THE PREVALENCE OF INFECTION FOLLOWING CONVERSION OF EXTERNAL FIXATION TO INTERNAL FIXATION IN OPEN TIBIA FRACTURE

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ABSTRAK

Pengenalan

Pembetulan luaran adalah satu cara bagi menstabilkan tulang yang patah, terutamanya yang melibatkan kepatahan tulang kompaun tibia. Ia dipasang setelah permbersihan luka kepatahan dilakukan melalui pembedahan sebelum ditukarkan kepada pembetulan dalaman. Walaubagaimanapun terdapat risiko jangkitan kuman selepas penukaran pembetulan luaran kepada pembetulan dalaman disebabkan oleh pendedahan secara langsung tulang yang patah dengan persekitaran melalui pin pembetulan luaran. Kami mengkaji kadar jangkitan kuman ke atas pesakit yang menjalani pembedahan penukaran pembetulan luaran ke pembetulan dalaman yang melibatkan kepatahan kompaun tibia dan faKtor-faktor yang menyebabkan jangkitan di tiga buah hospital.

Metodologi

Semua pesakit yang memenuhi syarat kajian dikaji melalui rekod perubatan yang dicari di Jabatan Rekod dan dianalisa dengan menggunakan perisian computer SPSS 26.

Keputusan

Terdapat 61 orang pesakit yang menjalani pembedahan penukaran pembetulan luaran kepada pembetulan dalaman bagi kepatahan kompaun tibia dengan kadar jangkitan kuman sebanyak 16.39%. Semua faktor yang dikaji seperti umur, jantina, jumlah masa pembetulan luaran yang dipasang, jenis pembetulan luaran yang digunakan, jumlah masa selepas pembetulan luaran dicabut, dan jenis pembetulan dalaman menunjukan keputusan yang tidak ketara.

Kesimpulan

Kadar jangkitan kuman dalam kajian kami adalah 16.39% dan setara dengan kajian-kajian lain. Faktor-faktor yang boleh menyumbang kepada jangkitan kuman seperti lokasi dan keterukan kepatahan tulang tibia, jenis implan dalaman yg digunakan , jangka masa pin

luaran dan jangka masa tiada pin adalah tidak ketara.Kesemua hospital menggunakan protocol rawatan yang sama bagi rawatan kepatahan tulang tibia kompaun. Faktor-faktor penting bagi mengurangkan risiko jangkitan adalah melalui pemberian antibiotik pencegah, pembedahan pencucian luka yang betul dan mengelakkan jangkitan pada pin pembetulan luaran. Kaedah penukaran pembetulan luaran kepada pembetulan dalaman adalah selamat jika ia dirancang dengan betul.

Kata Kunci

Jangkitan, pembetulan luaran, pembetulan dalaman, kadar jangkitan, antibiotik pencegah, pembedahan pencucian luka.

ABSTRACT

Introduction

External fixation is a method of temporary immobilisation of fracture after wound debridement in open tibia fracture before converting to internal fixation. However there is risk of infection following converting external fixation to internal fixation due to direct contact of bone with environment via pin site. We studied the prevalence of infection on patients that underwent conversion of external fixation to internal fixation and their related factors in three hospitals.

Methodology

All patients that fulfil the criteria of our study are reviewed retrospectively. The information are obtained from medical files that has been traced through record office. The result was analysed using Fisher's Exact Test for gender and age, Chi-Square for grade and site of fracture, duration of external fixation, period of free fixator and types of internal fixation. All the statistic values are calculated using SPSS 26.

Result

There are total 61 patients that underwent conversion of external fixation to internal fixation in open tibia fracture with prevalence of infection is 16.39%. All the factors that might affect the infection rate such as gender, ages, grade and sites of fracture, types and duration of external fixation, period of free fixators and types of internal fixation showed insignificant value.

Conclusion

The prevalence of infection post conversion external fixation to internal fixation in our study was 16.39% and comparable to other literatures. The factors that might lead to infection such as site and types of fracture, types of internal fixation, duration of external fixation and period of free external fixator were insignificant. All the hospitals had followed same protocol in managing open tibia fracture and the most important factor in preventing or reducing risk of infection were prophylactic antibiotic, adequate wound debridement and to avoid pin site infection. It is safe to convert external fixation to internal fixation if it is planned properly.

Key Words:

Infection ,open fracture, external fixation, internal fixation, prevalence, prophylactic antibiotic, wound debridement.

