. Only one patient had no pain at all during the procedure. Majority of them had moderate pain (61%) while 17% had mild pain. Severe pain was experienced by 21% of the patients.

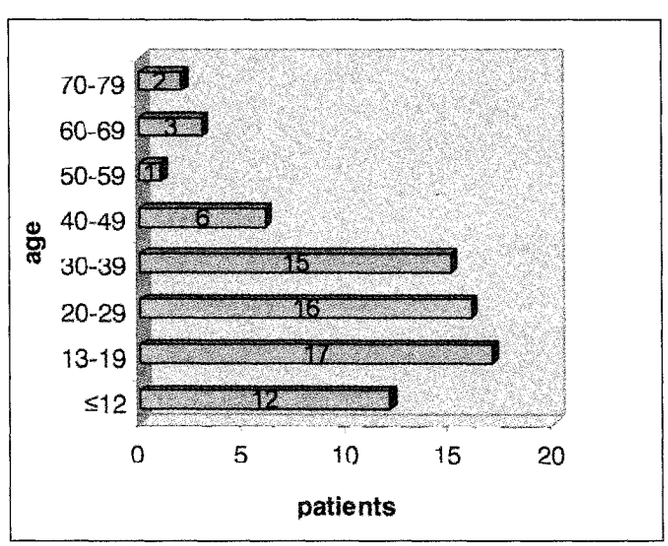


Fig. 1: Age Distribution

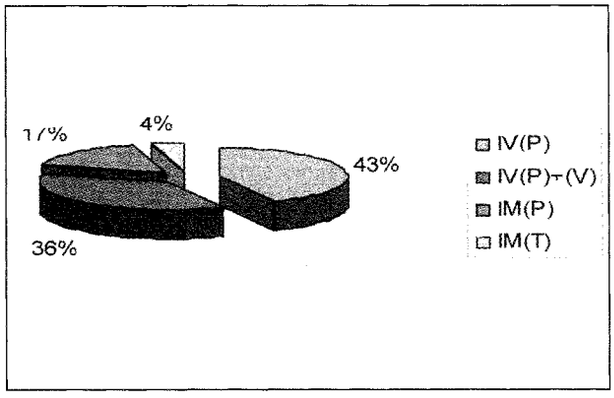


Fig. 2: Pain Relief Agents IV (P) -intravenous Pethidine, IV (P)+ (V)- intravenous Pethidine & Valium, IM (P)-intramuscular Pethidine, IM (T) -intramuscular Tramal.

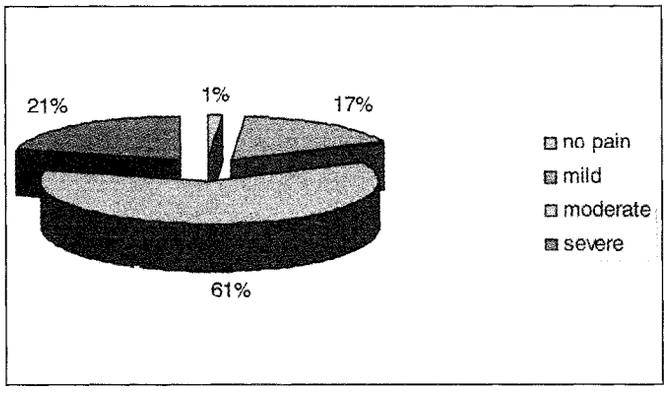


Fig. 4: Pain Score according to subgroup

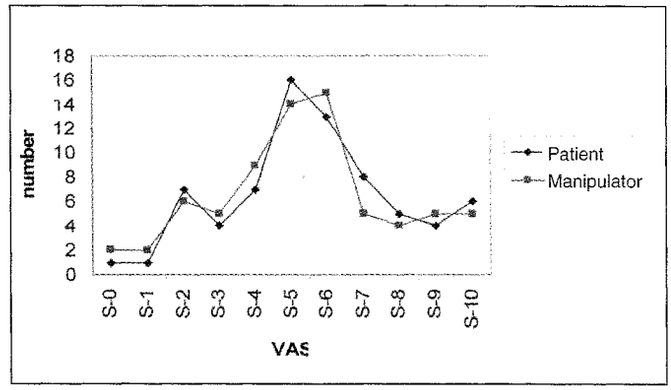


Fig. 3: Comparison of Pain Score

Discussion

Pain relief is a basic human right. Patients have the right for appropriate assessment and management of pain. In the past, the standard course of pain management includes medication taken on 'a la demand' basis, ending up with patients being under-treated with inadequate pain control. The current science of pain control emphasizes the concept that pain without treatment or under-treated will result in increased sensitivity to painful stimulus; therefore in the encounter of pain, more pain will be expected with a lesser stimulus.

Failure to perceive the degree of pain associated with acute musculoskeletal trauma [1,2] is the main reason for patients not receiving adequate analgesia. Morgan-Jones *et al*[3] in their prospective study on 100 patients admitted to the hospital for acute injury requiring orthopaedic intervention had demonstrated that 36% of patients perceive they were not receiving adequate pre-operative analgesia despite having severe pain. This can be addressed with improved information and education for both medical and nursing staff who may be making value judgements regarding the need for analgesics.

Intravenous opiates are the most effective analgesia in acute trauma[4]. However, CMR necessitates the use of forces which might worsen the post-injury tolerable pain. This study revealed that 61% of the patients had moderate pain while 21% had severe pain during the course of the procedure despite the sedation given. A more effective agent or dosage and even adjunct pain relieving modalities should be seriously considered to minimise the psychological trauma following such procedures.

In a more established centre, several other more convincing and effective drugs are being used with good results. Conventionally, this has been accomplished with conscious sedation, in which patients maintain protective airway reflexes and have some response to verbal and painful stimuli. Because some emergency physicians mindfully have administered traditional and new drugs in a manner that provided more profound sedation than is achievable by conscious sedation, the practice of deep sedation has grown. Controversy has arisen regarding the degree to which protective reflexes are reduced or lost as sedation deepens.

Ideally, the agent chosen would provide the patient with adequate sedation for the procedure, have a brief duration of action, and be safe and easy to administer. Previously described is the administration of potent

sedative hypnotic drugs such as propofol,[5] methohexital,[6] and ketamine[7] to provide brief deep sedation in the emergency department.

In the reduction of children's fractures, for example various sedative and local anesthetic techniques are being used including hematoma blocks, intravenous regional blocks, and sedative techniques such as parenteral narcotics, nitrous oxide, and benzodiazepines. In the emergency room setting, the choice of which technique to use is guided by the experience of the physicians, ease of administration, safety, efficacy, and patient and parental acceptance, among other factors. Several studies[8,9] had recommended the intravenous use of ketamine in trauma patients because of its excellent analgesia at subanaesthetic doses, in other word it is unique in that it seems to offer deep sedation without the loss of protective reflexes[7]. Nevertheless, several important aspects on the usage of ketamine should also to be considered including the need of preprocedural fasting because of the reported 8.5% incidence of emesis associated with the use of ketamine[8]. In addition, dysphoric reactions have been described.

In this ideal set-up the role of emergency physician with anaesthetic capability has always been an advantage both for the patients and the institution. The important functions of acute pain service in training and supervising acute pain management in the post-operative period, [10, 11]could have been extended to include preoperative analgesia. Adequate monitoring of the patients under sedation is mandatory and its implications should not be underestimated. Pain and analgesic side-effects should regularly be assessed; for example using pain charts and doses titrated accordingly. However, this ideal set-up is still beyond the reach of most of our public hospital.

There were several inherent limitations in this study. One is the time frame from the administration of the pain relieving agents to the application of the maneuver. The common practice was to perform the maneuver once the patient was clinically sedated.

Individual response to the given drugs might also influence the outcome of this study. So too the severity of fracture displacement which might contribute an additive element to pain. Nevertheless efforts were made within these limitations to ensure minimal discomfort to patients.

It is hoped that this study will initiate further reasearch on this subject. With contribution from anaesthetic colleagues and the health administrator, a general guideline and a better approach is expected. It is important to address our prescribing and administration of analgesics as well as the use of adjuvant treatment measures.

Conclusion

Suboptimum pain relief administered during closed manipulative reduction should prompt positive actions to ensure the patient is not subjected to undue pain just for the sake of an acceptable fracture reduction.

References

1. Morgan-Jones R. Pre-operative analgesia after injury. Injury. 1996; 27: 539-41.
2. McQuay H, Moore A and Justins D.Treating acute pain in hospital. BMJ. 1997; 314: 1531.
3. Morgan-Jones R, Cutler L, Kaul S, Smith K. Patients satisfaction with pre-operative analgesia in acute trauma. J R Coll Surg Edinb. 2000; 45: 371-2.
4. Smee WO, Crochard A. Trauma Care. London: Academic, 1981.
5. Swanson ER, Seaberg DC, Mathias S. The use of propofol for sedation in the emergency department. Acad Emerg Med 1996; 3: 234-8.
6. Zink BJ, Darfler K, Salluzzo RF, et al. Efficacy and safety of methohexital in the emergency department. Ann Emerg Med. 1991; 20: 1293-8.
7. Green SM, Clem KJ, Rothrock SG. Ketamine safety profile in the developing world: survey of practitioners. Acad Emerg Med. 1996; 3: 598-604.

8. McCarty EC, Mencio GA, Walker LA, Green NE. Ketamine sedation for the reduction of children's fractures in the emergency department. J Bone Joint Surg. 2000; 82-A(7): 912-8.

9. Mollman M, Auf der Landwehr U. Treatment of pain in trauma patients with injuries of the upper limb. Injury. 2000; 31 (Suppl 1): 3-10.

10. Rawal N and Beggren L. Organisation of acute pain services: a low cost model. Pain. 1994; 57: 117.

11. Gould TH, Crosby DL. Policy for controlling pain after surgery: effect of sequential changes in management. BMJ. 1992; 305: 1187.

ORIGINAL ARTICLE

Radiation Exposure to Operating Theatre Personnel During Fluoroscopic-Assisted Orthopaedic Surgery

A M Radhi, MS(Orth)*, O Masbah, MS(Orth)*, M H Shukur, MS(Orth)*, Y Shahril, MS(Orth)*, K Taiman, PhD**

*Department of Orthopaedics and Traumatology, Faculty of Medicine, UKM, Kuala Lumpur, **Malaysian Institute of Nuclear Technology (MINT)

Summary

Orthopaedic procedures especially dynamic hip screw (DHS) fixation, interlocking nailing (ILN) of the tibia and femur require fluoroscopic assistance. Frequent exposure to radiation is a major concern to members of the orthopaedic surgical team. This study was undertaken to measure shallow (skin) dose to the operating team personnel and deep (whole body) dose to the surgeon during such procedures in view to provide guidelines to the operating team members regarding the number of procedures allowable for them to perform or assist annually. Skin dose for the operating personnel and whole body dose for the operating surgeon during 25 procedures; ten cases of DHS, seven and six cases of ILN of the tibia and femur respectively, was measured using Thermoluminescent Dosimeter (TLD) chips. The shallow radiation dose for theatre personnel ranged from 0.19 mSy to 0.61 per case while the deep dose for the surgeon was 0.28, 0.55 and 0.81 mSy for seven cases of tibial ILN, ten cases of DHS and six cases of femur ILN respectively. The surgeon has the highest radiation exposure than other theatre personnel and the whole body exposure for DHS was higher than that of for ILN. However, the estimated cumulative dose was still far below the permissible annual dose limit.

Key Words: Radiation exposure, DHS, ILN

Introduction

Fluoroscopy has increasingly been used for a large number of orthopaedic operations. The intramedullary nailing of tibia (ILN-T) and femur (ILN-F), and dynamic hip screw (DHS) fixation are the common procedures requiring fluoroscopy and usually involve prolonged 'shooting' time. However, frequent use of fluoroscopy prompts concern about radiation exposure to members of the orthopaedic surgical team. The objectives of this study are to measure shallow (skin) dose to operating theatre personnel and deep (whole body) dose to surgeons during ILN-T, ILN-F and DHS, and to estimate cumulative skin dose to operating theatre personnel over one year and to estimate cumulative deep dose received by the surgeons over one year.

Materials and Methods

The study was conducted in HUKM trauma operating theatre for a period of four months from 22 October 2004 till 15 February 2005. In total, 25 procedures (ten cases for DHS, seven cases for ILN tibia and six cases for ILN femur) were examined for skin dose for operating theatre personnel and deep dose for the operating surgeon using Thermoluminescent Dosimeters (TLD) badges.

Results

All the thermoluminescent dosimeters showed positive result for radiation exposure. The shallow (skin) radiation dose per case detected was in the range of 0.19 mSv – 0.61 mSv.

The deep (whole body) dose for the surgeon was 0.28, 0.55 and 0.81 mSv for seven cases of ILN Tibia, ten cases of DHS and six cases of ILN Femur, respectively.

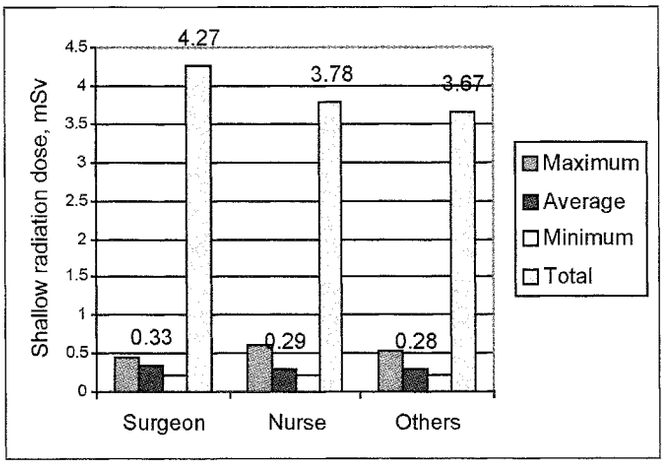


Fig. 1: Maximum, minimum, average and total shallow radiation dose received by personnel during DHS

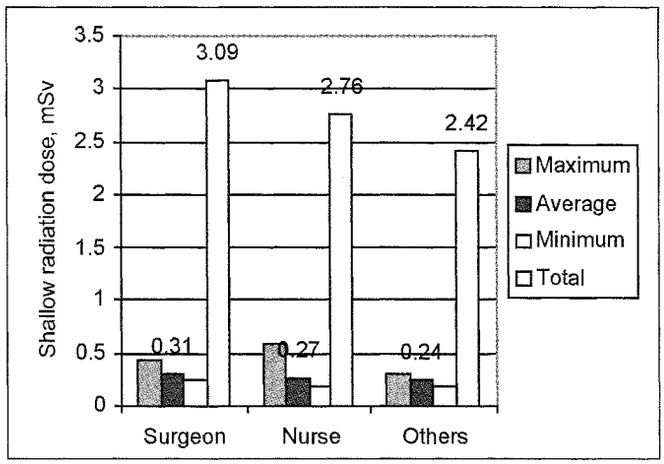


Fig. 2: Maximum, minimum, average and total shallow radiation dose exposed to the personnel during ILN procedures

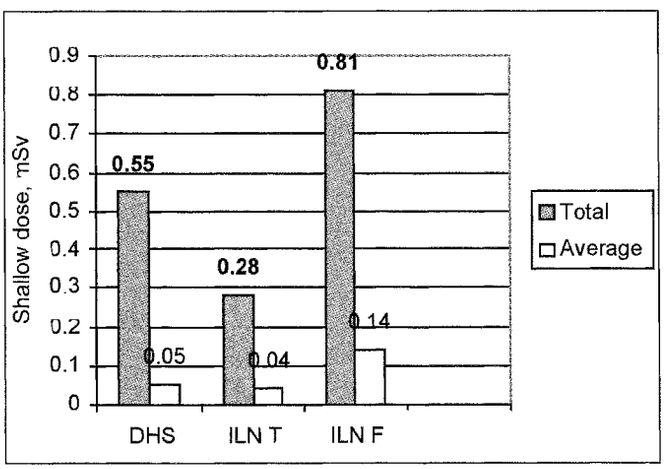


Fig. 3: Deep radiation dose during DHS, ILN T and ILN F procedures

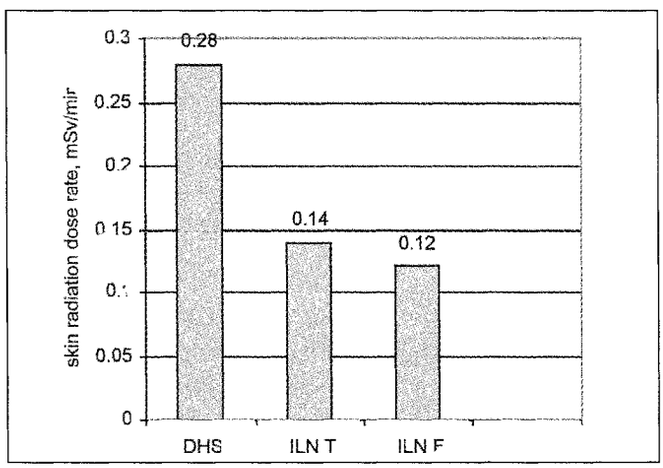


Fig. 4: Skin radiation dose rate per minute for DHS, ILN T and ILN F

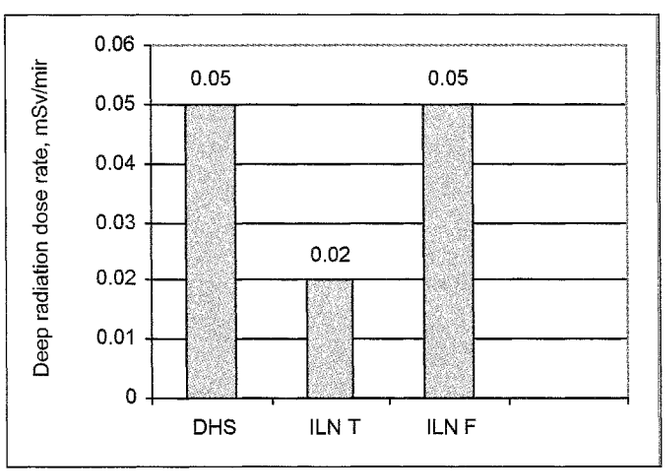


Fig. 5: Deep radiation dose rate per minute for DHS, ILN T and ILN F

Discussion

The amount of radiation exposure during a number of orthopaedic surgical procedures remains a matter of concern. With an increase in the number of procedures particularly as interlocking nailing of the tibia and femur, and dynamic hip screw fixation, such concern seems to be justifiable. Our study showed that during ten DHS procedures, the operating surgeon received the most total shallow radiation dose followed by the nurse and other personnel in the operating theatre. On average the surgeon received 0.34 mSv, the nurse 0.27 mSv and the others 0.24 mSv per DHS procedure (Fig. 1). A similar pattern was observed during 13 ILN procedures (Fig. 2); on average the surgeon received 0.33 mSv, the nurse 0.29 mSv and the others 0.28 mSv per ILN procedure. These results are to be expected as in most of the procedures the surgeon is the one who is in most close proximity to the radiation beam as well as subsequent scattered radiation.

The maximum reading recorded for skin dose in both ILN and DHS was 0.61 mSv. If the surgeon does 20 cases of DHS or ILN per year, he/she will receive a shallow radiation dose (skin/ hands) of about 12.2 mSv per year. This is well below the maximum permissible annual dose limit of 500 mSv.

From Fig. 3, it can be seen that deep radiation dose was detected most during ILN femur procedure followed by DHS and ILN tibia. The average deep radiation dose per procedure for ILN femur is 0.14 mSv, DHS is 0.05 mSv and ILN tibia is 0.04 mSv. The amount of radiation exposure is related to the duration needed for manipulative reduction. Creation of entry point, insertion of sliding screw and locking screws. For femoral shaft fractures, creation of nail entry point and manipulative reduction are time consuming depending on the skill of the operating surgeon. This explains the highest radiation dose for ILN femur which is three times more than that of tibial ILN and DHS fixation. If the surgeon performs 30 ILN femur procedures in a year; the total accumulative whole body deep radiation dose is only 4.2 mSv. This value is well below the annual permissible dose limit of 50 mSv.

As seen in Figures 4 and 5, the dose rate for superficial and deep radiation was highest in DHS as backscattered radiation was higher in the hip and femur because of the larger surrounding muscle mass compared to the tibia.

Conclusion

During all three procedures, all operating personnel were exposed to variable small degrees of radiation dose. The surgeon received the highest skin dose compared to other personnel. The whole body dose rate for DHS was the highest compared to ILN-T and ILN-F. The estimated cumulative dose for skin and whole body was still well below the maximum permissible annual dose limit. With proper regulation protection on radiation exposure and adherence to safety principles during fluoroscopy, the above results of skin and deep dose radiation to operating theatre personnel can be minimized. Application of computer-assisted navigation technique will be useful to exactly locate entry point for ILN, locking screw and sliding screw within the minimal period of time, thus minimizing the exposure time to radiation.

References

1. C T Mehlman, T G DiPasquale. Radiation Exposure to the Orthopaedic Surgical Team During Fluoroscopy: How Far Away Is Far Enough? J Orthop Trauma. 1997; 11(6): 392-8.
2. National Council on Radiation Protection and Measurements. Limitation of exposure to ionizing radiation: recommendations of the National Council on Radiation Protection and Measurements. NCRP Report. 1993; 116. Bethesda, MD: NCRP.
3. N Theocharopoulos. Ocupational exposure from common fluoroscopic projections used in Orthopaedic surgery. J Bone Joint Surg. 2003; 85-A(9): 1698-703.

ORIGINAL ARTICLE

Delay in Treatment of Primary Malignant and Aggressive Musculoskeletal Tumours

K L Pan, FRCS, A Zolqarnain, MMed (Orth), Y Y Chia, RN***

*Department of Orthopaedics, Universiti Malaysia Sarawak, ** Sarawak General Hospital, Kuching, Sarawak, Malaysia

Summary

Patients with aggressive musculoskeletal tumours often arrive at specialised treatment centres late. Such a delay could mean disfavour for potentially curable or long-term disease-free outcome of limb preserving surgery. This study was undertaken to identify the underlying problem-related delay with a view to propose solution for solving it. We reviewed 30 patients to determine the periods of delay between onset of the first symptom and the definitive treatment. The delays were categorized as 'patient' delay, 'referral' delay and 'treatment' delay. There was 'patient' delay in 57% of patients (n=17), ranging from 1 to 18 months; 'referral' delay in 67% of patients (n=20) ranging from 1 to 19 months and 23% of patients (n=7) had treatment delay (average 23 days) at the treatment centre. The causes of late arrival are not solely patient-related but are multifactorial. Measures to minimize such delays include enhancing awareness only with high index of suspicion among primary care practitioners, creating a special lane for specialized imaging studies and establishing a dedicated musculoskeletal tumour unit.

