ORIGINAL ARTICLE

Compartment Pressure Changes after Closed Reamed and Unreamed intramedullary nailing for fracture Tibia

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ABSTRACT

Objectives: The objectives of this study are to:1) Measure the anterior compartment pressure changes after closed reamed and unreamed intramedullary nailing for fracture tibia. 2) Evaluate the risk of compartment syndrome with reamed intramedullary nailing as compared to unreamed nailing

Study Design: Quasi experimental study.

Place and Duration: The study has been carried out at Orthopedics Department Sheikh Zayed Hospital, Lahore from 21st January 2016 to 20th October 2016.

Methodology: A total no of sixty cases were taken which were divided into two groups. All the patients between 18-65 years of age with closed fracture of tibia were admitted in orthopedics ward through emergency department. They were divided into two management groups randomly by using a random number table. Group A was dealt with reamed intramedullary nailing and B with un-reamed intramedullary nailing. The compartment pressure changes were measured in both groups.

Results: Majority of the patients in both groups were males. The mean age in Group A was 35.97±15.51 and in Group B were 35.30±12.29 years. Postoperative compartment pressure in Group A was 19.60±4.36mmHg and in Group B was 16.37±3.79mmHg. Both the values are clinically non-significant.

Conclusions: We concluded that reaming is not a significant cause in the development of compartment syndrome.

Keywords: Compartment Pressure, Compartment Syndrome, Reamed Intramedullary Nailing, Un-reamed Intramedullary Nailing.

Introduction

Compartment pressure is the pressure within a closed relatively non compliant osteofascial compartment containing skeletal muscles. Inelasticity of these boundaries does not allow the raised pressure to dissipate easily.[1]

Different methods for measurement of compartment pressure have been introduced in the past three decades including Wick catheter method, needle injection technique of Whiteside, continuous infusion technique and slit catheter technique.[2,3] Needle injection technique of Whiteside is an infusion technique in which a minute quantity of saline is injected to a closed compartment. Normal compartment pressure is between 0-8mmHg if the pressure exceeds 30mmHg. In addition to the above-mentioned techniques, diagnostic equipment like apparatus to measure peripheral oxygen saturation and Doppler ultrasound can help in the diagnosis.[4] Fractures of tibia constitute about 16.95% of all the bone fractures presented in an emergency. Risk of developing compartment syndrome is very high in tibia shaft fractures. About 45% of all the cases of compartment syndrome have tibia fractures.[5]

For management of tibia shaft fractures, one of the most acceptable methods is closed intramedullary nailing. Intramedullary nailing can be done by reaming or without reaming of the intramedullary canal prior to insertion of nail.[6]

Reaming may increase the compartment pressure and studies showed increased risk of compartment syndrome especially for fracture tibia.[7]

The classical signs of pain, pallor, paralysis and pulseless could not entirely be relied upon and for early diagnosis, measurement of intra compartmental pressure is essential.[8] Tissue pressure in mammals, the technique did not become popular as injection

of saline produced local oedema and the needles had very small pick up area.[9]

Wick catheter technique was developed by Scholander and collaborators in 1968 for measuring acute pressures in subcutaneous, intramuscular and peritoneal spaces in animals.[10]

Compartment pressure measurement in the anterior tibia compartment in healthy volunteers using microtip probe. They demonstrated that this method provides reliable data and can be used in acute cases as well as for a long-time measurement.[11]

In 1988 Brian and associates used a prototype handheld, digital, fluid pressure monitors to measure the intra-compartment pressure. Their study, in which 50 paired, single-blind measurements were taken, revealed that the digital monitor was accurate to ± 0.8 millimeters of mercury of actual pressure with no individual reading more than 1 millimeter of mercury from the actual pressure when compared directly with a mercury and a water column.[12]

A prospective study on seven cases of tibia fractures treated by intramedullary nailing who had continuous monitoring of pressure in deep posterior compartment. Their data revealed that pressure can become relatively high during the procedure, which included traction, reaming of the walls of the medullary cavity and insertion of an intramedullary nail and suggested that such patients need close clinical observation.[13]

Coworkers demonstrated the accuracy of a common readily available pressure transducer system (intravenous alarm control) pump comparing it with miniaturized digital fluid pressure manometer (stryker) and Hewlett packard manometer (HP 78532B) which was accurate within 2.4 millimeter mercury difference of the HP78532B and stryker manometers.[14]

Methodology

Clinical Presentation of Compartment Syndrome: The features of ischemia are the five Ps: Pain, par aesthesia, pallor, paralysis and pulseless.[16]

PAIN: Pain is persistent, progressive and unrelieved by immobilization. It is aggravated by passive stretching of the ischaemic muscle. An increased requirement for analgesia should arouse suspicion.[17]

Operational Definitions

Compartment Pressure: It is the interstitial pressure in closed osteofascial compartment. Normal compartment pressure is between 0-8mmHg.

Compartment Syndrome: Compartment syndrome is an elevation of the interstitial pressure in a closed osteofascial compartment that results in microvascular compromise.