CHAPTER 1 : INTRODUCTION

1.1 Study Background

External fixation is a method used in treatment of extremities injury especially open fracture and commonly uses in open fracture tibia. There are few advantages by using this method, firstly it is simple and save time. Apart from that external fixation is minimally invasive with minimal blood loss. It is suitable in polytraumatised patient that require immediate stabilisation and fractures with extensive soft tissue injury.

Open tibia fractures are frequently seen than femur fracture or upper extremities due to lack of soft tissue coverage, over 15% of tibia fracture is open fractures. Current method of stabilisation of closed and grade 1 open tibia fracture is intramedullary nailing, however there is controversial in open fracture grade 2 and 3, whether to debride and stabilised with external fixation or primary internal fixation.

There is increased risk of infection by using external fixation due to direct contact of bone with the environment. Increasing age, multiple medical co-morbidities and smoking are the factor associated with infection. Currently several studies has focused on conversion of external fixation to internal fixation however there is no proper guidelines on the strategy.

1.2 Rationale of study

Currently there is lack of data in our population regarding the prevalence of infection in open tibia fractures following conversion of external fixation to internal fixation and no proper protocol for the conversion of external fixation to internal fixation. From this study, we can develop measures that can be taken in preventing or reducing the infection.

CHAPTER 2 : RESEARCH QUESTIONS AND OBJECTIVE

2.1 Research questions

1. What are the prevalence of infection of tibia bone following conversion of external fixation to internal fixation?

2. What are the factors that associated with infection in conversion of external fixation to internal fixation?

3. What are the types of infection that will occur?

2.2 General objective

To study the prevalence of infection in patient with open tibia fracture (grade 2 and 3) that underwent conversion of external fixation to internal fixation and its associated factors among patients in HUSM,HRPZ 2 and HOSHAS.

2.3 Specific Objectives

1. To study the prevalence of infection in patient with open tibia fracture that underwent secondary internal fixation

2. To determine the associated factors for infection post conversion of external fixation to internal fixation

3. To describe the characteristic of each risk factor with infection including grade of open fracture, location of fracture, duration of external fixation, types of internal fixation and external fixation, period of free fixator.

4. To describe the types of infection that will occur following conversion of external fixation to internal fixation

CHAPTER 3: MANUSCRIPT

3.1 TITLE

THE PREVALENCE OF INFECTION FOLLOWING CONVERSION OF EXTERNAL TO INTERNAL FIXATION IN OPEN TIBIA FRACTURE

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All patients that fulfil the criteria of our study are reviewed retrospectively and the information are obtained from medical files that had been traced through record office. The result was analysed using SPSS 26.

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There are total 61 patients that underwent conversion of external fixation to internal fixation in open tibia fracture with prevalence of infection is 16.39%. All the factors that might affect the infection rate such as gender, ages, grade and sites of fracture, types and duration of external fixation, period of free fixators and types of internal fixation showed insignificant value.

Conclusion

The prevalence of infection post conversion external fixation to internal fixation in our study was comparable to others literature. All the hospitals were followed same protocol in managing open tibia fracture and the most important factor in preventing or reducing risk of infection were prophylactic antibiotic and adequate wound debridement.

Key Words:

Infection ,open fracture, external fixation, internal fixation, prevalence, prophylactic antibiotic, wound debridement.

3.3 INTRODUCTION

In managing severe open tibia fractures, most of orthopedic surgeons have been obliged to use and external fixator to gain initial bony and soft tissue stability after wound debridement [1-2]. Advantages of external fixator are easy application, minimal blood loss, less invasive and time saving [3] . However, there are several complications in related to usage of external fixator, they are delayed union, non-union, malunion and joint stiffness. For these reasons, external fixator should be converted to internal fixation such as intramedullary nailing and plating. Unfortunately, the conversion of external fixation to internal fixation either intramedullary nailing or plating has been associated with deep infection [3] and subsequently formation of chronic osteomyelitis as previously reported in the literatures. In all our institution where the sites of study had been carried out, strict protocol of open fracture management and conversion of external fixation had been followed to minimize the risk of infection. All the cases that underwent conversion before two weeks, the external fixator was removed within 48 hours before fixation with internal fixation using aseptic technique and the entire pin area was cleaned and cover with povidone sterile drapes. In cases that underwent conversion after 2 weeks, the external fixator was removed in aseptic technique and the pin site was dressing with the fracture temporarily immobilized with full length back slab until external fixator wound healed and blood parameter did not showed evidence of acute or chronic infection before definitive internal fixation.

Our aim in designing this retrospective study is to determine the prevalence of infection after conversion of external to internal fixation in open tibia fractures and investigate risk factors for the development of infection.