Key Words: Aggressive musculoskeletal tumours, Delay in treatment

Introduction

Primary malignant and aggressive musculoskeletal tumours are not common. Patients often present late when the tumour is in an advanced stage. Primary care practitioners often do not see the significance of signs and symptoms pointing to malignant tumours and delay referral for specialised treatment. Even at specialised treatment centres, the need for various imaging studies and expert histological diagnosis causes more loss of time. Delays in treatment can mean the difference between limb salvage surgery for potentially curative therapy and limb ablation surgery aiming for palliative therapy. The aim of this paper is to present a series of patients to elucidate the causes of this delay.

Materials and Methods

A review of 30 patients admitted to our hospital between January 2000 and February 2005 with malignant and aggressive musculoskeletal tumours was undertaken. Only primary tumours were considered. Metastatic bone disease was excluded.

The median age of the study population at the time of admission was 28.5 years with a range from nine months to 84 years. The sex incidence was 14 males and 16 females. All the patients were interviewed meticulously on admission by one of the authors (Y.Y.C) who is a staff nurse specialising in the care of patients with musculoskeletal tumours. In order to obtain a detailed and accurate history, an average of one and a half hours was spent with each of the patients. The dates obtained were: a) Onset of first symptom; b) First visit to a doctor (usually a general practitioner or medical officer in a hospital); c) First consultation with an orthopaedic tumour specialist (two of the authors) and d) Definitive surgery or commencement of neo-adjuvant chemotherapy for malignant bone tumours. The number of separate visits to a medical doctor before consultation with a tumour

specialist was also noted. This could mean the same or a different doctor. Visits to radiological clinics, medical assistants in rural hospitals or traditional practitioners were not included. The histological type and site of occurrence of the tumours are as presented in Table I.

Definitions

Patient delay is defined as longer than one month from the first symptom to the first doctor visit . Referral delay is defined as longer than one month from the first doctor visit to the first consultation with a tumour specialist. Treatment centre delay is defined as longer than one month from the first consultation with a tumour specialist at our hospital to the definitive treatment. This meant the definitive excision or start of definitive neo-adjuvant chemotherapy.

Results

Thirty patients were studied. There were 14 males and 16 females with a median age of 28 years.

Patient delay - It took a median time of four months, ranging from one to 18 months for a patient to visit a qualified medical doctor after the onset of the first symptom. Seventeen (57%) of the patients were delayed (taking more than 1 month).

Referral delay - There was a delay in referral for 20 patients (67%). The median time of delay was also four months, ranging from one to 19 months. On the average, a patient had 3.4 separate visits to a medical doctor before being referred to a tumour specialist.

Treatment centre delay - After being seen by a tumour specialist, seven (23%) patients took more than a month before definitive treatment was given. The median time was 23 days, ranging from eight to 84 days.

The median total time it took for definitive treatment to be given from the discovery of the first symptom was nine months, ranging from one to 37 months.

Discussion

It is the general feeling and experience of many orthopaedic surgeons in Malaysia that patients with aggressive musculoskeletal tumours often come late for treatment. We often see patients with huge, advanced tumours, which are amenable only to palliative treatment. The blame often falls on the patients for delaying the first consultation with a recognised medical practitioner. However, the result of this study shows that the problem can be multifactorial.

Fifty-seven percent of the patients took more than four months before seeing a doctor. This could be due to ignorance or hope that the symptom would recede spontaneously. Some would have sought traditional treatment while a few may not have access to a doctor until the symptoms became too pressing to ignore.

A higher percentage, 67%, was delayed due to late referral for definitive treatment. Repeated visits to doctors were often made. In most cases, a serious diagnosis was not suspected in the first place. This common error is also reported in the literature, that is, failure to recognise symptoms and signs as suspicious of malignancy even when patients presented more than once with worsening pain or with a mass that was increasing in size[2]. Many patients stated that they were given "pain-killers" and told to return if the symptom did not subside. Some were told to "wait and see" and a follow-up date given. Others were prescribed antibiotics. A few had aspirations or incision and drainage done. Not all were immediately suspected of having a sinister problem when no pus was obtained. It should be acknowledged that aggressive musculoskeletal tumours are rare and symptoms such as pain are much more commonly due to other causes[3]. Specialised treatment centres are often far away and a referring doctor would baulk at making a mistake that would engender unnecessary hardship and anxiety for the patient.

Delays at the treatment centre were due to the waiting period for imaging studies, biopsy and histological reporting. In two patients, we had to source for financial assistance to purchase the prosthesis required. These two patients refused other methods of limb-salvage surgery, which could have been done without delay.

It remains our hope that patients will come early. This would allow satisfying limb salvage surgery with good oncological margins and stable reconstructions with reduced morbidity[4]. Patient delay can probably be reduced by health education and awareness programmes, which may not be cost effective, given the rarity of aggressive musculoskeletal tumours. A more focussed approach could be directed at primary care practitioners, with constant reminders of the need for a good history and physical examination.

Table I: Summary of Cases Indicating Type of Tumour and Duration Prior to Referral and Treatment

Patient	Age	Sex	Diagnosis	Site	DURATION				
					Onset to 1st visit. (months)	1st visit to Tumour Specialist (months)	Specialis Consult to Rx(days)	Onset to Rx (months)	'N' visits before referral Specialist
1.	35	F	ES-OS	forearm	4	2	20	6.5	4
2.	33	F	FS	leg	0	0.5	10	1	4
3.	25	M	FS	thigh	3	0	33	4	1
4.	52	F	LS	arm	0	11	42	12	2
5.	45	M	FS	thigh	8	3	17	11.5	4
6.	84	M	MFH	thigh	9	0.5	12	10	3
7.	58	M	MFH	forearm	1	4	28	6	2
8.	24	F	HGS	thigh	0	2	32	3	5
9.	9 M	F	PNET	gluteal	1	2	39	4	6
10.	44	F	FS	thigh	18	19	15	37	4
11.	15	M	SS	popliteal fossa	17	10	12	27	5
12.	45	M	SS	elbow	13	1	24	15	2
13.	15	M	OS	distal femur	0.5	1	30	12	2
14.	21	M	OS	proximal tibia	0	2	20	3	4
15.	12	F	OS	distal femur	12	1	9	13	4
16.	14	M	OS	Prox fibula	1	5	11	6	2
17.	12	M	OS	proximal tibia	2	0	16	2.5	2
18.	14	F	OS	distal femur	0	0.5	9	1	2
19.	14	F	OS	distal femur	0	1	46	2	4
20.	27	M	FS	Prox humerus	5	2	10	8	3
21.	28	F	GCT	scapula	4	1	23	7	2
22.	26	F	GCT	proximal tibia	2	10	31	13	2
23.	25	M	GCT	distal radius	6	3	16	9	4
24.	35	M	GCT	proximal tibia	5	3	19	8.5	3
25.	31	M	GCT	proximal tibia	0	9	24	13	7
26.	32	F	GCT	proximal tibia	0.5	3.5	30	6.5	5
27.	26	F	GCT	distal femur	1	3	22	4.5	2
28.	26	F	GCT	proximal tibia	4	7	84	12	3
29.	25	F	GCT	distal femur	3	6	8	4.5	3
30.	7	F	GCT	tibia	0.5	6	8	6.5	5

OS=Osteosarcoma, FS=Fibrosarcoma, LS=Liposarcoma, SS=Synovial Sarcoma, MFH=Malignant Fibrous Histiocytoma, GCT=Giant Cell Tumour, PNET=Peripheral Neuroectodermal Tumour, HGS=High Grade Sarcoma, ES=Extraskeletal

Unexplained pain around the knee joint in teens and young adults that does not subside and progressive swellings that are deep seated and proximally situated should alert an attending doctor to consider something that may be sinister. Minimising delays at treatment centres would require substantial finances to upgrade and increase imaging and histopathological tools as well as medical expertise. Creating a special lane rather than jumping queue for specialized imaging studies for staging purposes may help to shorten waiting period for such imaging studies and tissue biopsy for confirming the diagnosis. Pathology service dedicated to musculoskeletal oncology which may include frozen section facility is an important component of the multidisciplinary team in the of musculoskeletal tumour unit.

References

1. Brouns F, Stas M, De Wever I. Delay in diagnosis of soft tissue sarcomas. Eur J Surg Oncol. 2003; 29(5): 440-5.
2. Clark MA, Thomas JM. Delay in referral to a specialist soft tissue sarcoma unit. Eur J Surg Oncol. 2005; 31(4): 443-8.
3. Muscolo L, Ayerza MA, Makino A, et al. Tumors about the knee misdiagnosed as athletic injuries. J Bone Joint Surg. 2003; 85-A: 1209-14.
4. Ashwood N, Witt JD, Hallam PJ, et al. Analysis of the referral patterns to a supraregional bone and soft tissue tumour service. Ann Royal Coll Surg Engl. 2003; 85(4): 272-6.

ORIGINAL ARTICLE

Forequarter Amputation of the Upper Extremity for Musculoskeletal Tumors: Posterior Approach Revisited

W I Faisham, MMed (Orth), W Zulmi, MS (Orth), M Z Nor Azman, MMed (Orth), M Z Rhendra Hardy, MMed (Anaest)

Musculoskeletal Oncology Unit, School of Medical Science Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia

Summary

Forequarter amputation entails surgical removal of entire upper extremity, scapula and clavicle. Several techniques of forequarter amputation have been described. The anterior approach has been the preferred technique of exploration of axillary vessels and brachial plexus. The posterior approach has been condemned to be unreliable and dangerous for most large tumor of the scapula and suprascapular area. We describe a surgical technique using posterior approach of exploration of major vessels for forequarter amputation of upper extremity in eight patients who presented with humeral-scapular tumor. There were six patients with osteosarcoma: three with tumor recurrent and three chemotherapy recalcitrant tumors with vessels involvement. One patient had massive fungating squamous cell carcinoma and another had recurrent rhabdomyosarcoma. Four patients had fungating ulcer and six patients had multiple pulmonary metastases at the time of surgery. The mean estimated blood transfusion was 900ml (range 0-1600ml) and two patients did not require transfusion. The duration of surgery ranged 2.5-6.0 hours (mean 3.8 hours). Two patients with known pulmonary metastases required post-operative intensive care monitoring. The mean duration of survival was 5.8 months. The posterior approach of exploring major vessels for forequarter amputation of upper extremity with musculoskeletal tumor is safe and reliable.

Key Words: Musculoskeletal tumor, Forequarter amputation, Posterior approach

Introduction

Forequarter amputation entails surgical removal of entire upper extremity, scapula and clavicle. It was traditionally indicated for the treatment of high-grade sarcoma of the shoulder girdle. However, as a result of advances in limb-sparing surgery, this procedure has infrequently been performed in only 5-10% of patients with primary sarcomas[1].

Several techniques of forequarter amputation have been described. Most surgeons preferred anterior approach for exploration of axillary vessels and brachial plexus[2,3]. The posterior approach has been condemned as unreliable and dangerous for most large tumors of the scapula and suprascapular area. The posterior approach was also difficult when large tumor has displaced the axillary and subclavian vessels and exploration of these neurovascular bundles can be extremely dangerous[2,3].

We describe a surgical technique of forequarter amputation using posterior approach for exploration of the major vessels. The advantages of this technique are discussed.

Materials and Methods

We present a series of eight patients who underwent forequarter amputation through posterior approach with exploration of major vessels. There were two

females and six males with average age of 27 years (range 17 – 44 years). The primary diseases were osteosarcoma in six patients, rhabdomyosarcoma and squamous cell carcinoma in one. The indications for amputation were recurrences in three cases, and vessels involvement in the remaining five patients. Four patients presented with fungating ulcers with active bleeding. Six patients had multiple pulmonary metastases and two required chest tube insertion for drainage of pleural effusion. Tumor extension to the thoracic wall was assessed by using magnetic resonance imaging (MRI) and was positive in one patient (Fig. 1).

Surgical Technique

The patient was placed in direct lateral position as major part of the surgery is performed posteriorly (Fig. 2). The upper extremity was covered with a sterile stocking so that it can be manipulated as the procedure evolved (Fig. 3).

The posterior approach was started by creating posterior skin flap medially. The exposure was preceded by detaching the scapula from trapezius, rhomboids, levator scapulae and latissimus dorsi muscles (Fig. 4). The scapula was then lifted from the chest wall with the subscapular muscle by detaching the latissimus dorsi at its lowest point.

The limb was swung anteriorly to improve exposure of the axillary fossa (Fig. 5). The brachial plexus and clavicle acted as pivotal point to protect the vessels from being avulsed. Both subclavian artery and vein were ligated 1cm from the chest wall before sectioning all the plexus and osteotomising the clavicle. The subclavian artery and axillary contents were included in the surgical tumor margins.

The anterior approach was utilized mainly to create a skin flap and to detach both the pectoralis major and minor from their origin. The proximal attachments of pectoralis major and minor at the clavicle were removed in toto for a better surgical margin.

Results

The average operative time was 3.8 hours (range between 2.5 – 6 hours). Five patients required blood transfusion and the mean volume of blood transfused was 900ml. Two patients required post-operative intensive care monitoring for massive blood loss. Surgical margins including node were wide in six patients and marginal in another two.

At the time of review, seven patients still survived with a mean survival of 5.8 months. Two patients had succumbed to the disease at five months and six months post-operatively. Patient with radioresistant squamous cell carcinoma developed recurrence and died after six months.

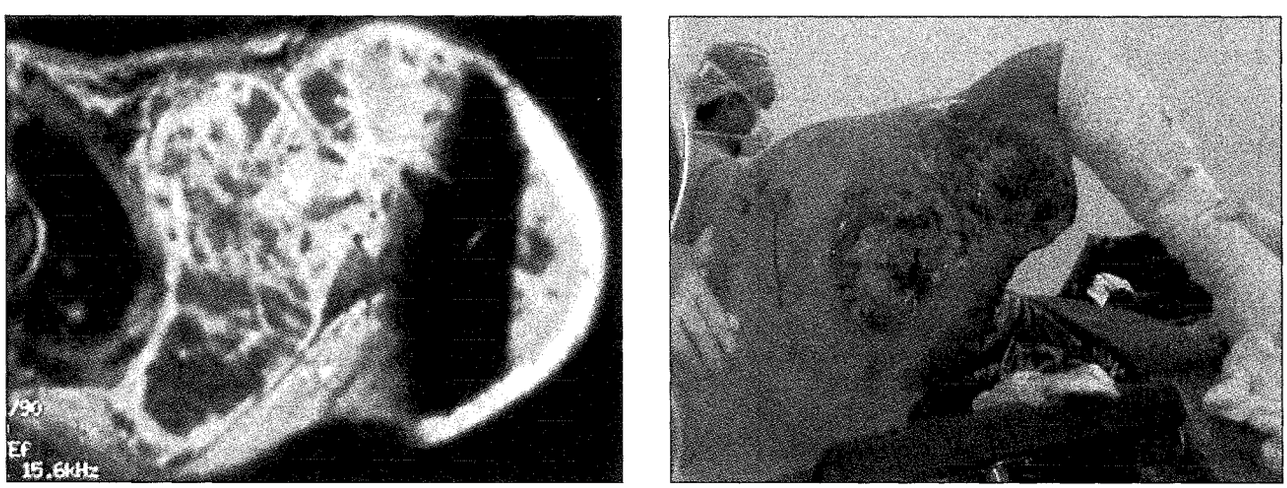


Fig. 1: MRI is mandatory to assess tumor extension to the thoracic wall.

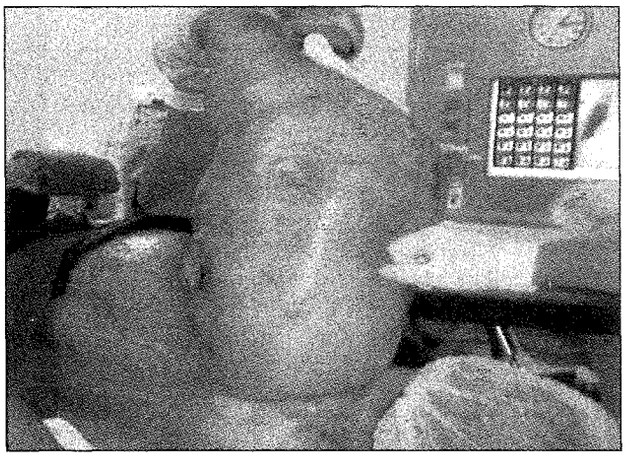


Fig. 2a: Showing ulcerating tumor on the anterior aspect of the upper arm; 2b -posterior view with the patient placed in lateral position.

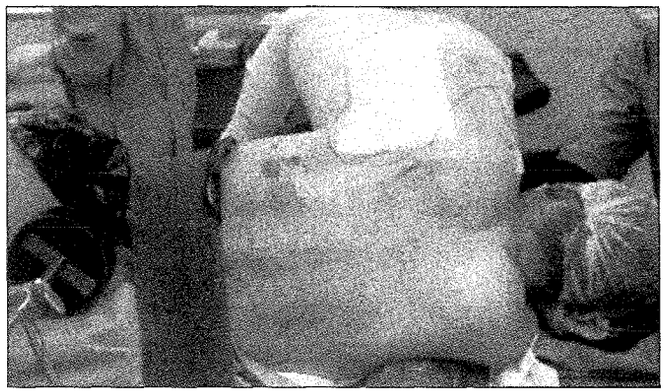


Fig. 3: The upper extremity was draped with surgical plastic drape to close the ulcerated growth.

Fig. 4: The posterior flap was raised and the periscapular muscles and levator scapulae were detached from the lateral border of the scapula.

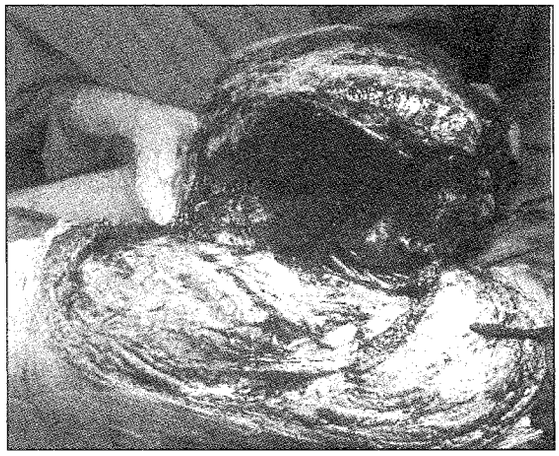


Fig. 5: The subclavian neurovascular bundle was exposed through the posterior approach.

Discussion

Forequarter amputation is surgical removal of the entire upper extremity, scapula and clavicle. It was traditionally used for treatment of high-grade bone sarcoma of the shoulder girdle, particularly osteosarcoma of the proximal humerus and scapula. Advances in limb sparing surgery limits forequarter amputation performed only for extremely large tumor arising from proximal humerus and scapula[1]. These lesions are usually associated with pathological fracture, recurrence, ulceration, infection and brachial plexus involvement.

The upper extremity and scapula are attached to the upper torso and chest wall by trapezius, rhomboid, levator scapulae, pectoralis major and minor, latissimus dorsi, teres major and serratus anterior muscle. Subscapularis muscle provides a good muscle border for defining the anatomical margin of tumor extension and the thoracic plane is occasionally involved in large tumor. Furthermore, exploration of the vessels through the posterior approach can be done at the apex of the axilla together with complete nodal dissection[4]. The argument that large tumor usually displaced the subclavian vessels and made it extremely dangerous when explored through posterior approach was

Table I: Summary of outcome following forequarter amputation in eight patients

No	Age	Sex	Diagnosis	Staging	Surgical duration (hours)	Blood transfusion	Ontological Outcome
1	44	M	Osteosarcoma	Multiple lung metastases	2.5	Nil	SWD 6 months
2	16	M	Recurrent Rhabdomyosarcoma	Multiple lung metastases	2.5	800ml	SWD 6 months
3	44	M	Osteosarcoma	Multiple lung metastases	4	1200ml	SWD 4 months
4	39	F	Recurrent Squamous cell carcinoma	Ribs involve	6	1300ml	DOD 6 months
5	20	M	Recurrent Osteosarcoma	Multiple lung metastases	3	Nil	SWD 3 months
6	18	M	Recurrent Osteosarcoma	Multiple Lung metastases	5.5	800ml	DOD 5 months
7	19	M	Osteosarcoma	Multiple lung metastases Pleural effusion	3.5	1600ml	SWD 10 months
8	17	M	Osteosarcoma	Nil	4	1500ml	SWD 6 months

disproved in all of our cases. The vessels can easily be explored via the posterior approach provided all structures attached to the scapulae were detached and the plane between the subscapular and thoracic wall was opened widely[4]. This was highlighted in all of our cases despite the presence of large tumor involving proximal humerus and scapula. The risk of avulsion of the vessels was minimised by the presence of brachial plexus and clavicle to protect the vessels during manipulation. Anterior release of the pectoralis major from its insertion also can reduce bleeding especially in large tumor resection. In the anterior approach, a segment of the middle of clavicle is removed, the subclavius muscle is divided and the subclavian vessels are dissected, ligated and divided. The dissection around the vessels can be very tedious as anatomical structures are crowded within a confined space and if inadvertent bleeding from the subclavian vein occurs, particularly from its posterior wall, it can be difficult to expose and control because these vessels may not be adequately mobilized[4].

Fungating malodorous tumors with intractable pain and bleeding are extremely disturbing manifestation of advanced sarcoma. Quality of life can be improved in at least two-third of these patients following forequarter amputation justifying the procedure as a palliative treatment option[5]. Premorbidly, some patients also have multiple lung metastases occasionally associated with malignant pleural effusion and pneumothorax. The high anesthetic risk is attributable to the presence of lung metastatic lesions, higher level of proximal vessels infiltration and malnutrition[6]. All these factors will contribute to prolonged operating time, massive blood loss and postoperative pneumonia. Postoperative pneumonia is more common in operation lasting more than four hours regardless of the site of operation[6]. On the other hand, with the described modified technique, the mean operating time is shortened and the amount of blood loss is reduced. These in turn, lessen the immediate postoperative morbidity in the subset of patients with high risk of anesthetic complications.

Conclusion

The described technique of vessels exploration through our modification of posterior approach for forequarter amputation is reliably safe as it shortened the operative time and blood loss is minimal.

References

1. Veth R, Hoesel RV, Pruszczynski M, Hoogenhout J. Limb salvage surgery in musculoskeletal oncology. Lancet Oncology 2003; 4: 343-50.
2. Sim FH, Pritchard DJ, Ivins JC. Forequarter amputation. Orthop. Clin. N. Am. 1977; 8: 921-31.
3. Bhagia SM, Elek EM, Grimer RJ. Forequarter amputation for high-grade malignant tumors of the shoulder girdle. J. Bone Joint Surg. 1997; 79: 924-6.
4. Ferrario T, Palmer P, Karakousis CP. Technique of interscapulothoracic (forequarter) amputation. Clin. Orthop. 2004; 423: 191-5.
5. Merinsky O, Kollender Y, Inbar M. Is forequarter amputation justified for palliation of intractable cancer symptoms? Oncology 2001; 60: 55-9.
6. Wong DH, Weber EC, Schell MJ. Factors associated with postoperative pulmonary complications in patients with severe chronic obstructive pulmonary disease. Anaesthesia Analgesia 1995; 80: 276-84.

ORIGINAL ARTICLE

A Simple Practical Protocol for Care of Metal-Skin Interface of External Fixation

A Saw, FRCS, C K Chan, MS(Orth), R Penafort, MS(Orth), S Sengupta, FRCS

Department of Orthopaedic Surgery, University Malaya Medical Center, Kuala Lumpur, Malaysia

Summary

Patients treated with external fixation for limb reconstruction or fracture stabilization require regular and prolonged period of pin-tract care involving frequent visits to clinic and dressing traditionally carried out by trained nurses or medical assistants. A simple method of do-it-yourself dressing was introduced in our institution and this study was undertaken to evaluate the effectiveness of the protocol. Sixty patients (40 trauma-related problems and 20 congenital or developmental disorders) were enrolled into the study. Following application of external fixation, the patients and/or their caretakers were taught on how to do pin-site dressing using normal saline or drinking water as cleansing solution on daily basis. Patients were discharged on the second or third post-operative day and were followed-up every two weeks for an average 182 days (range 66 to 379 days) with special attention on identifying pin-tract infection. A simple grading system for pin-tract infections was proposed. Of 40 patients with trauma-related problems, 65% were post-traumatic infections. There were 788 metal-skin interfaces (239 half-pin fixations and 549 tensioned wire fixations. A total 143 metal-skin interface infections (18.1%) involving half-pin sites (41.3%) and tensioned wire sites (58.7%) was noted. Majority were grade I infections (79.7%), 18.8% grade II and only 1.4% grade III. Most infections (81%) were caused by Staphylococcus aureus. Grade I infections were successfully treated with frequent dressing, grade II by adjunctive oral antibiotic but grade III infections required removal of fixator. All eventually healed. Do yourself non-sterile dressing of metal-skin interfaces is a cost-effective method of pin-site care with a low infection rate. The infections were sucessfully treated using guidelines according to the proposed classification of pin-tract infections.

Key Words: External fixation, Pin tract infection, Metal-skin interface

Introduction

For many decades, external fixation was mainly used for treating open fractures. With the introduction of Ilizarov ring fixator and principles of distraction osteogenesis, its use has been extended to include correction of bone and soft tissue deformities as well as management of complex non-union[1].

However, treatment with external fixation is associated with significant morbidities[2,3]. Infection of the contact area between pin or wire and skin is the most common problem. Incidence of metal-skin interface infection reported in literature varies from 8.5%[4] to 84%[5]. There are few publications examining the issues related to care of metal-skin interface. The main purpose of metal-skin interface dressing is to provide a protective barrier for the soft tissue tracts from the environment. It also helps to absorb exudation produced by the wound because this can serve as culture medium for infective organism. These functions are especially important during the initial post-operative period when the wound is raw with more exudation or bleeding. Optimum care of metal-skin interface for external fixation is yet to be defined. Frequency of dressing, type of solution, level of sterility and level of training for service providers remain controversial[6,7]. Some clinicians accept that patients with external fixator can be allowed to perform the care of metal-skin interface

if they were adequately trained[8,9]. However, in most institutions, this is performed by nurses or staffs with some medical training. Since some of these patients will require many months of fixation, cost of regular dressing in the clinics or health centers is substantial.

The limb lengthening and reconstruction surgery (LLRS) unit of our institution has developed a standard protocol for the care of metal-skin interface for the last few years. Based on available information in the literature, we developed a simple method of dressing that allowed patients or their relatives to do it in their home setting. This has significantly reduced the cost and time for patients and their caretakers. Considering the potential benefits especially to those treated with long-term external fixation, we decided to embark on a prospective study to evaluate this protocol.

Materials and Methods

Patients treated with external fixation under LLRS unit were prospectively recruited from 1st. June 2002 to 31st July 2003. They were being treated for various conditions, including complicated fractures and congenital or acquired deformities of the limbs. Bone fixations were attained by either rigid stainless steel half pins or smooth stainless steel wires under tension. Diameter of the half pins was 5mm and they were more commonly used for the fixation of the diaphyseal region. The stainless steel smooth wires were 1.8mm in diameter and they were mainly used to fix the metaphyseal bone. After surgery the patients or caretakers were taught how to take care of the wounds. A self dressing kit (Fig. 1) was provided together with printed instruction sheet.

After cleaning the hands, the patients prepare the gauze and dressing solution on a clean piece of cloth. Either normal saline available from the pharmacy or povidone iodine diluted with drinking water was used as the dressing solution. After wetting the gauze and laying them out, the old dressings were removed manually (Fig. 2a). No attempts were made to clean the skin, metal components or remove the adherent crusts. Subsequently with plastic forceps the prepared dressings were applied on to the interfaces (Fig. 2b).

Patients were usually discharged two to three days after surgery. They were advised to perform the dressing daily. They would return for follow up every two weeks and one of the authors will review them clinically. We based our findings on a pin tract infection scoring protocol developed by this unit (Table I). If there was increasing exudate or appearance of redness around the wound (corresponding to grade I infection), they were instructed to double the frequency of dressing. A course of oral Cloxacillin would be prescribed if there was any sign of grade II infection.

Results

Sixty patients were enrolled for this study over the period of 14 months. There were 24 Indian (40.0%), 23 Malay (38.3%), 3 Chinese (20.0%) and one Bangladeshi (1.7%). The mean age was 26.4 years, range from a one year old child treated with Ilizarov fixator for resistant club foot to a 76 year-old man treated also with Ilizarov frame for infected nonunion. Forty patients had trauma-related problems with 65% caused by post-traumatic infections. The remaining 20 patientss had either congenital or developmental pathologies. The mean period on the external frame was 181.90 days (ranges from 66 to 379 days).

There were a total of 788 metal-skin interfaces. Two hundred and thirty nine were half pin fixations while 549 were tensioned wire fixations. A total of 143 interfaces were infected giving rise to a general metal-skin interface infection rate of 18.1% (Table II). Of all the infected interfaces, 114 ((79.7%) were grade I infection, 27 (18.9%) were grade II infections and two (1.4%) were grade III infections. Fifty-nine (41.3%) of the infected interfaces were of half pin fixation and 84 (58.7%) were of tensioned wire fixation. Thirteen of the 16 (81%) positive cultures from the grade II infected wounds grew *Staphylococcus aureus.*

Most cases with grade I infection responded to more frequent dressing using the same technique and solution. All but two of the grade II infections responded to a course of oral cloxacillin. The two cases eventually progressed to grade III infection and the fixators were subsequently removed. Both of them were half pins. Since both of them occurred at later stages of treatment with stable callus already formed, stability of the fracture was not affected.

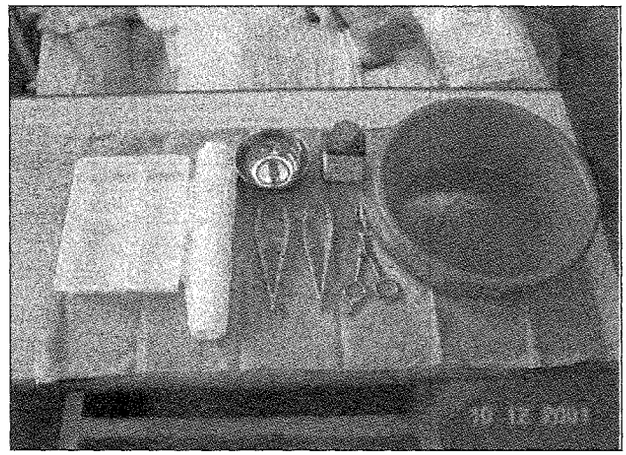


Fig. 1: Basic components of re-usable dressing set

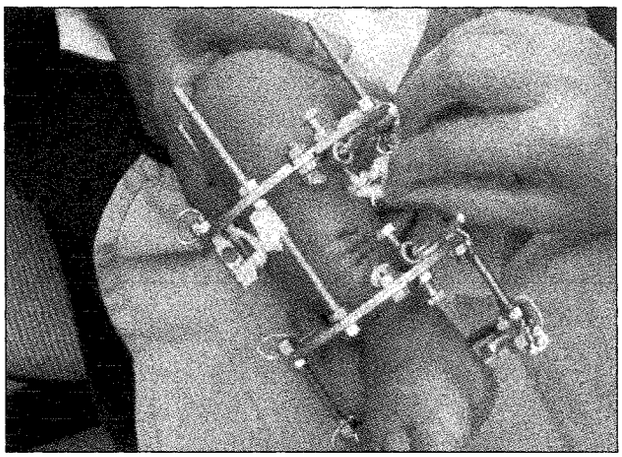


Fig. 2a: Manual removal of old dressings

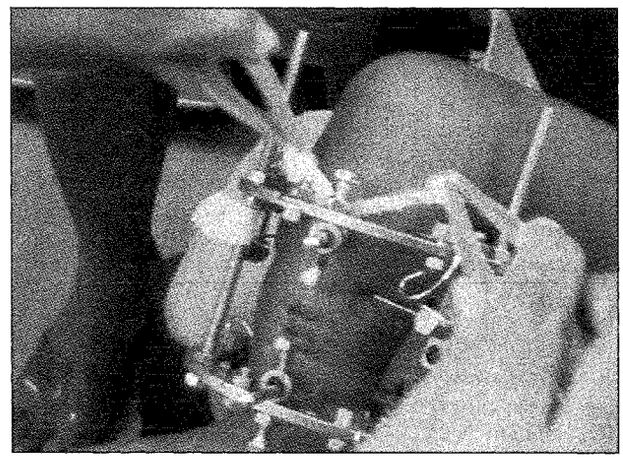


Fig. 2b: Application of new dressings with a pair of plastic forceps

Table I: Grading of Metal-Skin Interface Infections

Grading	Description
0	No skin erythema and no purulent discharge
1	Skin erythema only or purulent discharge only
2	Skin erythema and purulent discharge
3	Grade 2 findings with radiological evidence of osteomyelitis

Table II: Distribution of Metal-Skin Interface Infections

Metal-Skin Interface	Infection	% of Infection
Pin-skin interface n=239	59	24.7%
Wire-skin interface n=449	84	15.3%
Total=788	143	18.1%

Discussion

Overall infection rate of 18.1% for metal-skin interface is comparable to other studies. Aronson *et al* (1992) reported infection rate of 8.5% in the pin sites of 44 children treated with external fixation for femur fractures. On the other hand, Gordon (2000) reported infection rate of 84%. Routine administration of oral antibiotics in all patients for the whole duration of fixation resulted in an overal infection rate of 11.2%[10]. Available classifications for the evaluation of metal-skin interface infection were generally very complicated and relied on subjective observations[3,11]. In this study, our observations were clearly defined by a simple grading system that relied mainly on visual assessment (Table I). Some patients were able to relate the condition of the wounds between follow-ups based on these gradings.

Several dressing protocols were recommended in the nursing literature, but prospective evaluations were lacking[6,9]. Many clinicians do not recommend meticulous cleaning of the interface. Gordon *et al* encourage children undergoing external fixation procedures to take regular shower without other physical means of pin cleaning[5]. Physical handling of the tissue during the process may also interfere with the natural protective environment and introduce further contamination of the wound[12]. Appearance of blood-stained exudate on the cleaning gauze may also generate anxiety in some patients or their caretakers. Therefore, we discouraged any attempts to remove crust or exudates which remained on the wound. With regular dressing change, these substances will invariably be removed during the subsequent dressings. Sterile handling of the wound is generally considered unnecessary especially once the patients returned to their home environments[13,14]. In addition, cost of sterile gloves and disposable instruments can be eliminated.

The practical implication of this study is significant especially in developing countries where many patients are required to pay for their own medical treatment and their income and educational levels are low. With this simple and cost saving protocol, the patients were more likely to comply and perform the dressings regularly as instructed.

Conclusion

Do-it-yourself non-sterile dressing method for the metal-skin interface of external fixator is as affective as conventional care provided by trained medical personnel. With a new grading system for the metal-skin interface infection, wound assessment is made easier. This protocol allows patient participation in the management of their injury. It significantly reduces the overall cost of the treatment.

References

1. James JH. Reconstruction of bone and soft tissue loss in fractures of the tibia. Tech in Orthop. 2002; 17(1): 103-9.
2. Paley D. Problems, obstacles and complications of limb lengthening bythe Ilizarov technique. Clin Orthop.1990; 250: 81-104.
3. Dahl MT, Gulli B, Berg T.Complications of limb lengthening: A learning curve. Clin Orthop. 1994; 301: 10-8.
4. Aronson J, Tursky EA. External fixation of femoral fracture in children. J Pediatr Orthop.1992; 12(2): 157-63.
5. Gordon JE, Kelly-Hahn J, Schoenecker PL Carpenter CJ,Pin site care during external fixation in children: Results of a nihilistic approach. J Pediatr Orthop. 2000; 20(2): 163-5.
6. Ward P. Care of skeletal pins: A literature review. Nurs Stand. 1998; 12(39): 34-8.
7. Sproles KJ. Nursing care of skeletal pins: A closer look. Orthop Nurs. 1985; 4(1): 11-2.
8. Wallis S. An agenda to promote self-care. Nursing care of skeletal pin sites. Prof Nurs. 1991; 6(12): 715-6, 718-20.
9. Santy J. Nursing the patient with an external fixator. Nurs Stand. 2000; 14(31) 47-52.
10. Dushi P, Graig SR, David S, Micheal V.Pin tract infection with contemporary external fixation: How much a problem? J Orthop Trauma. 2003; 17(7): 501-7.
11. Checkets RG, Otterburn M. Pin tract Infection: Definition, prevention. incidence. Abstract The 2nd. Riva Congress. Riva di Garda, Italy. 1992; 98-9.
12. Trigueiro M. Pin site care protocol. Canadian Nurs. 1983; 79(8): 24-6.
13. Green SA. Complications of external fixation. Clin Orthop. 1983; 180: 109- 16.
14. McKenzie LL. In search of a standard for pin site care. Orthop Nurs. 1999; 180: 73-8.

ORIGINAL ARTICLE

Recalcitrant Post-traumatic Chronic Osteomyelitis/ Infected Non-union of the Tibia Following Open Grade-III Fractures: Treatment with Vascularized Osteocutaneous Fibular Graft

A S Halim, FCCP*, Y Imran, MMed(Orth)**

*Reconstructive Science Unit, Department of Surgery, **Department of Orthopaedics, School of Medical Science, Universiti Sains Malaysia, Kubang Kerian; Kelantan, Malaysia

Summary

Post-traumatic chronic osteomyelitis and infected non-unions of the tibia following severe type-III open fractures are difficult to treat Refractoy cases often necessitate amputation despite attempts to salvage the limb. We report our experience in treating such difficult cases with an alternative surgical option using free osteocutaneous fibular graft. Eight consecutive patients with post-traumatic chronic osteomyelitis/infected non-union were treated surgically with free vascularized osteocutaneous fibular graft. Outcomes in term of graft-host union and complication were evaluated. Four patients had anastomotic venous thrombosis requiring anastomotic revision. Five patients developed surgical site infections needing extended antibiotic therapy to achieve resolution at an average of 15.2 weeks. Fibular graft fracture occurred in three patients but all grafts survived and united after a mean time to union of 42.3 weeks (range 31 to 82 weeks). At the final follow-up, union of host-graft junction and control of infection were achieved in all patients except one who required a secondary amputation. Free vascularized osteo-cutaneous fibular graft is a viable limb salvage option for refractory chronic osteomyelitis or infected non-union following treatment of grade-III open tibial fractures.

Key Words: Chronic osteomyelitis, Infected non-union, Grade-III open tibial fracture, Vascularized fibular graft

Introduction

Open tibial fractures are common and in many occasions severe enough to end up with osteomyelitis and infected non-unions compounding severe soft tissue scarring. Problem of associated bone loss/defect may arise directly due to the injury or secondary to infection and repeated surgical debridement. The treatment of chronic osteomyelitis with infected non-union is difficult. Prolonged antibiotic therapy is usually inadequate as it only provides short-term suppression of infection and recurrent infection is to be expected. Resection of infected segment of bone and the surrounding scar tissues is essential and must be completed to ensure good control of infection. This typically requires an excision of more than 6cm of bone segment with osteomyelitis and the effect of this length of shortening is crippling. Bone defect reconstruction can be achieved by using conventional bone grafting techniques but it is unreliable when a bone gap of greater than 6cm is present[1]. Amputation is the easiest solution for the functionless and chronically discharging wound of an injured limb. However, it is not widely accepted. Vascularized osteocutaneous fibular graft is an available limb salvage option to solve

this problem. We report our experience in treating such difficult infections in the subset of patients who initially sustained grade-III open tibial fractures.

Materials and Methods

This retrospective study reviewed eight consecutive patients with post-traumatic chronic osteomyelitis treated with segmental resection of infection containing bone and soft tissue followed by reconstruction using vascularized osteocutaneou fibular graft at Hospital USM from 1998 to 2002. Inclusion criteria were who had refractory osteomyelitis or infected non-union despite prolonged treatment with antibiotics to adjunct multiple surgical debridement and stabilization procedure to achieve fracture union.

The procedure involved segmental resection of infected bone together with its overlying scarred soft tissue. Samples for culture and sensitivity were sent for microbiological examination. The defect was then reconstructed by using free oateocutaneous vascularized fibular graft taken from the contralateral leg. The fibula graft was fixed to the recipient site using cortical screw. Vascular anastomoses of the feeding artery and draining veins were performed in all patients. The wound was covered by the fasciocutaneous portion of the graft composite. Both resection and reconstruction procedures were done in one operating stage.

The viability of the fibula graft was monitored based on the skin paddle. Surgical site infection was clinically defined when there was pus discharge from the wound or any removal of skin sutures to allow drainage of pus from the deep site. Swab for culture and sensitivity would be taken to establish the microbiological diagnosis.

The patients were followed-up on regular basis in our outpatient clinic. Control of infection was monitored by using various parameters including the presence of wound discharge, erythrocyte sedimentation rate (ESR) level and serial plain radiographs. Graft-host union was assessed by serial plain radiographs. All patients were prohibited from full weight bearing until clinical and radiological evidence of union was established. This was followed by gradual conversion of partial to full weight bearing ambulation depending on the patient's tolerance. The total length of follow-up was at least one year for the evaluation of recurrent infection, union and other possible complications.

Surgical Technique

The procedures were performed simultaneously by two separate surgical teams. Resection of infected bone and scarred soft tissue as part of preparation of the recipient bed was performed by the orthopaedic team. The vascularized fibular graft was harvested by the plastic team. This was performed by using technique described by Weiland[1]. The skin paddle, length of fibula resection and localization of vascular pedicle were planned pre-operatively. The perforators to the skin paddle were identified by using the handheld Doppler. A skin incision was made from the level of fibular neck downwards to the required length and deepened to incise the fascia overlying the peroneus longus muscle.

The interval between the peroneus longus and soleus muscles was identified followed by deeper incision of the deep fascia along the muscle interval. The peroneus longus and soleus were separated extraperiosteally from the fibular diaphysis. The perforating vessels to the overlying skin were identified and preserved. The skin paddle was dissected as a graft composite devoid of muscle. The extensor digitorum longus, peroneus tertius and extensor hallucis longus were then dissected from the interosseous membrane. The anterior tibial artery and nerve were identified and protected.

The soleus and flexor hallucis muscles were then retracted from the posterior border of the fibula until the peroneal vessels encountered. Dissection was continued anteriorly and posteriorly along the whole length required. Proximal and distal ostetomy of the fibula was carried out by preserving the distal 6cm of the fibula to provide stability of the ankle.

The interosseous membrane was then divided along the entire length of the graft. The peroneal artery was traced proximally to its junction with the posterior tibial artery. The distal limb of the peroneal vessels was ligated at the site of the distal fibular osteotomy. The ligation was carried out after identification of both anterior and posterior tibial vessels. When the debridement and resection of the contralateral infected tibia was completed, the osteocutaneous fibular graft composite was transferred into the defect and fixed to the bony ends of the recipient tibia using a single cortical screw on each end. The tibia was then stabilized by using monolateral external fixateur. Microvascular anastomoses of the peroneal artery and veins to respective recipient vessels were performed followed by wound closure using fasciocutaneous

composite. Split skin graft was occasionally performed to cover the donor site in the event when primary closure was not feasible.

Results

Vascularized fibular grafting was carried out in eight patients who developed infected non-union following initial treatment of open grade-IIIB/C tibial fractures caused by road-traffic accident in seven cases and gun-shot injury in one patient. All had initial treatment in the form of multiple surgical debridement and prolonged antibiotic therapy. The bony defect following resection of infected bone segment ranged from 4cm to 16cm (average 10.6cm).

Graft-host Union and Complications

Graft-host union was achieved after an average of 42.3 weeks but the earliest union occurred at 31 weeks. Three patients had fracture of the graft: two occurred at 32 weeks and one at 60 weeks post-operation. Two fractures eventually united after conservative treatment but one ended up with secondary amputation.

Recurrent Osteomyelitis

All osteomyelitic lesions or infected tibia non-unions yielded positive pre-operative cultures of *Pseudomonas aeroginosa* and Methicillin Resistant *Staphylococcus aureus* (MRSA) isolated from four and two patients respectively. Five out of eight patients still had post-operative discharge from the operative wounds with three culture growth of similar organisms and two culture negative discharges. The infections took an average 15.2 weeks (range 6 to 24 weeks) to become discharge-free healed wounds.

Other Complications

Four out of eight patients developed anastomotic venous thrombosis requiring revision vascular surgery without further debridement of the wound. One patient on his own requested amputation at 21 months after failure to achieve union following fracture of the graft.