3.4 METHODOLOGY

This study was conducted in three orthopedics center in East Coast of Malaysia namely Hospital Universiti Sains Malaysia (HUSM), Hospital Raja Perempuan Zainab II (HRPZ II) and Hospital Sultan Haji Ahmad Shah (HoSHAS) between January 2017 until December 2019. All patient with open tibia fracture were treated based on grade. The inclusion criteria are age of 15 to 45 years old without medical illnesses whereas the exclusion criteria are polytrauma patients and pre-existing infection. All the cases started with short-term broad-spectrum antibiotics combined with aminoglycosides for grade 3 as prophylactic base on National Antibiotics Guideline, anti-tetanus, wound irrigation with at least 3 to 6 liters normal saline, wound debridement and skeletal stabilization using external fixator. In very severe soft tissue contamination and injury, second look debridement was repeated within 48 hours. Surgical debridement and skeletal stabilization were done as emergency within 48 hours, and some cases were delayed up to 72 hours. All the wound with the severely injured soft tissue and contaminated were left open and closed as delayed primary suturing and there are cases that need skin graft before conversion to internal fixation.

AO Synthase, Aesculap and Stulla Heis B Braun were used as external fixator with stainless steel 16mm threaded and size of pin diameter was 5 mm until soft tissue healed completely by evidence of wrinkle sign and reduction edema or swelling.

When plan for conversion of external fixation to internal fixation, all the cases that retained external fixator more than 2 weeks were followed up in clinic. The soft tissue condition, signs of pin site infection, plain radiograph and inflammatory markers such as erythrocyte sedimentation rate (ESR), C-Reactive Protein (CRP). Once all these parameters are normal and no signs of infection clinically and radiologically, patients will undergo definitive internal fixation as elective cases. There are three options of internal fixation namely intramedullary nail for diaphyseal fracture and plate for metadiaphyseal fracture. Prior to

definitive internal fixation, patient was admitted 1 day earlier and reassess again the soft tissue, pin site and blood parameters. Most of the cases with more than 2 weeks external fixator, the external fixator was removed in clinic using aseptic techniques and fracture immobilized temporarily using full length back slab to allow for pin holidays. The pin sites were dressing either with povidone iodine or chlorhexidine. Preoperatively for definitive fixation, second generation cephalosporin namely IV Cefuroxime 1.5g was given within 1 hour before the operation as prophylactic antibiotic in all centers.

Post operatively, the patients were discharged at day 3 after wound inspection provided the wound is clean and no signs of infection and was advised for wound dressing at the nearest clinic. At 2 weeks post operatively, the patients were reviewed in clinic and any signs of infection are documented and treated. The subsequent followed up at 6 weeks interval to look for evidence of bony union as well as signs of infections.

In our study, Surgical Site Infection (SSI) were diagnosed based on CDC criteria January 2021 and it is divided into superficial surgical site infection and deep surgical site infection. Patient should have at least one of the following criteria such as superficial purulent drainage, organism(s) isolated from specimen and incision made by a surgeon with the signs and symptoms of infection; localized pain, swelling, erythema or warm for diagnosing superficial surgical site infection [4]. In deep surgical site infection, patient should meet one of the criteria; deep incision pus drainage, wound breakdown and deep collection with signs and symptoms of infection such as high-grade fever (>38-degree Celcius) [4].

3.5 RESULT

There are total of 61 patients from all the 3 centers where 21(34.40%) from HUSM, 18 (29.50%) from HRPZ II and 22 (36.10%) from HoSHAS. Seven cases infected from HoSHAS followed by 3 cases from HRPZ II. Predominantly higher number of male compares to woman involved motor vehicle accident which is 50 (82%) and 11 (18%) respectively with the age of 15 to 25 years (mean of age is 19.87) old are highest. Common site of open tibia fracture in our study was midshaft followed by distal tibia, 49.20% and 37.70% respectively with most of them were grade 3. The p values for gender, age and sites of fracture were insignificant, where the $p > 0.05$

We found that in our study, there were 10 cases of deep infection with prevalence of 16.39%. This prevalence was comparable with previous literatures. Nine out of ten infected cases had undergone wound debridement and treated with a course of antibiotic based on culture and sensitivity. On subsequent follow up at 6 weeks and 3 months, the bone showed signs of union and the septic parameters were normal. All the patients start to partial weight bearing at 6 weeks post-operative. Common organism that had been isolated in our study were *Staphylococcus Aureus, Streptococcus Pyogenes, E Coli and Pseudomonas Aeruginosa*. Out of 10 infected cases, organism(s) was isolated from 7 patients with no growth in 2 patients and no culture taken in 1 patient. *Pseudomonas Aeruginosa* was isolated in 2 patients, *Staphylococcus Aureus* growth in 2 patients, MRSA was found in 2 patients and *Streptococcus Pyogenes* and *E.Coli* isolated in 1 patient. Only 1 case treated with intravenous and oral antibiotic, another 9 infected cases underwent wound debridement with antibiotic and out of 9 cases, 5 of them need removal of implant. There was 1 patient developed chronic osteomyelitis.