Table I: Summary of Eight Cases in the Present Series

Case	Age/Sex	Grading of Open Fracture	Tibial Defect	Pre-op Organism	Post-op Infection	Graft-Host Union	Complication and Outcome
1	22/M	IIIB	4cm	*Pseudomonas aeroginosa*	16 weeks *Pseudomonas aeroginosa*	38 weeks	
2	31/M	IIIB	16cm	MRSA	24 weeks No growth	32 weeks	Graft Fracture At 34 weeks. United
3	53/M	IIIB	9.5cm	*Staphylococcus aureus*	6 weeks No growth	33 weeks	Graft Fracture At 60 weeks. United4
4	40/M	IIIB	15cm	*Pseudomonas aeroginosa*	6 weeks *Pseudomonas aeroginosa*	30 weeks	Graft Fracture At 32 weeks. Malunited, BK Amputation
5	21/M	IIIB	12cm	MRSA	24 weeks MRSA	40 weeks	
6	28/M	IIIB	12cm	*Pseudomonas aeroginosa*		82 weeks	
7	38/M	IIIB	8cm	*Enterobacter sp*		41 weeks	
8	19/M	IIIC	8cm	*Pseudomonas aeroginosa*		32 weeks	

Discussion

Chronic post-traumatic osteomyelitis of the tibia remains a difficult entity to treat. Antibiotic therapy is of secondary importance to thorough debridement. Bone involvement is usually extensive and radical resection of segment of infected bone will eventually cause substantial bone defect. Reconstruction of the defect is necessary to preserve the length and vascularized fibula graft offers a good reconstruction option.

Reconstruction using an allograft is not recommended in the presence of infection as the risk of post-operative infection has been reported to be as high as 12%[3,4].

Distraction osteogenesis using Ilizarov technique is an alternative option but the problems associated with application of this technique are well described[5].

Vascularized fibular graft is superior to conventional bone grafting. Weiland et al. reported that it took three to five months for the bone to unite and full weight bearing was allowed after 15 months post-surgery[6]. Shaffer *et al.* had shown that both the strength and stiffness of the vascularized fibular grafts were found to be significantly greater from six weeks to six months post-operatively and throughout the reparative process[7]. Ability to weight bear fully at one year was observed in 75% of our patients.

Complete segmental resection of 4cm to 15cm allows adequate clearance of infected bone and its soft tissue envelope. The soft tissue envelope typically consists of scarred tissue inflicted by primary injury, infection and previous multiple surgery. In this series, all grafts were transferred as a composite osteocutaneous unit to replace defect created by resection of segment of infected bone and the surrounded scarred soft tissue. Most series did not include additional bone graft to enhance healing at the host-graft junction. Newington and Sykes reported that primary union without secondary grafting occurred within 5 months in 85% of their patients[8]. However, about 10%-20% of patients may require supplemental bone grafting to achieve union[6]. In our series, none of the patients required secondary bone grafting though the average rate of union was quite delayed.

Failure rate following the procedure was about 12.5% and mostly ended with secondary amputation[6]. The incidence of graft fracture has been reported to be as high as 25%[6,9-11] and about 25% of graft fractures occurred at an average time of 8 months[12]. Graft length did not influence the incidence of fracture[13]. In our series, graft fracture occurred in three (37.5%) patients with two of them occurring at an average 8 months after the surgery. The fracture eventually united after adequate protection in two patients. In one patient (12.5%) the fracture united in a severely angulated position and shortening leaving no other option than secondary amputation.

The incidence of infection and non-union was about 10%[10]. Minami *et al* reported a re-infection rate of 8.7% in a series of 23 patients with osteomyelitis[11]. In our series, five patients developed surgical site infections. All resolved after adequate antibiotic treatment and there was no reactivation of infection after an average follow-up of one year. Three patients were completely free of infection.

The use of vascularized iliac crest graft has been reported to give a more favourable result compared to that of fibular graft provided the defect is less than 10cm[14]. In the present series, vascularized fibular grafts gave satisfactory results in all patients with bone defect between 4cm and 15cm. Liberal use of vascularized skin paddle allowed complete resection of the overlying scar tissue. Therefore there is a complete vascularized seal of the transferred bone and graft tissue interface. The skin paddle acts as a useful indicator of the perfusion of the fibular graft hence the viability of the fibula. It also serves as an important vascularized cover for the graft. This allows coverage of the surgical wound without excessive tension, thus improving wound healing. Osteocutaneous fibular graft offers many advantages and gives consistent favourable outcome[15]. The overall success rate is more than 80%, and 67% of patients had good functional results[10]. In our series, the procedure has resulted in good control of infection and union in all graft-host junctions.

Conclusion

Free vascularized osteocutaneous fibular graft offers a good alternative for the treatment of infected non-union or chronic osteomyelitis of the tibia following severe open fracture. The segment of infected bone can be excised adequately and the defect created by resection is reconstructable by using fibular graft. This is a viable option to prevent primary amputation in the setting of severe grade-III open tibial fractures. In most cases, good control of infection and fracture union were achieved. Graft failure and secondary amputation remain possible late consequences.

References

1. Weiland AJ. Vascularized free bone transplants. J Bone Joint Surg. 1981; 63-A: 166-9.
2. Gustillo RB, Anderson JT. Prevention of infection in the treatment of 1025 open fractures of long bones. J Bone Joint Surg. 1976; 58-A: 453-8.
3. Lord CF, Gebhardt MC, Tomford WW, Mankin HJ. Infection in bone allografts. Incidence, nature and treatment. J Bone Joint Surg. 1988; 70-A: 369-76.
4. Mankin HJ, Doppelt S, Tomfort WW. Clinical experience with allograft implantation. Clin Orthop. 1983, 174: 69-86.
5. Velazquez RJ, Bell DF, Armstrong PF et al. Complications of use of the Ilizarov technique in the correction of limb deformities in children. J Bone Joint Surg. 1993: 75-A: 1148-56.
6. Weiland AJ, Moore JR, Daniel K. Vascularized bone autografts. Experience with 41 cases. Clin Orthop. 1983; 174: 87-95.
7. Shafer JW, Field JA, Goldberg VM, Davy DT. Fate of vascularized and non-vascularized autografts. Clin Orthop. 1985; 197: 32-43.
8. Newington DP, Sykes PJ. The versatility of the free fibular flap in the management of traumatic long bone defects. Injury; 1991; 22: 275-81.
9. Harrison DH. The osteocutaneous free fibular graft. J Bone Joint Surg. 1986; 68-B: 804-7.
10. Hsu RWW, Wood MB, Sim FH, Chao EYS. Free vascularized fibular grafting for reconstruction after tumor resection. J Bone Joint Surg., 1997; 79-B: 36-42.
11. Minami A, Kasashima T, Iwasaki N et al. Vascularized fibular grafts. J Bone Joint Surg. 2000; 82-B: 1022-5.
12. De Boer HH, Wood MB. Bone changes in the vascularized fibular graft. J Bone Joint Surg. 1989; 71-B: 374-8.
13. Wood MB. Free vascularized bone transfer for non-unions, segemental gaps and following tumor resection. Orthopaedics. 1986; 9: 810-6.
14. Hiener R, Wood MB. Comparison of vascularized iliac crest and vascularized fibula transfer for reconstruction of segmental and partial bone defects in long bones of the lower extremity Microsurgery. 1995; 16: 818-26.
15. Pande S, Kohli JS, Arora S, Bajaj P. The Osseofasciocutaneous flap: A new method of transfer fibula along with sufficient amount of skin. Br J Plast Surg. 2002; 55: 312-9.

ORIGINAL ARTICLE

Slipped Capital Femoral Epiphysis (SCFE): A 12-year Review

M A Kamarulzaman, MS(Orth)*, A R Abdul Halim, MS (Orth), S Ibrahim, FRCS****

*Department of Orthopaedics, Batu Pahat Hospital, Johor, **Department of Orthopaedics and Traumatology, Hospital Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia

Summary

Slipped capital femoral epiphysis (SCFE) is a relatively uncommon hip disorder in adolescents and its prevalence in Malaysia has not been studied. This retrospective study is undertaken to provide an overview of a 12-year review of SCFE treated in our institution. Fourteen patients (19 hips) with slipped capital femoral epiphysis (SCFE) admitted to Hospital UKM from 1990 to 2002 were reviewed with respect to demographic profile, functional outcome according to the Iowa Hip Score, and complications. There were ten boys (average age, 12.5 years) and four girls (average age, 12 years). Eight were Malays and six were Indians. The average body mass index was 26.1 (overweight). The left hips (11 hips) were affected more than the right hips (eight hips). Five patients had bilateral slips. Thirteen hips were considered stable while the other six hips were unstable. The majority of cases were moderate slips (12 hips), four hips had severe slips while three hips had mild slips. Several methods of treatment were instituted. These include in situ cannulated screw fixation (11 hips), Knowles pin fixation (three hips) and gentle closed manipulative reduction with cannulated screw fixation (three hips). One patient with bilateral slips refused surgical treatment. Based on the Iowa Hip Score, most patients (nine) had satisfactory results (excellent or good), three had fair results while one patient had a poor result. Avascular necrosis developed in five hips while chondrolysis occurred in one hip. In situ cannulated screw fixation is the treatment of choice. SCFE is an uncommon condition in Malaysia.

Key Words: Capital femur epiphysis, Hip, Children

Introduction

Slipped capital femoral epiphysis (SCFE) is an adolescent disorder characterized by displacement of the capital femoral epiphysis from the metaphysis through the physis. Its aetiology remains unclear though a complex interplay between vulnerable 'sick' physis and mechanical stress, endocrine and metabolic factors has been postulated.

An international multicentre study[1] in 1996 showed that most of the cases reported in Asia were from Japan. In other parts of Asia, less than 10 cases were reported from a single institution each in Taiwan, Thailand, India and Pakistan[1].

The purpose of this study is to review the outcome of patients with SCFE admitted to our institution in Kuala Lumpur, Malaysia.

Materials and Methods

Between 1990 and 2002, 20 patients were treated for SCFE in the Department of Orthopaedics and Traumatology, Universiti Kebangsaan Malaysia. They were admitted to the Kuala Lumpur Hospital from 1990 to 1996 and Hospital Universiti Kebangsaan Malaysia from 1997 to 2002.

Six patients were excluded from the study because they could not be contacted. Fourteen patients were

available for review. The case notes and radiographs for each patient were obtained and reviewed. All 14 patients were called for review but only ten returned for follow-up. These patients had a detailed history, physical and radiographic examination. The four patients who were not able to return for follow-up were interviewed via telephone or through a mailed questionnaire. The Iowa Hip Score was determined in each patient, based on function, deformity, gait, pain and range of motion. An excellent rating is considered to be 90 to 100 points; good, 80-89 points; fair, 70 to 79 points; and poor, less than 70 points. The rating was determined by personal examination or from the records of the most recent clinical visit and from a completed clinical questionnaire. Radiographic examination was obtained from the most recent follow-up records.

The medical records of all patients were reviewed to obtain data on gender, hip affected, age at the onset of symptoms, any endocrine disorder, type and duration of symptoms, stability (based on the symptoms), treatment and complications. The height and weight of the patients during the presentation were noted and body mass index (BMI) were calculated for each patient (less than 18.5 is underweight, 18.5-24.9 is normal, 25- 29.9 is overweight and over 30 is obese). The complications that occurred were identified.

The slip was classified as unstable if the child had severe pain preventing walking even with crutches[2]. A slip was stable when walking and weight bearing was possible, with or without crutches[2].

According to the duration of symptoms[3], the hips were classified as chronic (having symptoms > 3 weeks), acute (having symptoms for < 3 weeks) and acute-on-chronic (having exacerbation of chronic symptoms).

The severity of the slip[4] was graded on the basis of the difference in the head-shaft angle between both sides, as seen on the true lateral or anteroposterior radiograph. The slip was considered mild if the measured difference was less than 30 degrees, moderate if the difference was between 30 and 50 degrees, and severe if difference was more than 50 degrees. The joint space was measured to determine if there was any narrowing, which indicates the presence of chondrolysis. Chondrolysis is defined as a decrease in the apparent joint space of more than 2mm from that of the contra-lateral hip. In the case of bilateral narrowing after bilateral slip, chondrolysis was defined as a decrease in the joint space to a width of 3 mm or less[5].

The mode of treatment reviewed includes closed reduction under general anesthesia prior to fixation or in situ fixation, type of fixation (screw fixation or Knowles pin).

Results

Demographic Profile

A total of 14 patients (19 hips) were reviewed (Table I). There were ten boys and four girls. The age of presentation ranged from nine years to 15 years. The average age at presentation in boys (12.5 years) was slightly higher than in girls (12 years). The average follow-up was 4.4 years (range, 0.3 to 12 years). Eight were Malays while six were Indians. There were no Chinese patients in our series.

The average body mass index was 26.5 (range, 22.3 to 37.1), which was overweight. None of these patients had any endocrine disorder except one patient (case 7) who was diagnosed with panhypopituitarism secondary to recurrence of a craniopharyngioma at the age of nine years (Fig. 1a-e).

The most common presenting symptom was pain in the affected hip with limping in nine patients. The other five patients had distal thigh or knee pain.

Thirteen hips were considered stable slips, since they were able to weight bear with or without crutches during the onset of symptoms. However, six hips were considered unstable due to inability to weight bear. The average duration of symptoms for 19 hips was 14 weeks (range, one week to 78 weeks). Twelve of the hips were chronic slips, six hips were acute slips and only one hip was acute on-chronic-slip.

The left hips (11 hips) were more affected than the right hips (eight hips). The slips were unilateral in nine patients and bilateral in five patients. In five patients with bilateral slips, one patient presented with synchronous, unstable slips. The remaining four cases of bilateral slips were not synchronous. The main presenting symptoms were bilateral distal thigh and knee pain. The average interval between the slips was 40 weeks (range, 12 weeks to 64 weeks). In the unilateral slips, six of nine cases involved the left hip. Three hips had mild slips, 12 hips had moderate slips and another four hips were considered as severe slips.

Internal fixation was performed in 13 cases (17 hips). Case 12 had bilateral slips but the parents refused surgery.

Functional Outcome

The average Iowa Hip Score was 83 points (range, 48-96 points). Four patients had excellent results, five had good results, three with fair and one had a poor result (Table I).

Complications

There were several complications found in this study. The major complications were avascular necrosis (AVN) and chondrolysis. AVN was seen in five hips.

Case 13 was the only patient to have a pre-operative magnetic resonance imaging (MRI) and AVN was identified in both hips with the mild chronic stable right hip showing a large area of osteonecrosis (Fig. 2a-e).

Seven hips healed with coxa vara. The only patient who refused surgery (Case 12) was reviewed after five years. She had bilateral coxa vara but was otherwise asymptomatic (Fig. 3).

Case 9 had screw tip protrusion but this did not lead to chondrolysis. Chondrolysis occurred in only one patient who presented with chronic mild stable slip. He was treated with two *in situ* cannulated screws and one screw tip had protruded.

Other complications include a reduced range of internal rotation in 12 hips, an increase in external rotation with hip flexion in 16 hips, coxa vara in seven hips, a limp in eight patients and hip pain in seven hips.

Discussion

The goals of treatment in SCFE are to prevent further displacement until physeal closure, avoid complications and maintain adequate hip function.

SCFE is an uncommon condition in our institution. This is similar to published reports from other Asian countries[1,6] except Japan. In a recent multicentre study by the Japanese Paediatric Orthopaedic Association in 2002[7], the average annual incidence was estimated to be 2.22 for boys and 0.76 for girls for every 100 000 children in the age group of 10- to 14-year olds. These figures are five times higher than the 1976 study[8] from Eastern Japan.

In Connecticut, USA the average annual incidence of slipped capital femoral epiphysis was higher at 3.19 and 7.24 per 100 000 white and black children respectively[9].

Our study exhibits several typical features of SCFE which includes more frequent involvement in boys than girls (71% versus 29%), the more frequent involvement of the left hip than right hip (58% versus 42%) and on average, boys are older than girls (12.5 years versus 12 years at onset of symptoms). The age, gender and side of involvement in our study are similar to other series [10, 11].

Obesity has a definite association with the development of SCFE. This is attributed to an increased shear stress across the physis and femoral retroversion. Most of our patients were overweight and two were considered obese. In an international multicentre study[12], the child's weight was equal to or greater than the 90th percentile in 63% of the children.

We had one patient with panhypopituitarism. Heatley *et al*[13] reported four cases of slipped capital femoral epiphysis in patients with intracranial tumours causing hypopituitarism and chiasmal compression. All of these cases were bilateral slips and were treated with screw fixation.

Five patients in our study presented initially with distal thigh or knee pain. The diagnosis was delayed up to one year in one patient and two months in the other patient because only the knee was examined clinically and radiographically. Matava *et al*[14] found that the initial presentation of distal thigh or knee pain or both had led to higher rates of unnecessary or inconclusive radiographic studies, missed diagnosis and inappropriate treatment and resulted in more severe slips in 15 of his 65 patients with SCFE

We concur with these authors and would like to stress the importance of a hip examination in all children with distal thigh or knee pain and to request for appropriate radiographs when in doubt.

The concept of physeal stability in SCFE has gained popularity and is widely accepted. This classification is of prognostic significance for the development of AVN[2]. Our study demonstrated that 13 hips were stable while the other six were unstable slips. Four out of six unstable slips and only one stable slip subsequently developed AVN.

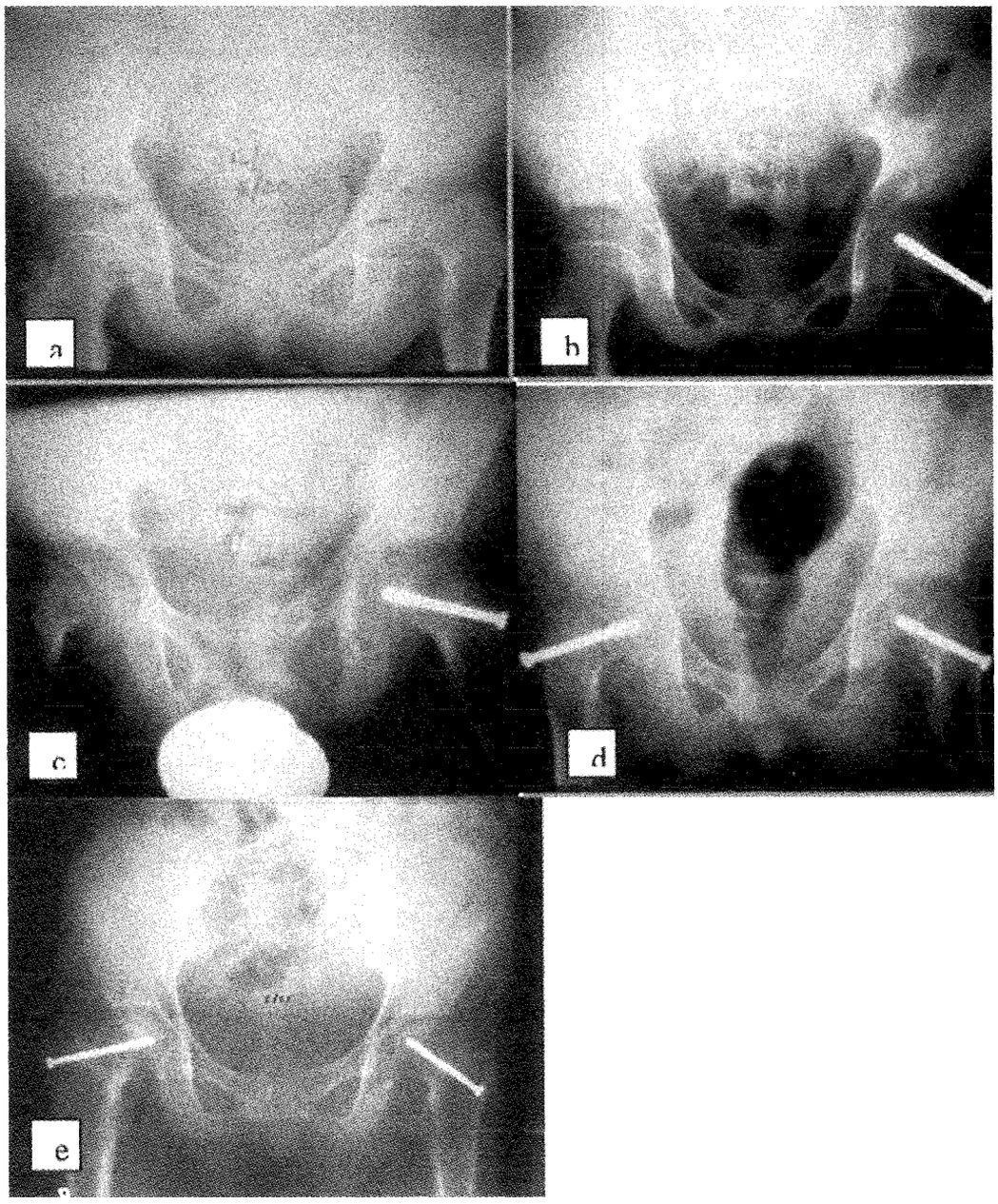


Fig. 1: (Case 7) - A 12 year-old boy diagnosed to have panhypopituitarism secondary to a craniopharyngioma, at the age of 9 years, developed left hip pain 2 weeks before admission. (a) Radiograph showed left hip SCFE (b) He was treated with an in situ cannulated screw fixation. (c) Three months later, the right hip had slipped. (d) The right hip was treated with a single in situ cannulated screw. (e) The latest radiograph 5 years post-surgery showed no AVN. He was asymptomatic.

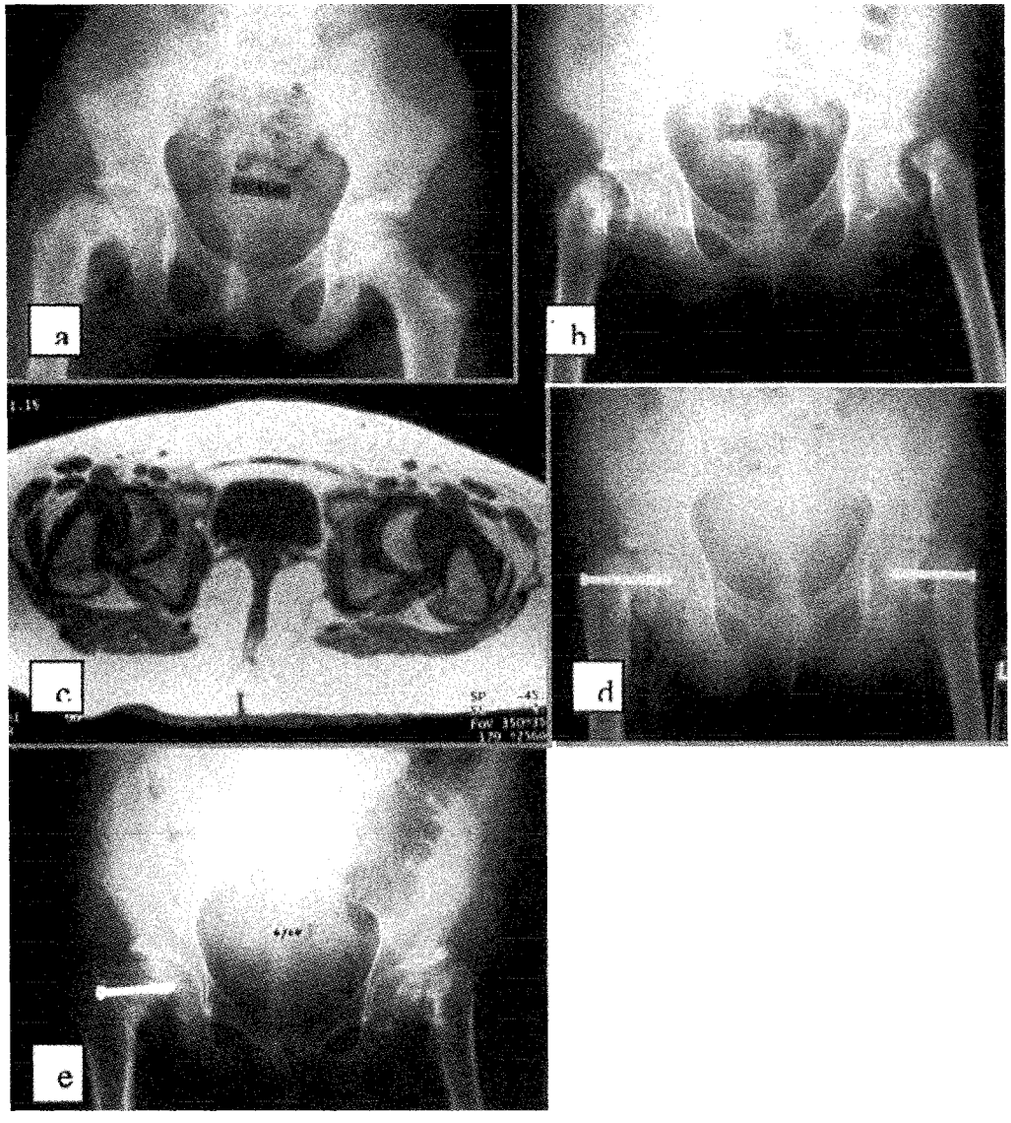


Fig. 2: (Case 13) - A 12 year-old girl presented with one month history of right knee pain. (a) The radiograph showed a chronic, severe slip of the right capital femoral epiphysis and normal looking left hip. She developed left knee pain five day after admission. (b) Radiograph depicted an acute severe slip of the left capital femoral epiphysis. (c) Magnetic resonance imaging showed a large AVN of the right femoral head and a small AVN of the left femoral head. (d) The right hip had an in situ cannulated screw fixation while the left hip had a gentle closed reduction before cannulated screw fixation. (e) Nineteen months after surgery, the left femoral head had collapsed due to AVN and the screw was removed. The proximal physis of the right femur has closed.

Table I: Details of the 14 Children with Slipped Capital Femoral Epiphysis

No	Age/Sex/Race	Wt (K)	Ht (m)	BMI	Endocrinopathy	Site of Pain	WB	Severity	Duration of Symptom	No of Screw	IOWA Sore or Pin	Complication
1	15/♂/Indian	70	1.68	24.8	Nil	Rt. Hip	Yes	Mod	2 Months	2	71	Screw Penetration, Chondrolysis, Coxa Vara
2	14/♂/Indian	75	1.70	25.9	Nil	Lt. Hip	Yes	Mod	2 Weeks	1	84	AVN
3	13/♂/Indian	70	1.65	25.7	Nil	Both Hips	Yes	Lt. Mild, Rt. Mod	Lt. 1 Month, Rt. 2 Months	Left 3, Right 2	95	Nil
4	13/♂/Indian	64	1.70	22.1	Nil	Rt. Thigh	Yes	Mild	1 Month	1	87	Nil
5	14/♂/Malay	67	1.63	25.2	Nil	Lt. Thigh	Yes	Mod	1 Year	1	93	Coxa Vara
6	13/♂/Malay	65	1.60	25.4	Nil	Rt. Hip	Yes	Mild	2 Weeks	3	96	Nil
7	12/♂/Malay	95	1.60	37.1	Panhypopituitarism	Both Hips	Yes	Both Mod	Lt. 2 Weeks, Rt. 1 Month	Left 1, Right 1	84	Nil
8	10/♂/Malay	50	1.48	22.7	Nil	Lt. Hip	No	Severe	2 Weeks	1	85	AVN
9	9/♂/Malay	70	1.60	27.3	Nil	Both Hips	Yes	Both Mod	Lt. 2 Months, Rt. 1 Week	Left 2, Right 2	85	Broken Wire, Screw Penetration
10	13/♂/Malay	79	1.65	29.0	Nil	Lt. Knee	Yes	Mod	1.5 Years	1	90	Coxa Vara
11	10/♂/Indian	49	1.50	22.0	Nil	Lt. Hip	Yes	Mod	1 Year	1	95	Nil
12	12/♀/Malay	60	1.50	26.7	Nil	Lt. Hip, Rt. Knee	No	Both Mod	1 Month	Deferred Surgery	72	Bilateral Coxa Vara
13	12/♀/Malay	55	1.30	32.5	Nil	Both Knees	No	Both Severe	1 Month		48	Bilateral AVN
14	14/♀/Indian	58	1.50	25.8	Nil	Lt. Hip	No	Severe	2 Weeks	2	79	AVN

Wt = Weight, Ht = Height, BMI = Body Mass Index, WB = Weight Bearing, AVN = Avascular Necrosis

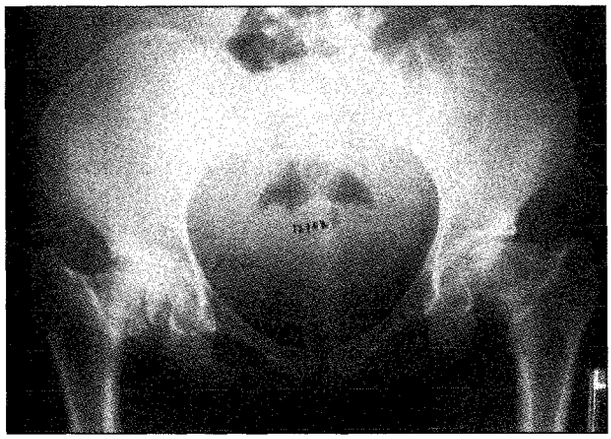


Fig. 3: (Case 12). Bilateral SCFE presented at the age of 12 years. The radiograph at the age of 17 years and she remained asymptomatic

In our study, the prevalence of bilateral slips was 37% with the average interval of eight months between the diagnoses of the first and second slip. In a study from Michigan[15], 82 (37%) of 224 children, had bilateral slips. The second slip was diagnosed within 18 months after the diagnosis of the first slip in 88% of the patients with sequential slips.

Knowles pin were used in two patients in the early 1990's before the use of threaded screws in our institution. A recent survey by the Paediatric Orthopaedic Society of North America, showed that 57% of respondents used a single threaded screw while 40% used two threaded screws for fixation of an unstable SCFE[15].

The major complication commonly associated with closed manipulation of SCFE is AVN of the femoral head. Two of three hips which were severe slips and had closed reduction, developed AVN compared to only one out of 16 hips in which reduction was not attempted. The reduction in these three cases was done gently using the traction table with the patient under general anesthesia. Although MRI was not available for earlier patients, we were able to document that AVN had already occurred in one patient with bilateral slips who had a preoperative MRI. The closed reduction prior to screw fixation may have caused further ischaemia leading to collapse of the left femoral head (Case 13).

With patients under general anaesthesia, incidental reduction of the slip often occurs by simple positioning on the fracture table. Any intentional reduction maneuver is not recommended unless the deformity is so severe that adequate internal fixation is not possible due to inadequate osseous contact between the epiphysis and metaphysis[16].

Conclusion

SCFE is uncommon in Malaysia. The hip must be examined in any child presenting with distal thigh or knee pain. Our treatment of choice for SCFE is a single in situ, cannulated screw fixation

References

1. Loder RT and 47 Coinvestigators from 33 Orthopaedic Centers and 6 Continents. A worldwide study on the seasonal variation of slipped capital femoral epiphysis. Clin Orthop. 1996; 322: 28-36.
2. Loder RT, Richard B, Stephens S, Paul S, Reznick LR, Aronson D. The importance of physeal stability. J Bone Joint Surg. 1993; 75-A: 1134-46.
3. Boyer DW, Mickelson MR, Ponseti IV. Slipped capital femoral epiphysis: long-term follow-up study of one hundred and twenty-one patients. J Bone Joint Surg. 1981; 63-A: 85-95.
4. Hansson G, Billing L, Hogstedt B, Jerre R, Wallin J. Long-term results after nailing in situ of slipped upper femoral epiphysis: a 30-year follow-up of 59 hips. J Bone Joint Surg. 1998; 80-B: 70-7.

5. Ingram AJ, Clarke MS, Clark CS, Marshall WR. Chondrolysis complicating slipped capital femoral epiphysis. Clin Orthop. 165: 99-109.

6. Mulpruek P, Laohacharoensombat W, Mahachoklertwattana P, Pookarnjanamorakot C. Slipped capital femoral epiphysis in Ramathibodi Hospital. J Med Assoc Thai. 1997; 80: 446-53.

7. Noguchi Y, Sakamaki T; Multicenter Study Committee of the Japanese Paediatric Orthopaedic Association. Epidemiology and demographics of slipped capital femoral epihysis in Japan: a multicenter study by the Japanese Paediatric Orthopaedic Association. J Orthop Sci. 2002; 7: 610-7.

8. Ninomiya S, Nagasaka Y, Tagawa H. Slipped capital femoral epiphysis. A study of 68 cases in the eastern half area of Japan. Clin Orthop. 1976; 119: 172-6.

9. Kelsey JL. The incidence and distribution of slipped capital femoral epiphysis in Connecticut. J Chron Dis. 1971; 23: 567-78.

10. Dreghorn CR, Knight D, Mainds CC, Blockey NJ. Slipped capital femoral epiphysis. A review of 12 years of experience in Glasgow (1972-1983). J Pediatr Orthop. 1987; 7: 283- 7.

11. Loder RT, Aronsson DD, Greenfield ML. The epidemiology of bilateral slipped capital femoral epiphysis. A study of children in Michigan. J Bone Joint Surg. 1993; 75-A: 1141-7.

12. Loder RT and 47 Coinvestigators from 33 Orthopaedic Centers and 6 Continents. The demographics of slipped capital femoral epiphysis: an international multicenter study. Clin Orthop. 1996; 322: 8-27.

13. Heatley FW, Greenwood RH, Boase DL. Slipping of the capital femoral epiphysis in patients with intracranial tumors causing hypopituitarism and chiasmal compression. J Bone Joint Surg . 1976; 58: 169-72.

14. Matava MJ, Patton CM, Luhmann S, Gordon JE, Schoenecker PL. Knee pain as the initial symptom of slipped capital femoral epiphysis: an analysis of initial presentation and treatment. J Pediatr Orthop. 1999; 19: 455-60.

15. Mooney JF 3rd, Sanders JO, Browne RH, Anderson DJ, Jofe M, Feldman D, Raney EM. Management of unstable/acute slipped capital femoral epiphysis: results of a survey of the POSNA membership. J Pediatr Orthop. 2005; 25(2): 162-6.

16. Loder RT. Unstable slipped capital femoral epiphysis. J Pediatr Orthop. 2001; 21(5): 694-9.

ORIGINAL ARTICLE

The Pattern of Femoral Diaphyseal Fractures in Children Admitted in Sarawak General Hospital

A H Rasit, MS(Orth), A W Mohammad, MS(Orth), K L Pan, MS(Orth)

Department of Orthopaedic Surgery, Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak, Kuching, Sarawak, Malaysia

Summary

Trend towards changing the face of management for pediatric femoral fractures tends to advocate operative treatment. This study was undertaken to review our current practice in the wake of recent progress in the management of pediatric femoral fractures. Fifty patients with femoral diaphyseal fracture treated in Sarawak General Hospital were reviewed retrospectively after an average follow-up of 2.6 years. There were 36 boys and 14 girls, with a mean age of 6.2 years (range five months to 14 years). Children under six years of age constituted the majority of the patients. Half of the fractures were caused by road traffic accident. Nine patients had associated injuries. The most common site of fracture was at the middle third (N = 31). The treatment regimens were delayed hip spica (DHS) in 16, immediate hip spica (IHS) in 24, plate osteosynthesis (PO) in five, titanium elastic nailing (TEN) in five, and external fixation (EF) in one. The minimum hospital stay was two days, and the maximum 33 days (mean, 9.7 days). Malunion was the commonest complication. Conservative treatment is the preferred option for children under six years of age. It is cost-effective with minimal complication. The other treatment options are reserved for specific indication in older children. Diaphyseal fractures of the femur in children can be adequately managed non-operatively.

Key Words: Femur, Children, Fracture, Sarawak General Hospital

Introduction

There has been no reported case study on pediatric femoral fractures in Sarawak. The purpose of this study is to provide an epidemiology data on pediatric femoral fractures treated in Sarawak General Hospital. This study is very important to initiate further clinical study for the reason of providing the optimum care to the paediatric orthopaedic patients.

Materials and Methods

Study Design

This is a retrospective study on femoral fractures in children age below 14 years old admitted in the Sarawak General Hospital from January 2002 until December 2004.

Patients

There were fifty femoral fractures (50 children: 36 boys and 14 girls) with an average age of 6.2 years old. The majority of patients were Malay (57%), followed by Chinese (23%), Iban (10%) and Bidayuh (10%).

Treatment Options

The treatment options include immediate hip spica (IHS), delayed hip spica (DHS), plate osteosynthesis (PO), titanium elastic nailing (TEN) and external fixation (EF). Immediate hip spica is defined as application of hip spica cast within 72 hours following injury. Delayed hip spica indicates application of hip spica 72 hours after the injury. Plating is performed by using standard internal fixation techniques as described by the AO/ASIF. Titanium elastic nailing is performed by closed reduction under image intensifier guidance

using two titanium elastic nails of similar diameter. External fixation is performed by reduction of fracture and stabilization with any type of external fixator. The choice of the treatment method is based on the age of the patient and the presence of open fracture and polytrauma.

Results

Demographic Data

The age distribution for femoral fractures in children in our series showed a peak incidence between 2 to 4 years (Fig. 1). The fractures affected boys (72%) more than girls (28%). This finding is similar to other series[1,2]. Majority of the cases were Malay (57%); followed by Chinese (23%), Iban (10%) and Bidayuh (10%). These data correspond to racial distribution of patients admitted to the Sarawak General Hospital.

Half of the fractures were caused by a fall occurring at home in 80% and at school in 20% of the cases. Road traffic accidents accounted for the remaining 50% involving bicycle riders in 29%, pedestrians 29%, pillion riders 28% and car occupants 14%.

The most common site of fracture was the middle third (N = 31), and 34 were at the right femur. Except for one case, all fractures were closed.

Treatment

DHS was used in 16 patients (32%), IHS 24(46%), PO 5(10%), TEN 5(10%), and EF in one (two percent) as shown in Fig. 2. The minimum duration of hospital stay was two days, and the maximum was 33 days (mean, 9.7 days). The average follow-up was 2.6 years. The treatment trend for pediatric femoral fractures in our series showed increasing preference to flexible nailing. However the preamble choice of treatment was still immediate or delayed spica cast as shown in Fig. 3.

Outcome

All fractures united. In two patients in the group treated with immediate hip spica who developed significant loss of fracture reduction at two weeks post-treatment, the spica was noted to be loose. Both patients underwent second closed reduction and reapplication of hip spica. Two patients with osteogenesis imperfecta who were treated with hip spica had re-fracture at the old fracture site, and immediate reapplication of the hip spica was carried out. At two years follow-up, two patients treated with delayed hip spica had malunion with an angulation of more than 20°. There was no major complication in the operative group except for one patient treated with TEN. He had 15° of angulation, due to early weight bearing.

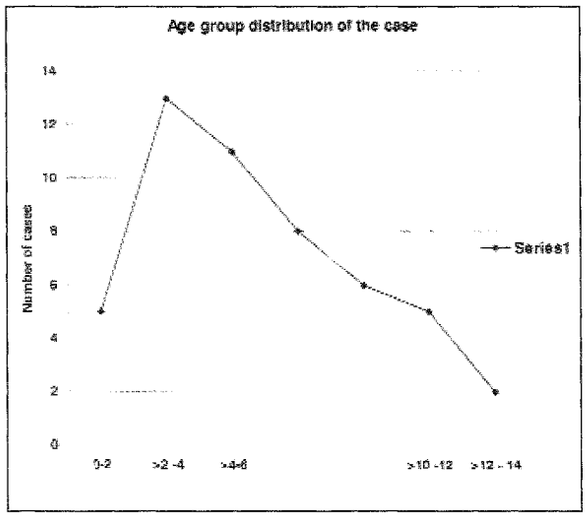


Fig. 1: Distribution of the cases according to age group

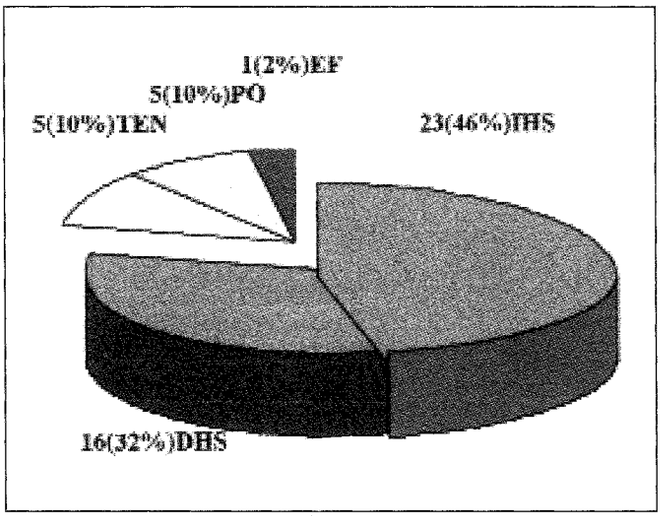


Fig. 2: Distribution of Treatment Options

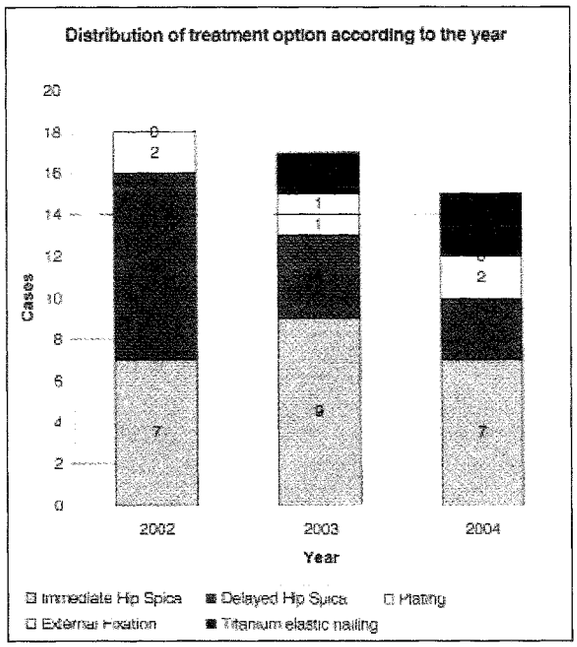


Fig. 3: Distribution of the treatment option by year

Discussion

Fractures of the femur can be the most disturbing injury to both the child and the parent. Femoral fractures represent about two percent of all fractures in children. Children with femoral fractures always require hospitalization with much higher resources than that of other childhood fractures[1].

Until the last few years, the treatment for pediatric femoral shaft fractures in our center has been DHS cast after two weeks of preliminary traction. This regime is preferred as it was cheaper and it needed limited resource to provide the treatment.

Hedin *et al.*[1] in their multicenter study reported that the main factor in determining the cost of treatment was the number of days in hospital. In other study in West Malaysia, Moses *et al.*(1998) reported that the conservative management of femur fracture in children is a safe, simple and practical method to treat the childhood femoral shaft fracture. In our series, non-operative treatment was the preferred choice based on two considerations: the cost and the age of the patient. The majority of our patients are in the age group of two to six years, and these patients tolerated non-operative treatment regime. Conservative treatment remains safe and affordable to our local population.

In the last decade, there has been a trend towards surgical treatment for pediatric femoral fractures. The main advantage of operative treatment is the shortened hospitalization time. Available options include PO, EF and TEN. Our experience in using TEN is still early but we have been using External Fixation (EF) and Plate Osteosynthesis (PO) for open fractures and polytrauma patients.

Metaizeau strongly suggested that the new treatment with TEN was becoming more practical as non-operative treatment necessitated a long hospital stay for traction and subsequent immobilisation in an uncomfortable cast. This treatment was not well tolerated, especially in adolescents. Moreover, near the end of growth, accurate reduction was necessary, as malunion was no longer correctable by growth.

TEN uses two flexible nails which are introduced percutaneously either through the lower metaphysis or the subtrochanteric area. This technique does not disturb the healing of the fracture. The elasticity of the device allows slight movement at the fracture site which favours union. Reduction and stabilisation are adequate and the operative risk is very low. A cast is not required, functional recovery is rapid and the patient is allowed to walk with crutches after seven to ten days according to the type of fracture. This technique is very efficient in adolescents and can be used after the age of seven years when non-operative treatment is unsuccessful.

In other study Houshian *et al.*[2] reported that TEN seemed to be a safe method for the treatment of femoral shaft fractures in children between four and 11 years of age even in grade I open fracture of femur.

Flyn *et al.*[3] in their cohort study further supported that the patient treated in TEN group achieved recovery milestones significantly faster than a child treated with traction and a spica cast. They also reported that the hospital charges for the two treatment methods were similar. The complication rate associated with nailing compared favorably with that associated with traction and application of a spica cast.

Narayanan *et al.*[4] analyzed their first 5-year experience with TEN, specifically highlighting the complications associated with this technique and the pitfalls to avoid. The surgeon should advance nail ends to lie against the supracondylar flare to avoid symptoms at the insertion site and should avoid implanting nails of two different

diameters. In cases of comminuted fractures, close monitoring should be carried out with a view to provide additional immobilization.

However, Luhmann *et al.*[5] reported that there were two major postoperative complications: one septic arthritis after nail removal and one hypertrophic nonunion. Minor postoperative complications were pain at the nails in 13 extremities, nail protrusion through the skin in four, and one delayed union. To minimize the complication they recommended leaving less than 2.5cm of nail out of the femur and using the largest nail size possible.