All the 10 cases presented with purulent discharge from surgical site, pain, swelling and erythematous. The clinical examination showed erythematous, sinus and tender at the surgical site. Intraoperatively we found there was deep collection abscess with sinus communicating with the bone and most of them had isolated organisms from tissue culture where it is fulfilled the criteria of deep infection.

Despite of normal all infective parameters, clinical and radiological assessment, the infection still can occur. Range of infective parameters such as ESR was 2.0-53.0mm/hr, CRP : 0.02-7.2mg/L and no signs of infection on plain radiograph. All the risk factors that had been evaluated in our study such as duration of external fixation, period of free fixators and type of internal fixation showed no significant value ($p>0.05$). There were 34(55.7%) patients that had been on external fixation less than 6 weeks with mean duration of 20.21 days, 42 (68.9%) of patients were kept with pin free holidays of more than 2 weeks (mean duration of 88.30 days). Intramedullary nail frequently used for conversion which was 43 (70.5%).

TABLE I: Demographic characteristics and risk factors for infection in open tibia fracture patients

Risk factors	All patients (n=61)	Infected patients (n=10)	Non-infected patients (n=51)	p value
Location				
HUSM	21 (34.4 %)	0	21 (100 %)	0.011
HRPZ II	18 (29.5 %)	3 (16.4 %)	15 (83.3 %)	1.000
HoSHAS	22 (36.1 %)	7 (31.8 %)	15 (68.2 %)	0.027
Gender				0.673
Male	50 (82.0 %)	9 (18.0 %)	41 (82.0 %)	
Female	11 (18.0 %)	1 (9.1 %)	10 (90.9 %)	
Age				
15-25	32 (52.5 %)	4 (12.5 %)	28 (87.5 %)	0.496
26-35	18 (29.5 %)	4 (22.2 %)	14 (77.8%)	0.462
36-45	11	2 (18.2 %)	9 (81.8 %)	1.000
Grade				
I	4 (6.6 %)	0	4 (100 %)	0.36
II	9 (14.8 %)	1 (11.1 %)	8 (88.9 %)	0.643
III	48 (78.7 %)	9 (18.8 %)	39 (81.3 %)	0.339
Site of fracture				
Proximal	8 (13.1 %)	2 (25.0 %)	6 (75.0 %)	0.481
Distal	23 (37.7 %)	3 (13.0 %)	20 (87.0 %)	0.582
Midshaft	31(49.2%)	5 (16.1 %)	26 (83.9 %)	0.955
External fixation				
Conventional	61	10 (16.4 %)	51 (83.6 %)	
Ring	0	0	0	
Duration of external fixation				0.767
< 6 weeks	34 (55.7 %)	6 (17.6 %)	28 (82.4 %)	
> 6 weeks	27 (44.3 %)	4 (14.8 %)	23 (85.2 %)	
Period of free fixator				0.405
< 2 weeks	19 (31.1 %)	2 (10.5 %)	17 (89.5 %)	
> 2 weeks	42 (68.9 %)	8 (19.0 %)	34 (81.0 %)	

Internal fixation				
Plate	17 (27.9 %)	3 (17.6 %)	14 (82.4 %)	0.869
IM Nail	43 (70.5 %)	6 (14.0 %)	37 (86.0 %)	0.426
Screw	1 (1.6 %)	1 (100 %)	0	0.023
Type of infection				
Deep	10	10 (100 %)	0	
Superficial	0	0	0	

Fisher's Exact Test: Location, Gender, Age
Chi-square: Grade, Site of Fracture, Type of External fixation, Duration to external fixation, Period of free fixator, Types of Internal fixation
The values are given as the number of patients with the percentage in the parentheses unless otherwise indicated.
*The difference was significant at $p < 0.05$.