Our experience indicates that conservative treatment is still preferable not only because of the cost but the majority of our patients are in age group below six years in which non-operative treatment is safe with minimal complication. Other treatment options are reserved for specific indication for example; external fixation for open fracture, plating for polytrauma patient and TEN for patients above six years of age where non-operative treatment is less tolerable in our hot and humid weather. The new treatment trend for pediatric femoral fractures, especially TEN should provide improved care in the near future after refining the technique to avoid major complications as well as to provide comfort to our patients in the temperate region.

Conclusion

Femoral fracture in children represents a potentially disturbing and disabling injury. Current trend favoring surgical treatment is appealing but conservative treatment remains a viable option especially for those below the age of six years.

Acknowledgement

We are grateful to Miss Bibiana Wong and staff of medical report department of Sarawak General Hospital. We also would like to thank the Director of Sarawak general hospital for permission to carry out this study.

References

1. Hedin H. Surgical treatment of femoral fractures in children. Comparison between external fixation and elastic intramedullary nails: A review. Acta Orthop Scand. 2004; 75(3): 231-40.
2. Bridgman S, Wilson R. Epidemiology of femoral fractures in children in the West Midlands region of England 1991 to 2001. J Bone Joint Surg. 2004; 86-B(8): 1152-7.
3. Al-Habdan I. Diaphyseal femoral fractures in children. Should we change the present mode of treatment? Int Surg. 2004; 89(4): 236-9.
4. Hedin H, Borgquist L, Larsson S. A Cost analysis of three methods of treating femoral shaft fractures in children: A comparison of traction in hospital, traction in hospital/home and external fixation. Acta Orthop Scand. 2004; 75(3): 241-8.
5. Moses T, Pan KL, Razak MA. Conservative treatment of femoral shaft fractures in children. Med J Malaysia. 1998; 53 (Suppl. A): 22-6.
6. Metaizeau JP. Stable elastic intramedullary nailing for fractures of the femur in children. J Bone Joint Surg. 2004; 86-B(7): 954-7.
7. Houshian S, Gothgen CB, Pederson NW, Harving S. Femoral shaft fractures in children: Elastic stable intramedullary nailing in 31 cases. Acta Orthop Scand. 2004; 75(3): 249-51.
8. Flynn JM, Leudtke LM, Ganley TJ *et al.* Comparison of titanium elastic nails with traction and a spica cast to treat femoral fractures in children. J Bone J Surg. 2004; 86-A(4): 770-7.
9. Narayanan UG, Hyman JE, Wainwright AM *et al.* Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures, and how to avoid them? J Pediatr Orthop. 2004; 24(4): 363- 9.
10. Luhmann SJ, Schootman M, Schoenecker Pl *et al.* Complications of titanium elastic nails for pediatric femoral shaft fractures. J Pediatr Orthop. 2003; 23(4); 443-7.

ORIGINAL ARTICLE

Apollo® Total Knee Replacements in University Malaya Medical Centre: A Short-term Outcome

A A Abbas, MS (Orth), A M Merican, MS (Orth), M K Kwan, MS (Orth), J A Mohamad, MS (Orth)*

Department of Orthopaedic Surgery, University Malaya Medical Centre, Kuala Lumpur, *Selangor Medical Centre, Shah Alam, Selangor, Malaysia

Summary

Total knee arthroplasty is the most preferred option for treatment of severe osteoarthritis of the knee. We report the short-term outcome of 48 total knee replacements in 31 patients utilizing the Apollo® Total Knee System after an average follow-up of 48 months (range 15 to 70 months). Records of all patients who underwent TKA using Apollo® Total Knee System were retrospectively reviewed. Functional outcome was evaluated using visual analogue scale for pain rating and the Oxford 12-item questionnaire. Postoperative radiographs of the replaced knees were assessed by using the Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System. Degenerative osteoarthritis was the commonest indication for TKA. The average patient's age was 63.7 years (range, 30 – 77 years). The mean visual analogue scale for pre- and post-operative pain was eight and zero respectively. The mean Oxford 12-item questionnaire score pre- and post-operatively was 44.8 and 16.5 respectively. Patient satisfaction was notable in 98% of the cases with an average improvement in arc of flexion of 111°. There were four failures; deep infection (one) and aseptic loosening (three) giving rise to a 94% implant survivor. The short-term results of this series is comparable with or better than a number of outcome studies of the Apollo® Knee System or other implants of similar design,

Key Words: Total knee replacement, Short term outcome

Introduction

Total knee arthroplasty (TKA) has become a preferred treatment for severe tricompartmental or bicompartmental osteoarthritis of the knee. The desired goals of TKA are pain relief, correction of deformity, restoration of function by improving knee stability and range of motion. Follow-up studies in most series have confirmed that TKA has been successful in achieving these aims[1,2].

The aim of this study is to evaluate patient satisfaction and functional results of total knee replacement utilizing the Apollo® Knee System in University of Malaya Medical Centre, Kuala Lumpur, Malaysia.

Materials and Methods

All patients who underwent TKA with the Apollo® total knee system (SulzerMedica, Sulzer Orthopaedics Inc, Austin, Texas) in University of Malaya Medical Centre, Kuala Lumpur, between December 1999 and December 2003 were included in this study.

Functional and clinical scoring was performed by direct interview, using a visual analogue scale (VAS) for rating of pain and the Oxford 12-item questionnaire[3]. Clinical examination of the affected knees was done by a single examiner.

Preoperative and postoperative deformity and range of motion were recorded. Postoperative radiographs of the replaced knees were assessed with the Knee

Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System[4] (Fig. 1).

From the operative notes, duration of surgery, implant sizes, intra- and post-operative complications were recorded. Finally, duration of hospital stay postoperatively was documented.

Results

Sixty seven Apollo® total knee prostheses were implanted in 43 patients by two main surgeons in University of Malaya Medical Centre, between December 1999 and December 2003. The male to female ratio was 1:3. The mean patient age was 63.7 years (range, 30 – 77 years). The ethnic origin of the patients was Malay (26%), Chinese (42%) and Indian (30%).

All except one were primary replacements. Degenerative knee arthritis was the preoperative diagnosis in 33 (77%) of the cases, rheumatoid knees with secondary osteoarthritis in eight (18%), and psoriatic arthritis in one (2%). Rheumatoid arthritis was the most common in the younger patients. As the age of the patients increased, primary osteoarthritis became the most common indication for TKR. One patient was operated for a ruptured posterior cruciate ligament five years after a primary total knee replacement at another centre.

Twenty four patients underwent bilateral total knee replacement (23 simultaneous, one sequential) and the remainder underwent unilateral total knee replacement. Four were cruciate-retaining (CR) TKR and 44 were posterior stabilized (PS) TKR. Twenty six knees had the patella resurfaced.

Of the 43 patients, four patients (four knees) had died and seven patients (11 knees) were not contactable. A total of 31 patients (48 knees) were available for follow-up and the mean follow-up period was 48 months (range, 15 – 70 months).

Four knees diagnosed as failure of primary surgery were reviewed separately to ascertain the cause of failure. The ratio of patients with 0:1:2:3 co-morbidities were 16:6:8:1. The average length of hospital stay of all the patients reviewed was 13.9 days (range, 7 – 23 days).

Pain Score

The mean pain score based on VAS was 8 (range, 1 – 10) preoperatively. The postoperative pain score ranged between zero and seven. Six patients had persistent postoperative pain but felt that it was better compared to the preoperative values. None of the patients reported any anterior knee pain at the last follow-up.

Functional Outcome

The mean pre- and post-operative Oxford Knee Scores were 44.8 (range 12–60) and 16.5 (range 12–28) respectively. At the time of review, five patients still required walking aid as a precautionary measure as compared to 24 patients preoperatively. The walking aid was used only when they were in crowded, public places to serve as a visual warning to the public. However, all the patients reviewed did not require a walking aid when they were at home. 43.7% of patients who had difficulty with stairs or were unable to preoperatively had no difficulty at the last follow-up. Postoperatively, majority of patients were able to walk for at least 30 minutes.

All patients who were dependent on others to administer care and to carry out activities of daily living preoperatively were able to do so independently at the time of review. This was also the case for all the patients who were not able to participate in social activities preoperatively. All the patients except for one were satisfied with their treatment citing decrease of pain and return to functional independence as the main reasons for their satisfaction and would recommend the surgery to friends and family. Although they enjoyed the benefits of total knee replacement, 16% of the patients said if given a choice, they would not undergo the surgery again as the immediate postoperative pain was unbearable and the rehabilitative process was difficult to bear due to the pain.

Range of Motion

Preoperatively, 37 knees had a fixed flexion deformity, ranging from 10° to 60°. Twenty-nine knees had moderate (6° – 10°) to severe (more than 11°) varus deformity, whereas five knees had moderate (11° – 15°) to severe (more than 16°) valgus deformity. Postoperatively, there were no fixed flexion deformities detected. All the knees had normal alignment. The average arc of motion was 87° (range, 20° - 140°) preoperatively, and 111° (range, 72° – 130°) at the last follow-up. Patients who had a smaller arc of motion preoperatively, i.e. those who had flexion arc of less than 50°, gained the most in arc of motion at the last follow-up.

The Knee Society Roentgenographic Evaluation and Scoring System showed no significant radiolucency in any of the knees reviewed. In all these patients, postoperative alignment was within the acceptable range. The average alpha, beta, gamma and delta angles are 95°, 88°, 1° (flexion) and 2° (flexion) respectively. The normal acceptable range of angles are alpha angle of 94° – 105°, beta angle of 84° – 94°, sagittal femoral (gamma) angle of 2° (extension) – 3° (flexion), and sagittal tibial (delta) angle of 3° (extension) – 3° (flexion).[5,6]

Complications

Intraoperative - One patient with a preoperative diagnosis of osteoarthritis secondary to rheumatoid arthritis had an intraoperative injury to the medial collateral ligament. The ligament was repaired immediately. At the time of follow-up, the knee was stable and had a range of motion of 0° – 72°.

Local – Immediate postoperative complications included stitch abscess (one), haematoma (one), wound dehiscence (two) and superficial blister (one). The infections resolved with debridement, administration of intravenous antibiotics and regular wound dressing.

Deep Vein Thrombosis (DVT) – One patient developed symptomatic DVT. Pre-operative thromboprophylaxis was not administrated to this patient. The diagnosis was confirmed by venography. This patient was treated conservatively. At the time of follow-up, the patient was well.

Foot Drop - One patient had a postoperative foot drop. This was treated conservatively with an orthosis. The foot drop completely resolved approximately 1 year after the surgery.

Patellofemoral Osteoarthritis - One patient who underwent total knee replacement without patellar resurfacing had to undergo another surgery two years after the primary surgery to have the patella resurfaced. This was because of persistent complaints of anterior knee pain and radiographs of the knee revealed patellofemoral osteoarthritis.

Periprosthetic Fracture - One patient had periprosthetic fracture of the femur following a fall 29 months after primary total knee replacement. The prosthesis was not loosened or displaced as a result of the fracture. He underwent open reduction and internal fixation of the femur. However, due to non-union, he refractured the femur when he attempted to bear weight on the affected limb three months postoperatively. Open reduction, internal fixation and bone grafting was performed. At the time of follow-up, six months after the surgery, he was able to bear weight on the affected limb. Range of motion of the knee was 0° – 104°.

Deep Infection - One patient had a deep infection which resulted in removal of the prosthesis. An antibiotic cement spacer was inserted, and once the local infection was eradicated, arthrodesis of the knee was performed. Revision TKA was not performed as the source of the initial infection, i.e. chronic urinary tract infection, could not be controlled.

Aseptic Loosening - The average time of diagnosis was 43.7 months post primary TKR. In two patients, the femoral component was mal-aligned, with one femoral component placed in 8° of femoral extension and the other in 6° of femoral flexion. The cause of failure in the remaining knee was presumed to be caused by osteonecrosis as part of the lateral condyle adjacent to the femoral componenet rapidly collapsed. Two patients had undergone revision total knee arthroplasty. There was no evidence of infection intra-operatively. The remaining patient has been deemed unfit for surgery due to ischaemic heart disease.

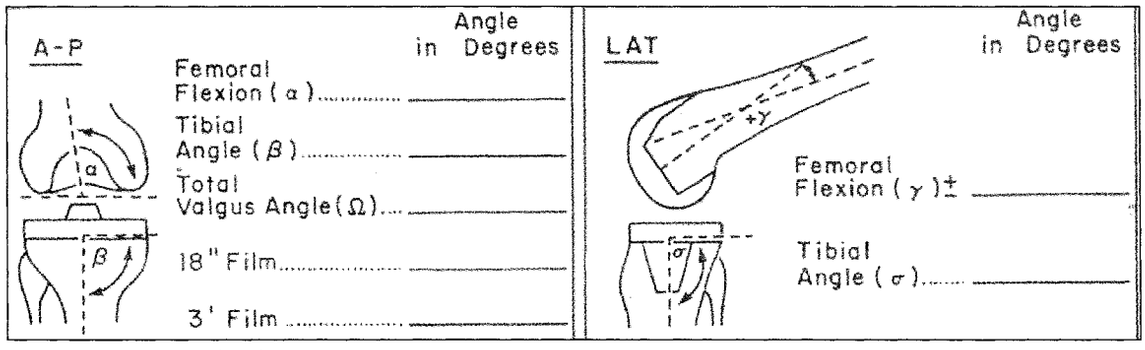


Fig. 1: Measurement of Alignment in Knee Society Roentgenographic Evaluation and Scoring System

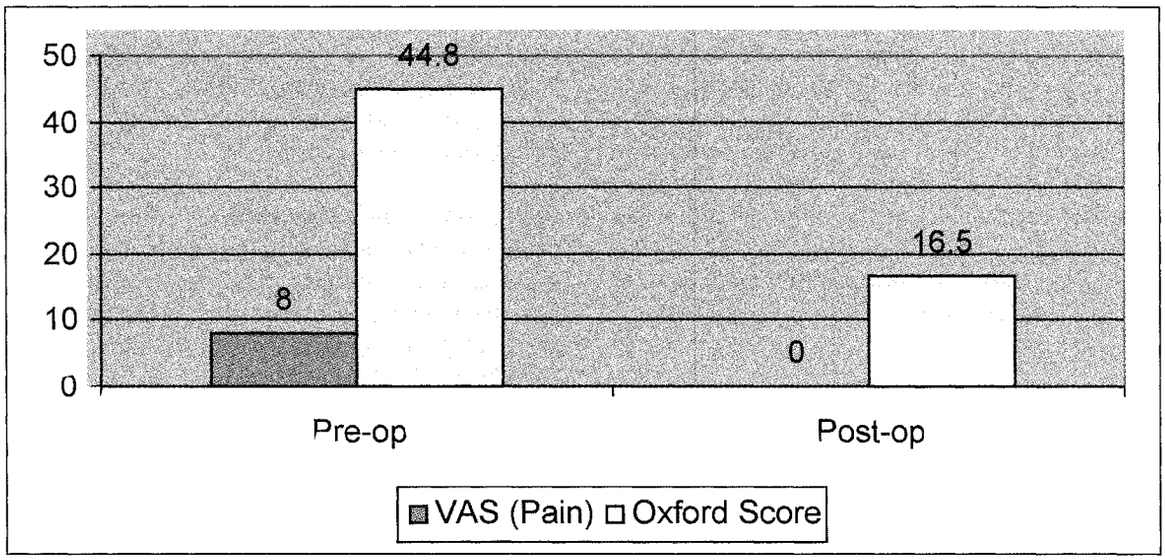


Fig. 2: Pain and Oxford Score Averages

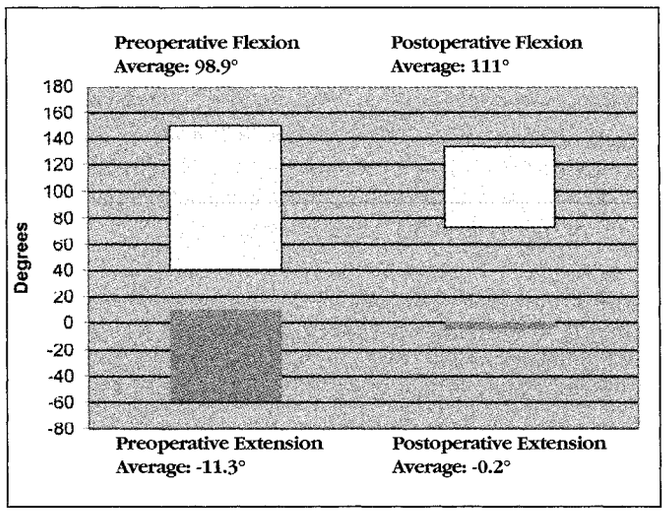


Fig. 3: Pre- and post-operative range of motion

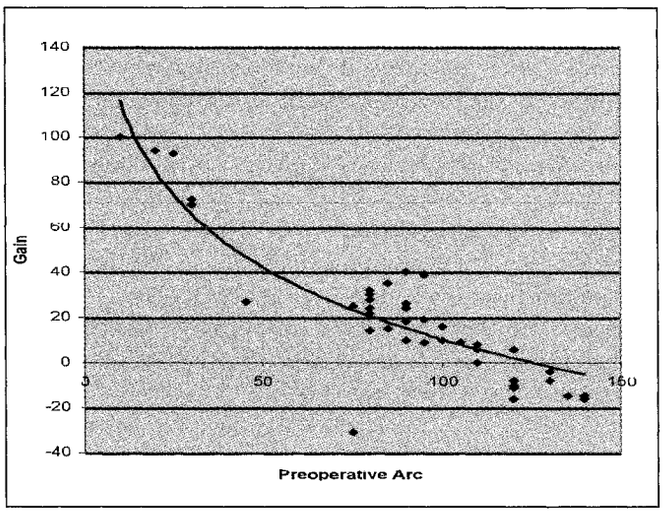


Fig. 4: Gain in motion arc versus pre-operative arc of motion

Discussion

With 98% reporting satisfaction with the surgery, an average postoperative arc of flexion of 111° and 94% implant survivorship, the results of this series is comparable to or better than a number of outcome studies of the Apollo® Knee System or other implants of similar design, like the Total Condylar Knee and the Insall-Burstein II Knee System. In a study of 146 Insall-Burstein II total knee replacements with an average follow-up of ten years, Li *et al*[7] reported 93% of patients had excellent, good or fair postoperative outcomes and the average arc of flexion was 100°. The cumulative survival rate for the implant in this study was 92.3%. Ip *et al*[8] reported a mean postoperative knee flexion of 115° in a short-term follow-up study (average follow-up of 21 months) of the NexGen Legacy total knee prosthesis, which is a newer version of the Insall-Burstein II posterior stabilized implant. Pavone *et al*[9] studied the long-term outcome of the Total Condylar Knee arthroplasty, with an average follow-up of 23 years. He reported 96% patient satisfaction. The average postoperative arc of flexion was between 110° - 115° and survivorship of 91% at 23 years follow-up. In a 20-year follow-up study of 45 knees replaced with the Total Condylar Knee replacement by Rodriguez *et al*,[10] the average flexion was 100° and the overall

survivorship was 93.6%. Udomkiat *et al*[11] compared the outcome between all-polyethylene and metal-backed tibial (MBT) components utilizing the Apollo® Knee System at an average three years after surgery. He reported the mean flexion for knees with MTB components was 118.3° + 10.4°. All patients with MBT knees (48 knees) reported improvement in pain, with 95.8% reporting significant pain improvement. All patients with MBT knees could also resume usual activities after surgery, with 36 reporting marked resumption of usual activities, ten moderately so, and two could somewhat resume activities. In another study by Udomkiat *et al* comparing the functional outcome between a cruciate retention and posterior stabilized Apollo® Knee System,[12] he reported that functional improvement was achieved in 95% of the posterior stabilized knees at an average of two years after surgery. The mean flexion postoperatively for posterior stabilized knees was 118.7° + 11.2°. Ninety-seven percent of the patients graded the surgical outcome as "good" or better.

Prosthetic joint infection is potentially catastrophic. In this series, the rate of deep infection was 1.5%. This is within the current reported rates of 1% to 2%,[13,14] and well below the rate of deep infection of 9% in local series as reported by Sharizal *et al.*[15] .

Of the three cases of aseptic loosening, minor femoral implant malalignment was the cause of loosening in two cases and osteonecrosis in the remaining one patient. This emphasizes that even minor malalignment of components has an adverse effect on implant survival.

Conclusion

TKA has proven to be a reliable treatment for end-stage arthritis. Its primary aims of pain relief, correction of deformity, improvement of range of motion and restoration of function and stability was achieved in most instances. This cohort of patients needs to be followed-up for a longer period to determine long-term outcomes.

References

1. Swanik CB, Lephart SM, Rubash HE. Proprioception, kinesthesia, and balance after total knee arthroplasty with cruciate-retaining and posterior-stabilized prostheses. J Bone Joint Surg. 2004; 86(2): 328-34.
2. Malkani AL, Rand JA, Bryan RS, Wallrichs SL. Total knee arthroplasty with the Kinematic Condylar prosthesis: A ten-year follow-up study. J Bone Joint Surg. 1995; 77-A(3): 423-31.
3. Dawson J, Fitzpatrick R, Murray D *et al.* Questionnaire on the perception of patients about total knee replacement. J Bone Joint Surg. 1998; 80-B: 63- 9.
4. Ewald FC. The Knee Society Total Knee Arthroplasty Roentgenographic Evaluation and Scoring System. Clin Orthop. 1989; 248: 9-12.
5. Bach, C.; Steingruber, I.; Peer, S.; Nogler, M.; Wimmer, C.; and Ogon, M.: Radiographic Assessment in Total Knee Arthroplasty. Clin Orthop. 2001; 385: 144-50.
6. Mont, M. M.; Fairbank, A. C.; and Yammamoto, V.: Radiographic Characterization of Aseptically Loosened Cementless Total Knee Replacement. Clinical Orthop. 1995; 321: 73-8.
7. Li PLS, Zamora J, Bentley G. The results at ten years of the Insall-Burstein II Total Knee Replacement: clinical, radiological and survivorship studies. J Bone Joint Surg. 1999; 81-B(4): 647-53.
8. Ip D, Wu WC, Tsang WL. Early results of posterior-stabilised NexGen Legacy total knee arthroplasty. J Orthop Surg. 2003; 11(1): 38-42.
9. Pavone V, Boettner F, Fickert S, Sculco T. Total condylar knee arthroplasty: a long-term follow-up. Clin. Orthop. 2001; 388: 18-25.
10. Rodriguez JA, Bhende H *et al.* Total condylar knee replacement: a 20-year follow-up study. Clin Orthop. 2001; 388: 10-7.
11. Udomkiat P, Dorr LD, Long W. Matched-pair analysis of all-polyethylene versus metal-backed tibial components. J Arthroplasty. 2001; 16(6): 689-96.
12. Udomkiat P, Meng BJ, Dorr LD, Wan Z. Functional comparison of posterior cruciate retention and substitution knee replacement. Clin Orthop. 2000; 378: 192-201.
13. Bengston S, Knutson K, Lidgren L. Treatment of infected knee arthoplasty. Clin Orthop. 1989; 245: 173.
14. Rorabeck CH: Salvage of the infected total knee replacement. Clin Orthop. 2002; 404: 113.
15. Syahrizal AB, Kareem BA, Anbanadan S, Harwant S. Risk factors for infection in total knee replacement surgery at Hospital Kuala Lumpur. Med J Malaysia. 2001; 56 (Suppl D): 5-8.

CASE REPORT

Venous Gas Embolism Following Hydrogen Peroxide Irrigation During Debridement of Chronic Osteomyelitis Lesion

A Shukrimi, MMed (Orth)*, C A Aminudin, MS (Orth)*, M A Azril, MMed (Orth)*, M R A Hadi, MMed (Anaest)**

*Department of Orthopaedics, Traumatology & Rehabilitation, **Department of Anaesthesiology, Kulliyyah of Medicine, International Islamic University of Malaysia, Kuantan, Pahang, Malaysia

Summary

We report a case of a previously healthy 53 year-old man who developed an intra-operative catastrophic event occurring in association with the use of hydrogen peroxide for wound irrigation following surgical debridement of a chronic osteomyelitis lesion of the humerus. It is our intention to highlight this potentially fatal consequence of hydrogen peroxide irrigation as part of bone debridement procedure. This case will serve as a reminder to orthopaedic surgeons who frequently use hydrogen peroxide in their surgical practice.

Key Words: Hydrogen peroxide, Gas embolism, Debridement, Osteomyelitis

Introduction

Hydrogen peroxide solution is commonly used to adjunct surgical debridement. It can be hazardous when irrigated into stomach, subcutaneous tissue and open wound[1]. We report herein an adverse effect of hydrogen peroxide irrigation used to adjunct surgical debridement of a chronic osteomyelitis lesion. We hope that our illustrative case will serve as a reminder and help others to avoid similar complication of application of hydrogen peroxide.

Case Report

A 53 year-old previously healthy man presented with a two-month history of swelling and pain of left arm. There was no significant history of recent trauma or febrile episodes. The left upper arm was swollen, warm and tender on palpation. Plain radiographs of the left humerus revealed an osteolytic lesion containing sclerotic bone (sequestrum) affecting the distal two-thirds of the humeral diaphysis and a fracture at the proximal-middle third junction (Fig. 1a). Soft tissue shadow of the distal-half of the upper arm was increased. The above findings were consistent with pathological fracture through a chronic osteomyelitis lesion. Laboratory investigations showed an increased total white cell count of 13,300 cells/mm^3, elevated erythrocyte sedimentation rate of 93mm/hour and a normal electrocardiogram. A clinical diagnosis of Cierny-Mader type-IVA chronic osteomyelitis was made.

Patient was scheduled for a semi-emergency surgical debridement, sequestrectomy and stabilization with external fixator. Following induction of general anesthesia using fentanyl 75mg, sodium thiopentone 250mg and tracheal intubation facilitated with Rocuronium 40mg, the lesion was approached via an incision over the lateral side of the upper arm. Thick pus was drained once the periosteum was opened (Fig. 1b) and a 2x4 cm sequestrum was removed using rongeur and curette. The humerus was stabilized using external fixator crossing the elbow joint (Fig. 2). The wound was copiously irrigated with normal saline

and at least 200ml of diluted hydrogen peroxide (6%), using syringe and a Ryle's tube was instilled into the medullary cavity. About 10 minutes after that, a precipitous drop in the blood pressure and oxygen saturation was noted by the anaesthesiology team. Immediate cardiopulmonary resuscitation according to the standard advanced cardiac life support (ACLS) protocol which includes ventilation with 100% oxygen and administration of one pint Gelafundin was commenced. The patient resumed sinus rhythm after ten minutes. The wound was quickly lavaged with normal saline and closed. He was then transferred to the intensive care unit for further management. He was intubated for five days, later changed to temporary tracheostomy due to poor Glasgow Coma Scale score and prolonged intubation.

Investigations done in the intensive care unit: electrocardiogram, cardiac enzymes, computed tomography scans of brain and chest, showed no evidences of brain infarction, or pulmonary embolism or myocardial infarction. Plain chest radiographs were unremarkable. The cardiac enzymes were minimally elevated secondary to cardiopulmonary resuscitation.

The patient was able to be weaned from ventilator and transferred to normal ward after being managed in Intensive Care unit for two weeks. Unfortunately, due to a low Glasgow Coma Scale (GCS) of 8/15, the patient was still dependent on 3l/minute oxygen supplement delivered through trachy-vent.

Discussion

Hydrogen peroxide is frequently used to cleanse and irrigate open fracture wounds and diabetic foot ulcers as part of wound care procedure. Its rapid dissociation to water and oxygen micro bubbles when in contact with blood and tissue peroxidase is often considered a harmless surgeon-friendly antiseptic and cleansing agent. The foamy form of oxygen micro bubbles help to mechanically dislodge bacteria, debris and other contaminants from small cavities in tissue, and. have a weak and brief germicide effect[1]. It is also known to produce vasoconstriction, and hence used to secure haemostasis of small bleeders. For the same reasons, hydrogen peroxide is also used as part of medullary canal preparation for cementation in total joint replacement surgery.

At low concentrations, hydrogen peroxide has cytotoxic effect to osteoblast[3]. Oxygen microbubbles have also been shown to cause separation of new epithelial cells from granulation tissue. As such, its use for daily wound cleansing is not recommended as it will favour delay in healing via de-epithelization.

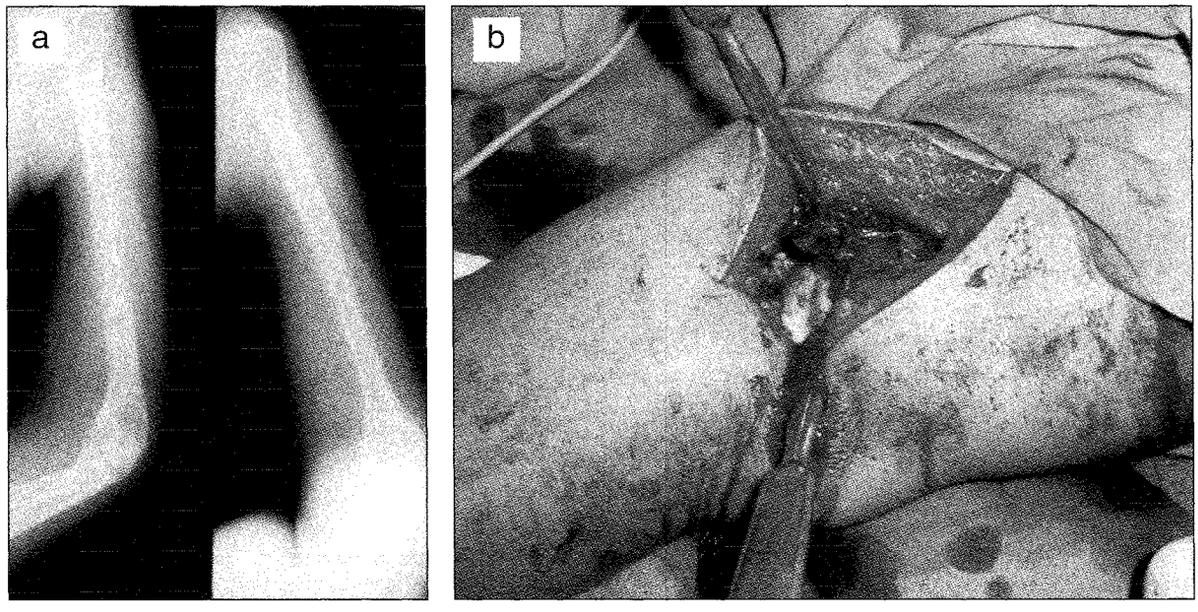


Fig. 1: Left: Radiographs of the humerus showing pathological fracture through chronic osteomyelitis segment, Right: Intra-operative finding of thick pus coming out from the medullary cavity.

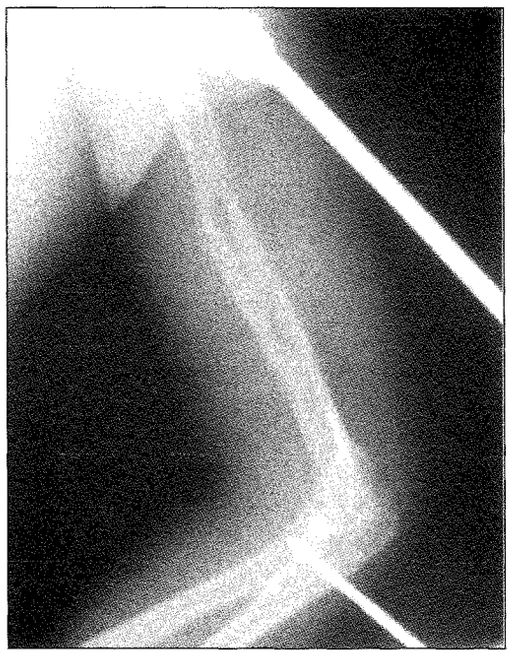


Fig. 2: Post-operative radiograph of the humerus after application of external fixation.

However, when hydrogen peroxide is delivered under high pressure using syringe and Ryle's tube to an area containing non-collapsing veins such as in the endosteal raw surface, intravasation of oxygen microbubbles in the form of a string of pearls occurred. Since 1ml of 3% hydrogen peroxide produces 9.8ml oxygen, delivery of 200ml diluted 6% hydrogen peroxide into the medullary cavity such as in this case will inevitably liberate large volume of microbubbles with eventual intravasation into the systemic vein. Rapid entry or large volumes of gas and embolization to the pulmonary circulation will eventually put a strain on the right ventricle as the pulmonary arterial pressure increases. This will lead to an increase in right ventricular outflow resistance, and a decrease in pulmonary venous return and left ventricular preload, resulting in diminishing cardiac output leading to systemic cardiovascular collapse and. peripheral ischemia[2].

There are several reported cases of oxygen embolism following irrigation of surgical field with hydrogen peroxide. Irrigation of a semi-closed space with hydrogen peroxide has been reported to be associated with higher risk of oxygen embolism than that of open surgical field irrigation. However, its occurrence was rarely reported in the orthopaedic literature. Our case represents an example of venous oxygen embolism following irrigation of a semi-closed space medullary cavity of the long bone. The sudden onset of intra-operative cardio-respiratory adverse effects is attributed to delivery of relatively high pressure irrigation with hydrogen peroxide using syringe and Ryle's tube. Because the incidence of overt venous gas embolism during orthopaedic surgery is relatively uncommon, most surgeons or even anaesthetists are not aware of this potential iatrogenic clinical complication.

Conclusion

Hydrogen peroxide is a potentially dangerous solution, particularly when it is used for irrigation of a semi-closed space such as medullary canal of the long bone. In such circumstance, hydrogen peroxide should not be used as a chemical adjunct to surgical debridement and/or securing hemostatsis because the evolved gas cannot be dissipated freely. Its clinical use should be restricted to a role as an adjunctive agent for wound encrusted with blood. Greater pre-emptive awareness among surgeons and anaesthetists for this potential iatrogenic consequence is important.

References

1. Morikawa H, Mima H, Fujita H, Mishima S. Oxygen embolism due hydrogen peroxide irrigation during cervical spinal surgery. Can J Anaesth. 1995; 42(3): 231-3.
2. Muth CM, Shank ES. Gas embolism. N Engl J Med. 2000; 342: 476-82.
3. Kaysinger KK, Nicholson NC, Ramp WK, Kellam JF. Toxic effects of wound irrigation solutions on cultured tibiae and osteobalsts. J Orthop Trauma.1995; 9: 303-11.
4. Noel H, DuWayne AC, David MK, Brittany C. Air embolism associated with irrigation of external fixator pin sites with hydrogen peroxide. J Bone Joint Surg. 2004; 86-A: 821-2.

CASE REPORT

Marjolin's Ulcer - A Near Forgotten Entity

B C Tan, MS (Orth), T C Horton, FRCS, T Sara Ahmad, FRCS

Department of Orthopaedic Surgery, University Malaya Medical Centre, Kuala Lumpur, Malaysia

Summary

We report a case of a 55 year-old man who presented with a 6-month history of a fungating ulcer on the right hand at the site of a previously healed ulcer that had been present for 40 years. Histopathological examination of four-quadrant biopsy specimens showed a moderately differentiated squamous cell carcinoma (SCC). A transradiocarpal amputation with stump closure using radial flap was performed as it was not possible to achieve a functionally and cosmetically acceptable hand after a wide excision with 2cm tumour-free margin. It is our intention to highlight this rare condition as reminder to consider this entity as a differential diagnosis of chronic non-healing skin ulcer.

Key Words: Chronic non-healing ulcer, Marjolin's ulcer

Introduction

Marjolin's ulcer is a rare malignant tumour arising from scar tissue of chronic ulcers and wounds of the skin, sinuses and previous burns. Today, since most of these precursor lesions are aggressively treated surgically to minimize formation of scar tissue and contracture, the eventual malignant transformation may be considered as a non-existing entity. As such, Marjolin's ulcer is fast becoming a forgotten entity and often missing from the list of possible causes of chronic non-healing cutaneous ulcers.

Case Report

A 55 year-old Chinese man with a background past history of having an ulcer over his right hand which took approximately two years to heal by second intention healing when he was 15 years old, presented with a six-month history of progressive ulcerated fungating growth over the ulnar site of the hand. The growth became larger to cover two-thirds of the dorsum of the right hand and it was associated with foul smelling discharge (Fig. 1), contact bleeding and pain. He experienced a marked loss of appetite and weight loss. Examination of the right hand revealed an ulcerated malodorous exophytic growth measuring 9x8x1cm covering the dorsum of the right hand from the ulnar margin of the fifth metacarpal to the second web space. There was foul smelling discharge. The epitrochlear nodes were not enlarged. Plain radiographs of the right hand showed the fourth and fifth metacarpals were involved. Magnetic Resonance Imaging revealed a large 6x8.2x4.4cm ill-defined soft tissue mass with involvement of the middle, ring and little fingers extending from the metacarpal proximally to the phalanges distally. The palmar and dorsal interossei, and hypothenar muscles were involved. A breach at the cortex of the fourth and fifth metacarpals was noted. Computerized tomographic scans of the chest and abdomen revealed no detectable metastatic lesion. The white cell count and erythrocyte sedimentation rate were elevated, 25.2x10^9/l and 78 mm/hour respectively. Four-quadrant biopsy was performed and a histopathological diagnosis of squamous cell carcinoma (SCC) was arrived at. A decision to carry out ablative amputation of the hand was made as a planned hand salvage surgery in the form of wide local excision with 2cm tumor-free margin will not be expected to result in a functional hand with acceptable cosmesis. A transradiocarpal amputation was carried out and histopathological examination of the amputated specimen confirmed the diagnosis of squamous cell carcinoma with clear surgical margins of dissection. His progress after being discharged was uneventful and on the last follow-up, the wound had healed.

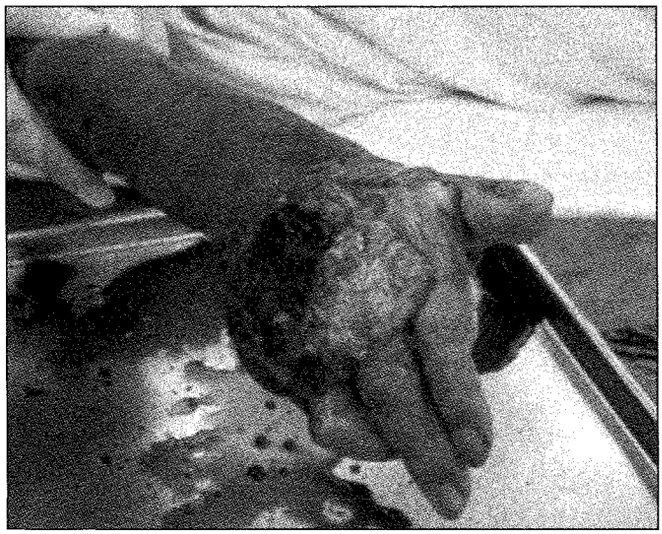


Fig. 1: Ulcerated fungating growth on the dorsum of the right hand

Discussion

The first description of chronic ulcer arising in scar tissue was reported by Jean-Nicholas Marjolin in 1828. Although this lesion was not originally considered as a malignant condition, the term Marjolin's ulcer is now synonymously referred to malignant transformation occurring in chronic scarring ulcers and wounds of the skin, sinus tracts, and burn scars[1].

The epidemiology of scar SCC shows that chronic scarring associated with prolonged inflammation or low grade infection may predispose to malignant changes. These include chronic ulcers especially varicose ulcers, diabetic foot ulcers, and leprotic neuropathic ulcers, burn scars, chronic osteomyelitic sinuses, pilonidal sinuses, chronic hidradenitis suppurutiva, epidermolysis bullosa dystrophica, acne conglobata, granuloma inguinale, lymphogranuloma venereum, erythema ab ingne, discoid lupus erythromatosus and lupus vulgaris and lupus sclerosis.

Most reported cases of Marjolin's ulcer occurred in burn scars. It is estimated that 2% of burn scars will eventually undergo malignant transformation. The average age of patients with burn scar malignancy was 53.5 years. The latency period of a Marjolin's ulcer is inversely proportional to the patient's age at the time of the burn injury with an average of 36 years (range between one and 75 years). Our patient is a 55 year-old man and developed Marjolin's ulcer after 40 years of latency period.

The pathogenesis of chronic scar malignant changes is unknown but speculated to be chronic irritation-induced production of carcinogens within an acquired 'immunologically privileged' scar tissue leading to a multistep carcinogenesis involving induction, promotion and progression of unchecked DNA damage favoring malignant transformation instead of the natural apoptosis[2]. Other theories include radiation-induced metaplasia and foreign body reaction to implantation of epidermal cells into the dermis that causes alteration of normal regeneration of tissue. Characteristics of the scar that predispose to malignant transformation include a prolonged healing time like in this case, repetitive trauma, and rejected grafted site.

The most common histological variant of malignant transformation is well differentiated squamous cell type. Transformation into basal cell carcinoma has also been reported. In most instances, certain areas of Marjolin's ulcer may exhibit a typical pseudoepitheliomatous hyperplasia of benign reactionary process. These findings emphasize the importance of four-quadrant biopsy as a diagnostic procedure to avoid a false-negative result or misdiagnosis.

Nodal metastasis on presentation is the most important prognostic indicator. The incidence of regional nodes involvement in Marjolin's ulcer arising from burn scars carcinoma is approximately 35%. The overall metastatic rate of squamous cell carcinoma of Marjolin's ulcer is greater (18% to 38%) when compared to primary cutaneous squamous cell carcinoma (0.5% to 6%)[3]. Lower limb lesions have the highest rate of metastasis, averaging 50%, while those on the upper limbs were lower.

The principles of surgical treatment of malignant ulcer dictate wide local excision with at least 2cm clear margin and regional nodes clearance. For our patient, this form of limb salvage surgery was contraindicated because it was almost impossible to reconstruct an expected post-excisional defect without the entire segment of four metacarpals with its overlying soft tissue and skin, and the function and gross appearance of the hand was expected to be unacceptable. This left us an option none other than carrying out ablative surgery in the form of amputation.

Viewing the rarity of Marjolin's ulcer as a potential risk of slipping into oblivion, the case reported herein is aimed at reminding our junior doctors to continue

considering Marjolin's ulcer in the differential diagnosis of a chronic non-healing ulcer or chronic ulcerating scar with elevated margin and exophytic fungating granulation tissue. Four-quadrant biopsy remains a valid requisite to avoid missing the diagnosis

References

1. Schwartz RA, Stoll HL Jr. Epidermal precancerous lesions. In: Fitzpatrick TB, Eisen AZ, Wolff K, et al. (eds). Dermatology in General Medicine. 4thed. New York. McGraw-Hill. 1998; 821-39.
2. Tutela Jr, Granick M, Benevenia J. Marjolin's Ulcer arising in a Pressure Ulcer. Advances in Skin and Wound Care.2004; 17(9): 462-4.
3. Goldman G D. Squamous Cell Cancers. A Practical Approach. Seminar Cut Med Surg. 1998; 17: 80-7.

CASE REPORT

Transphyseal Fracture-Separation of the Femoral Capital Epiphysis: A True SCFE of Traumatic Origin

C A Aminudin, MS(Orth), A Suhail, MS(Orth)*, M H Shukur, MS(Orth)*, J K Yeap, MS(Orth)**

Department of Orthopaedics, Traumatology and Rehabilitation, Kulliyah of Medicine, International Islamic University of Malaysia, Kuantan, Pahang; *Department of Orthopaedics and Traumatology, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, Kuala Lumpur, Malaysia; **Tawakal Hospital, Kuala Lumpur, Malaysia

Summary

Acute traumatic transphyseal fracture of the capital femoral epiphysis in children is a rare but serious injury. The injury is typically inflicted by a severe trauma. Because of the vulnerability and predisposed anatomy of the femoral epiphysis in relation to its blood supply, the fracture has been designated to have poor prognosis with inevitable osteonecrosis and eventual deformity of the hip. We report a case of such fracture in a 13 year-old child in view to highlight some of the anticipated problems in the management of such injury.

Key Words: Physeal injury, Paediatric hip fracture

Introduction

Despite being widely acknowledged as a misnomer, the term slipped capital femoral epiphysis (SCFE) continued to be an accepted description of an entity in which the femoral head is never ever slipped out of the acetabulum. We report herein the case of a true traumatic 'SCFE' occurring in a 13-year old boy clinically simulating a typical case of SCFE.

Acute transphyseal fracture-separation of the capital femoral epiphysis in children and aldolescents represents a rare injury. It is categorized as type-1 pediatric hip fractures according to Delbet classification system. Delbet type-1A fracture is difficult to differentiate from an acute unstable slipped capital femoral epiphysis (SCFE). The fracture typically affects children below nine year of age compared to 11 to 16 year-old for SCFE. Delbet type-1B fracture typically exhibits a total dislocation of the capital femoral epiphysis from the acetabulum and this should not be confused with SCFE. The trauma that is required to fracture a healthy proximal femur is typically more severe than the trauma that is associated with an acute SCFE.

Case Report

A 13 year-old Chinese boy was admitted after sustaining hip injury following a fall while being chased by a stray dog a day earlier. He was initially seen by a general practitioner and was sent home without any radiograph investigation. However, the pain remained severe despite analgesics and this had prompted his parent to take him to our hospital on the next morning.