3.6 DISCUSSION

The prevalence of deep infection after immediate intramedullary nailing was high for open tibia fracture due to contamination of the entire medullary and lead to pan diaphyseal osteomyelitis. The application of external fixation is thought to be beneficial to provide fracture and soft tissue stabilization and preventing further damage by restoring bone length and alignment with less time and surgical exposure [5,6]. Prolong use of external fixation for definitive procedure always complicated with late pin tract infection, non-union and malunion [7], however it is safe if the two stage treatment is planned properly[5].
Current studies showed that primary intramedullary nails are better than external fixation as definitive treatment of open long bone fractures in terms of infections, non-union, malunion and reoperation rate [1,7]. In addition, primary intramedullary nailing have same benefit as delayed intramedullary nails after external fixation in term of union, malunion, and non-union rate with a lower rate of deep infection compared to delayed intramedullary nails [1] , this is supported by a clinical studies showed that superiority of intramedullary nailing in term of low risk of deep infection and improved fracture healing[8].It is reported that the infection rate is increasing with increase the grade of open fractures[5].

The reported rate of infections for treatment of open tibial shaft fractures with external fixation range from 7% to 30% depending on severity of the fracture. Malunion rates range from 10.5% to 46% and non-union is reported in 11% to 48%. Conversion of external fixation to nailing and plate was associated with high risk of osteomyelitis and pin tract infection is main problem that led to osteomyelitis[10,11]. Rate of pin tract infection based on literature is between 21% to 42%. It occur due to communication between environment and bone [9] . Redness with persistent discharge from the pin tract or positive bacterial cultures may suggest the infection[9-10] . In case of pre-existing pin tract infection, there is increase rate of deep infection after internal fixation with intramedullary nailing [1,10-11] . In a study by *Nikolas H. Kazmers et al*., risk of intramedullary infection is increased from 6% to 70% with the presence of pin tract infection in patients undergoing conversion to internal fixation [11] . There is still debatable on the optimum time for conversion of external fixation to internal fixation [12] . Based on the international consensus with level of evidence is IV, optimum result for conversion should be less or equal to two weeks [13] with at least 9 days of pin holidays[9,14-16]. However there is still controversial regarding time of pin holidays[10] .It has been reported in a literature, keeping external fixation more than two weeks is associated with pin tract infection[11,17] . To prevent or reduce pin tract infections, there are several methods of pin care namely frequent clean with saline or antiseptic, protection pin site with dry gauze, use of hydroxyapatite-coated pins [9] and short duration of external fixation[2-3,8]. Delayed conversion of external fixation was associated with higher incidence of infection [1,16,18] due to colonization of bacterial over the pin site and subclinical pin tract infection. However as reported by *Emmanuele Santolini et al*., there is no significant correlation in between time of conversion and rate of deep infection, this has been supported by other multiples literatures that has been published [17] . The conversion should base on the soft tissue and patient's condition[16]. As reported by *K. A. Siebenrock et al.*,

early conversion as soon as soft tissue have healed may decrease the infection rate[6,10] . Reported by *Takashi Noumi et al*., severity of soft tissue injury became contributing factor toward risk of deep infection [14] . From our study, delayed conversion did not increase the rate of infection provided that in late conversion protocol of removed and delayed surgery with strict parameter to exclude infection prior to intervention such as patient's general condition, soft tissue and inflammatory markers including erythrocyte sedimentation rate (ESR), C-Reactive protein (CRP). Pre existing pin tract infection should be consider as contraindication for conversion [3,10] unless it has been treated completely[3] .

As reported by several literatures, most of infection in open fracture wounds are nosocomial mainly enteric flora [19]. It was documented by several authors the beneficial effect of prophylactic antibiotic coverage against most of the organisms that might develop infection. A study by *W I Faisham et al*, gram positive organisms are the main contaminant in open tibia fractures, but infecting organisms are gram negative or MRSA. In our series, the infecting organisms are from gram positive, gram negative and MRSA. All these infecting organisms cause surgical site infection in open fracture was mentioned in a paper by *Priscila Rosalba Oliveira et al*. All the infected cases were treated based on targeted culture therapy such as cloxacillin, cefuroxime, rifampicin and vancomycin with duration of antibiotic range from 2 weeks to 6 weeks in addition with wound debridement.

3.7 CONCLUSION

In conclusion, conversion of external fixation to internal fixation in open tibia fractures is an effective treatment method for open tibial fractures. Based on our data as well as on literatures review, there is no significant risk of infection following conversion of external fixation to internal fixation when the procedure is done with absence of pre-existing pin tract infection . Principally the conversion can be done as soon as patients or local soft tissue

permit. Alternatively, if present of pin site infections, two-stage conversion can be performed after resolving the infection.

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