Examination revealed that he was overweight (65 kg) for his height (158cm). The right lower limb was shortened with the hip held in flexion and abduction. The range of hip motion was grossly restricted in all directions by severe pain. Plain radiographs of the pelvis showed a transphyseal fracture with the right capital femoral epiphysis dislocated inferiorly in relation to the acetabulum (Delbet type 1B pediatric hip fracture). The left hip was radiographically normal (Fig. 1).

An emergency open reduction was performed 44 hours after the injury. Under general anesthesia, the hip was opened through an anterior Smith-Peterson approach. The femoral head was found outside the hip embedded

in the adductor muscles. The head was 'anatomically' placed in a reduced position and fixed by using two smooth Kirschner wires of 1.8mm diameter. The hip was then reduced. The child was immobilized in a hip spica for six weeks followed by a strict non-weight bearing ambulation on the affected hip for six months. At 24 months post-trauma, osteonecrosis was depicted on radiographic evaluation of the affected hip though he was clinically asymptomatic.

Discussion

Traumatic transphyseal fracture-separation of the femoral head is a rare but serious pediatric injury. Proximal femoral fracture in children and adolescents are less common than dislocations. In our case, the fracture was associated with inferior dislocation of the femoral head (Delbet type-1B). Complication such as coxa vara and osteonecrosis can occur. The reported incidence of osteonecrosis with a Delbet type-1B injury is up to 100%. The poor prognosis of this injury is related to disruption of the lateral and medial epiphyseal blood vessels which are the main source of blood supply to the epiphysis.

A transphyseal fracture is defined as acute traumatic epiphyseal separation occurring at the level of the capital femoral epipyseal line through a healthy normal epiphysis. This is to distinguish traumatic separation from unstable or acute SCFE in which the physis is abnormal and biomechanically weak[3]. Transphyseal fracture of the femoral neck occurs through the region of hypertrophic cartilage cell as quoted by Werkmen[4] from work done by Aiken in 1936. The prognosis for acute traumatic transphyseal fracture of the femoral head is the worst as greater force is needed to fracture a normal physis and inflict damage to the retinacular vessels.

Ingram and Bachynski[3] had six Delbet type-1 fractures in their series of 24 children with hip fractures over the 23 years period from 1930 to 1953. In five of the six cases, the femoral head had also dislocated from the acetabulum (Delbet type-1B). All patients were involved in violent trauma. However, our patient sustained Delbet type-1B fracture-dislocation after a fall while running. The patients with Delbet type-1B injury had the poorest outcome resulting from osteonecrosis in four patients and deep surgical site infection with subsequent resorption of the femoral head in the remaining one.

Canale and Bourland[1] in 1977 did a prospective long-term follow-up of 61 children with hip fractures (average follow-up of 17 years). Eighteen of their patients were previously included in short-term follow-up study by Ingram and Bachynski. Four out of five patients with Delbet type-1B fracture had poor outcome after open reduction and internal fixation, and one had fair result. Three patients had reduction done after ten to 60 days following the injury. All five patients eventually had osteonecrosis of the femoral head with four of the five developing premature degenerative osteoarthritis.

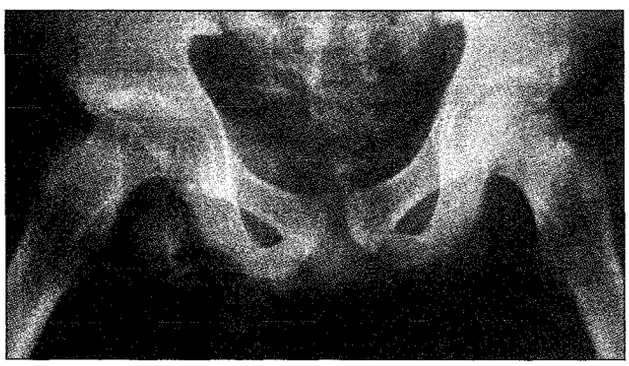


Fig. 1: Antero-posterior radiograph of the pelvis showing transepiphyseal separation with the capital epiphysis dislocated inferiorly.

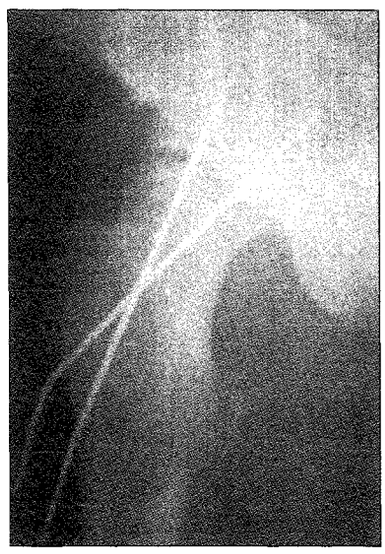


Fig. 2: Post-operative check radiograph depicting a non-anatomical fracture reduction and unstable fixation with two smooth Kirschner wires.

Traumatic transphyseal fracture-separation of the capital femoral epiphysis is a true surgical emergency and patients should be subjected to surgery immediately[2,5]. The timing of surgery is crucial. The surgical approach must avoid further damage to the injured structures in addition to attempt to preserve the remaining blood supply. Open reduction is deemed necessary as anatomic placement of the head is best achieved under direct vision. In adolescent, cancellous screw fixation provides the best stabilization to allow early epiphysiodesis. In our case, the reduction was not anatomical and K-wire fixation was not the best option to achieve adequate stabilization to allow early epiphysiodesis. Although the risk of osteonecrosis of the femoral head is high in the range of 80% to 100%, accurate anatomical reduction should be aimed for as this will simplify reconstructive or arthrodesis procedure at a later stage if necessary[4].

References

1. Canale T, Bourland WL. Fracture of the neck and intertrochanteric region of the femur in children. J Bone Joint Surg. 1997; 59-A: 431-43.
2. Groneberg DA, Adolphs W, Hensel G. Traumatic transepiphyseal fracture of the femoral neck in early adolescence. Eur J Orthop Surg Traumatol.2000; 10: 261-3.
3. Ingram AJ, Bachynski B. Fractures of the hip in children. Treatment and result J Bone Joint Surg. 1953; 35-A: 867-86.
4. Werkman DM. The transepiphyseal fracture of the femoral neck. Injury. 1980; 12: 50-2.
5. Weber BG, Brunner C, Freuler F. Treatment of fractures in children and adolescents. Springer-Verlag, Berlin Heidelberg. 1980.

CASE REPORT

Bilateral Femoral Neuropathy Associated with Disseminated Intravascular Coagulopathy: A Case Report

C Y Cheok, MS(Orth), A Merican, MS(Orth)*, W M Ng, MS(Orth)

Orthopaedic Unit, Department of Surgery, Universiti Putra Malaysia, Kuala Lumpur; *Department of Orthopaedic Surgery, University Malaya Medical Center, Kuala Lumpur, Malaysia

Summary

We report a case of 20 year-old man who presented with bilateral femoral nerve palsy following resuscitation for traumatic massive blood loss and its consequence. A high suspicious index for this complication may lead to its early recognition. Its related pathoanatomy is discussed based on the described evidences in the literature. Non-operative treatment remains as a recommended option for coagulopathy-related neuropathy.

Key Words: Femoral neuropathy, Coagulopathy

Introduction

Coagulopathy-related femoral neuropathy has been a well-recognized entity in haemophilics[1] and patients receiving anticoagulation therapy[2]. Due to an increased risk of post-operative bleeding, most of the cases are treated non-operatively with expectant recovery. We report herein a case of bilateral femoral neuropathy to highlight the outcome of conservative treatment of such lesion using the traditionally recommended option.

Case Report

A 20 year-old man was admitted with on arrival hypovolaemic shock after sustaining traumatic amputation of the right forearm. On primary survey and resuscitation, attempts to insert intravenous lines were made at different locations including the groins. Following an hour of resuscitation and stabilization in the emergency department, he was rushed to the operation room for which a successful forearm re-implantation was carried out over a period of 11 hours. Despite a total eight units of whole blood and blood products were transfused to replaced massive blood loss, he inevitably developed intra-operative disseminated intravascular coagulopathy (DIVC). There was no anticoagulation therapy administrated during the post-operative period. The DIVC was corrected over the subsequent three days.

Post-operatively, he was noted to have bilateral groin and scrotal swelling. During the first week, the patient complained of numbness and weakness of his lower extremities. Clinical examination revealed the presence of bilateral grade 2/5 weakness of the quadriceps with absent knee reflex. There were areas of hypoaesthesia in the distribution of femoral nerve supply as shown in Fig. 1. A palpable groin mass was noted and confirmed as an illiacus haematoma on ultrasonographic scanning.

He was treated conservatively by commencement of physiotherapy from the second week onwards. His quadriceps power improved to grade $3^{+}/5$ after three weeks but hypoaesthesia remained unchanged in the same area. He regained his ability to walk unaided after one year. The return of sensation was noted to be slow and incomplete even after two years following the injury.

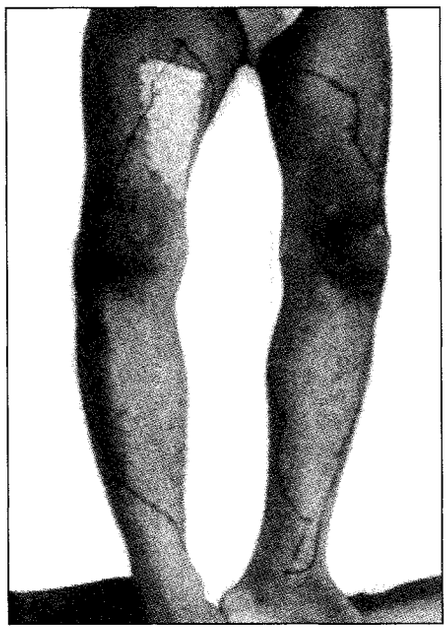


Fig. 1: The quadriceps muscles were wasted and areas of hypoaesthesia correspond to the femoral nerve distribution

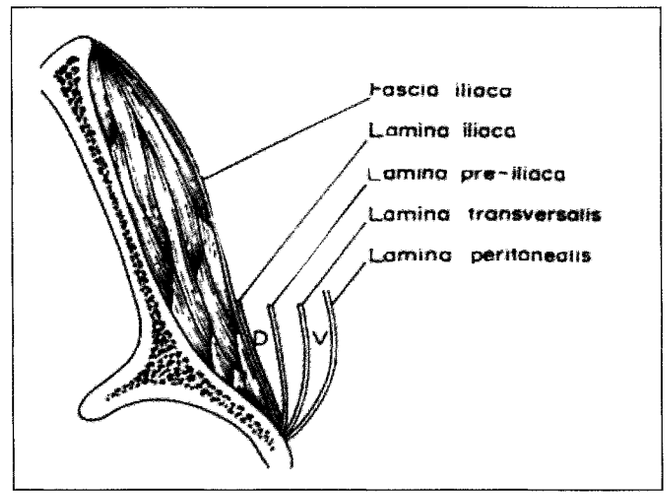


Fig. 2: Sagital section through the iliacus muscle and ilium showing their relationship with the fascial layers. These fasciae reinforce the antero-inferior aspects of the iliacus fascia.

Discussion

Bleeding in critical organs and predilected anatomical regions remains a major concern of anticoagulation therapy for DVT-PE and myocardial infarction. There have been many isolated case reports on anticoagulation-induced femoral neuropathy since it was first reported by De Bolt in 1966. In his report on two cases of femoral neuropathy associated with heparin therapy, De Bolt felt that inappropriate deep penetration of the needle during administration of heparin may allow haematoma to track down along the abdominal wall into the retroperitoneal space in the iliac fossa with eventual space occupying lesion pressure effect on the femoral nerve. In 1967, Goodfellow *et al.* reported similar lesions of spontaneous iliacus haematoma in patients with haemophilia and those receiving oral anticoagulation therapy[2]. In the case reported herein, multiple venupuncture during the primary survey and resuscitation is the likely cause, and DIVC may have a role in aggravating the formation of haematoma.

It is essential to appreciate the anatomy related to the course of the femoral nerve in order to understand how the haematoma could compress the nerve. Nobel *et al.* described the anatomical basis of the course of the femoral nerve in relation to its surrounding structures[3]. In their cadaver dissection, they had demonstrated that in the iliac fossa, there were at least three distinct fascial layers or laminae that reinforced the distal portion of the iliac fascia[3]. These laminae were either fused or separated to form three pouches of various sizes. Their attenuated proximal extensions reached mid-lumbar region. The fascia wall and the laminae of the pouch tended to reinforce the rigidity of the fibrous arch over the femoral nerve in the intermuscular plane between the iliacus and psoas muscles. The presence of any space occupying lesion such as haematoma or pus collection would further increase the pressure on the femoral nerve. Openings were often found in various pouches which could allow bleeding from the illiacus fossa or from the pouch walls themselves to enter the femoral triangle. This explains the existence of large groin swelling in some patients. The predilection of iliacus muscle to intramuscular bleeding remained unexplained.

The recommended conservative treatment for haematoma-induced femoral neuropathy is purely based on the fact that most patients are at higher risk of post-operative bleeding. Progressive or worsening neurological deficit is the only valid indication for surgical evacuation of the haematoma. However, our

patient probably had a better chance for neurological recovery if early decompression had been performed once the derangement in DIVC was corrected. His prolonged motor recovery and incomplete return of sensation represent pathological consequences of irreversible nerve damage attributable to long standing compression.

References

1. DeBolt WL, Jordan JC. Femoral neuropathy due to heparin-induced haematoma. Bull Los Angeles Neurol Soc. 1966; 31: 45.
2. Goodfellow J. Fearncbt A, Matthews JM. Illiacus haematoma. A common complication of haemophilia J Bone Joint Surg. 1967; 49-B: 748-56.
3. Nobel W, Marks SC, Kubic S. Thr anatomical basis for femoral nerve palsy following illiacus haematoma J Neurosurg. 1980; 52: 533-40.

CASE REPORT

Revision Total Hip Arthroplasty Using Impaction Bone Grafting Technique

A Nisar, FCPS, David S K Choon, FRCS, M Varaprasad, FRCS, A A Abbas, MS(Orth)

Department of Orthopaedic Surgery, University Malaya Medical Center, Kuala Lumpur, Malaysia

Summary

A variety of reconstructive options exist for revision of both femoral and acetabular components in total hip replacement surgery. The use of impaction bone grafting with morsellised allograft has shown promising results in revision total hip arthroplasty. It works as a biologic reconstitution of bone stock defects and provides a solid construct with stable fixation. We present a case of bilateral revision total hip arthroplasty with poor bone stock where reconstructive surgery was done by using impaction bone grafting, mesh and C-stem implants.

Key Words: Revision total hip arthroplasty, Allograft, impaction bone grafting, Osteolysis

Introduction

As the number of primary total hip arthroplasty (THA) has increased over the past two decades, the number of revision surgeries has slowly increased. Revision surgery for THA is technically demanding as problems related to bone loss need to be addressed. The loss of bone stock in the form of large bone defects secondary to osteolysis or mechanical instability present a major challenge in revision (THA) [1]. Bone loss may vary from small to massive defect involving selectively medial wall, acetabular dome or anterior and posterior walls. It affects the technique and implant selection. Poor bone stock can be adequately restored with impaction bone grafting and cementing. The main goal of any revision THA is to restore the patient's hip function by repairing the biomechanical kinetics.

Case Report

A 65 year-old Chinese lady is a known case of Systemic Lupus Erythromatosis (SLE) treated with intermittent steroid for 35 years. She was subsequently diagnosed to develop stage-IV corticosteroid-induced bilateral avascular necrosis of the hip in 1980, and had bilateral total hip replacement done in the same year. She remained pain-free and mobile for nearly 15 years before started to experience increasing pain associated with restricted right hip motion attributed to mechanical loosening of the prosthesis. She underwent a salvage surgical procedure i.e. conversion to resection or Girdlestone arthroplasty of the right hip. However, her disability worsened following resection arthroplasty. For the next five years, she had to endure considerable degree of disability attributable to limited mobility and gross shortening of the right leg, and increasing pain in her left hip. Radiographic studies at that time confirmed a diagnosis of aseptic left THA loosening (Fig. 1).

In February 2000, she had two revision hip surgeries performed within a time interval of two weeks. On the right side, a non-cemented acetabular cup size 52 was used along with polished tapered stem size one and head size 28+0mm. The acetabular component was fixated by using screw and morsellised bone graft. A left revision arthroplasty was accomplished by impaction bone grafting and cemented implants using acetabular cup size 47 and polished tapered femoral stem size one and head size 22+0mm. However, the cementless acetabular cup on right hip has failed due to progressive loosening and a large non-contained bone defect involving the anterior half of the acetabulum.

On May 2002, she underwent a second revision surgery for the right hip. A hammock or sling to reconstitute the wall was constructed with flat metal mesh which was cut-shapped and fixated superiorly and inferiorly with 3.5mm screws. An Ogee cup size 22.225/47 was cemented with impaction bone grafting into the reconstructed cavity.

At present she is in a good state of health with quiescent SLE. She is very happy and fully satisfied. She could walk at her own with cane for unlimited distance and has pain-free hips with adequate range of motion despite possessing bilateral Trendelenburg gait and 1cm limb length discrepancy. Recent functional evaluation revealed overall improvement with Oxford Hip Scores of 21 for the right hip and 60 for the worse left hip. The cumulative Harris scores were 78 and 79 for the right and left hip respectively. Radiographs of both hips (Fig. 2) showed all implants were well fixed without any evidence of loosing or subsidence.

Discussion

Revision THR represents a great challenge even for the most experienced surgeon. In revision surgery for THR, a multitude of problems need to be considered for each individual patient. It is even more challenging in patients with severe bone loss and prolonged disability. In our case, revision of a long standing Girdlestone arthroplasty was very difficult as there were no landmarks and the proximal tronchanter and acetabulum were destroyed. Of several techniques for reconstruction of bone defects in both the acetabulum and femur, impaction bone grafting using morsellised allograft and second generation cementing technique is a useful technique to restore the bone stock in revision THA[3]. The graft must be adequately impacted to provide immediately stability[4]. It gets incorporated into host bone to replace bone defects and forming a solid construct for stable fixation. Massive acetabular defects can be adequately restored by combination of metal mesh and impaction bone grafting which make a solid construct. Revision of femoral component in presence of large bone defects with impaction bone grafting and cemented collarless polished tapered stem has given more promising results than cementless cups as bony ingrowth is less dependable in the elderly.

In our case combination of impaction bone grafting with second generation cementing technique and polished tapered stem with smaller head size gave satisfactory clinical and radiological outcome.

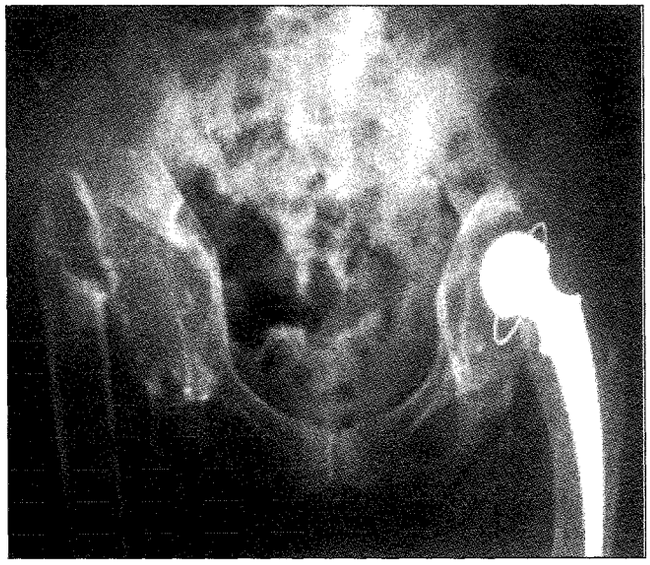


Fig. 1: Antero-posterior radiograph of the pelvis showing right Girdlestone arthroplasty and left Charnley THA with acetabular component loosening and low bone stock acetabulum

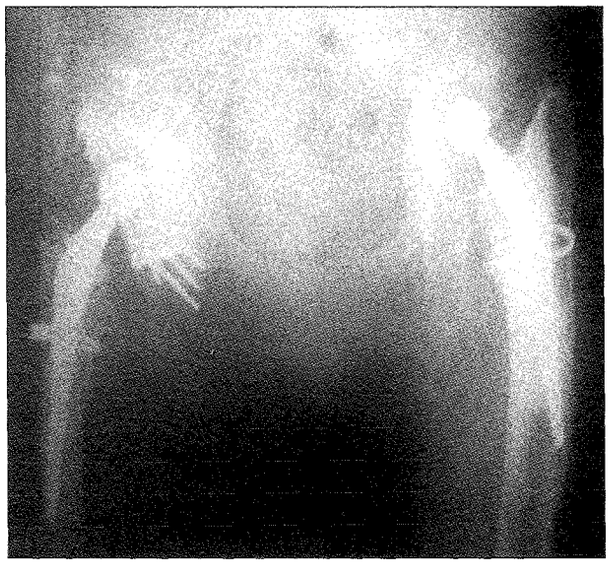


Fig. 2: Antero-posterior radiograph of the pelvis showing bilateral revision THR

References

1. Gie GA, Linder LL, Ling RS et al. Impacted cancellous allografts and cement for revision total hip arthroplasty. J Bone J Surg. 1993; 75-B: 14-21.
2. Schreurs BW, Sloof TJ, Buma P et al. Acetabular reconstruction and impacted morsellised bone graft and cement. J Bone J Surg. 1998; 80-B: 391-5.
3. Schreurs BW, Sloof TJ, Gardeniers JW, Buma P. Acetabular reconstruction with impaction bone grafting and a cemented cup:20 years experience. Clin Orthop. 2001; 393: 202-15.

Malaysian Orthopaedic Association

CORRECTION

5th August 2005

In the previous issue of Orthopedic Supplement of the Medical Journal of Malaysia, the name of one co-author of the below article was wrongly spelled and his address was incorrect.

Refers to M K Kwan, A M Marican, T Sara Ahmad. Reconstruction of the Heel Defect with In-step Island Flap. A Report of Four Cases. Med J Malaysia. 2005; 60 (Suppl C): 104-7.

The correct version should read as

M K Kwan, MS(Orth), A M Merican, MS(Orth), T Sara Ahmad, FRCS

Department of Orthopaedic Surgery, University Malaya Medical Centre, Kuala Lumpur, Malaysia

The editor would like to apologize for inconveniences arising from the mentioned typing errors.

M Hassan Shukur
Editor, Orthopaedic Supplement
Medical Journal of Malaysia