Evaluation of Risk of Compartment Syndrome

Evaluation of risk of compartment syndrome was done by measuring compartment pressure changes and also by the signs and symptoms like pain, out of proportion, paraesthesia, pallor, paralysis and PULSELESS.

Inclusion Criteria: Patient with either sex between 18-65 years of age who underwent closed reamed and unreamed intramedullary nailing for a closed fracture of tibia were studied.

Exclusion Criteria: a) Open fractures. B) Pathological fractures. Intra-articular fractures. C) Fractures with neurovascular damage. d) Revision surgery.

Surgical Treatment

Indication for Surgical Decompression: Compartments demonstrating equivocal or ambiguous clinical signs in the presence of significantly elevated intra compartmental pressure are also decompressed.[18]

Techniques of Surgical Decompression: The goal of surgical decompression in compartmental syndrome is the expedient, complete opening of all tight fascial envelopes. One may be tempted to, by doing a faisciotomy through limited skin incision or by not decompressing all of the potentially involved compartments. In a significantly involved limb, limited skin incisions or subcutaneous fasciotomy are not used for two reasons. First, complete decompression of all fascial and epimysial envelopes cannot be assured; and second the postischemic hyperemia and swelling that are expected within the first hour after decompression of an ischemic compartment may well cause a secondary compartmental syndrome within the intact cutaneous envelop.[19]

Through each of the four osseofascial compartments of the leg courses a nerve, important not only in diagnosis of the compartment syndrome but also in the surgical approach.[20]

Anterolateral Approach: The lateral compartment fasciotomy is made just anterior and parallel to the fibular shaft.[21]

Posteromedial Approach: Where the skin incision for the anterolateral approach is centered in the midportion of the lower leg, the posteromedial incision should be centered slightly distal to this, in order to identify the deep posterior compartment as it becomes superficial distally. A vertical incision is made 15 to 25 cm long, depending on the posteromedial tibial border. The superficial posterior compartment is decompressed first. Then the deep compartment fusciotomy is extended distally behind the medial malleolus and proximally beneath the soleus bridge. The distal end of the soleus bridge varies from case to case and if it extends distally more than halfway down the tibia, it may be necessary to release the soleus bridge partially from its tibial

attachment, in order to complete the proximal portion of deep compartment fasciotomy. In cases of massive swelling, complete detachment of the soleus bridge may be necessary.[22]

Post-Operative Management: If the diagnosis is made early and there is relatively little swelling, primary skin closure may be possible. In the case of a large open wound, split-thickness skin grafting is often necessary. Splinting may also be necessary to prevent contracture. Routinely, apply a posterior splint to hold ankle in neutral to prevent any plantar flexion contracture. In presence of a tibial fracture, external fixation has proved very useful not only in immobilizing and treating the fracture primarily but in facilitating wound management as well.[23,24]

Data Collection Procedure: All the patients between 18-65 years of age with closed fracture of tibia were admitted in orthopaedic ward through the emergency department. They were asked to sign an informed consent form for including them in the either group and using their data in research. They were divided into two management groups randomly by using a random number table. There was no extra risk involved and both methods were ethical. Group A was dealt with by reamed intramedullary nailing and B by unreamed intramedullary nailing. They were matched for age, sex, type of fracture and duration of fracture to avoid any bias.

The demographic features along with the history of the fracture were obtained. In each case compartment pressure was measured 24 hours before operation by using white side needle injection technique and again compartment pressure was measured within four hours after surgery by the same method and at both times diastolic blood pressure was also recorded and delta P values [(diastolic blood pressure) – (compartment pressure)] were also calculated and the patients were observed up to 24 hours after operation for any signs and symptoms of compartment syndrome like pain, out of proportion, paraesthesia, pallor, paralysis and PULSELESS.

With proper aseptic technique and after sterile preparation of the extremity, the point of insertion of the needle in the anterior compartment was marked which was within 5cm from the fracture site and 1.5cm lateral to anterior tibial crest the site was prepared with povidone iodine and skin anaesthetized with plain xylocin without epinephrine.

The collected information were entered into the SPSS version 21 and analyzed.

The general variables were included demographic (age, sex), history of fracture (type of trauma) and extent of damage by examination. These were presented as simple descriptive statistics giving mean and standard deviation of each group for their numeric values and "t" test was applied for significance. The outcome investigation was listed as frequencies and proportions.

The outcome of procedures was provided the scaled observation for comparison of success or failure. These were compared for significance between the two groups by testing their statistical significance. Chi-square test was used as the outcome of qualitative data. A p-value of 0.05 or less was taken as significant.

Results

A total of 60 patients were included in the study. These were divided in two groups. Group A consisted of patients with tibial shaft fractures fixed with reamed intramedullary nailing whereas Group B contained those patients who underwent un-reamed intramedullary nailing of tibial fractures.

Out of 30 patients in Group A 25 (83%) were males and 5 (17%) were females. Similarly in Group B 26 (87%) were male patients and 4 (13%) were female patients (Table I).

Table I: Gender distribution of patients between two groups (n=60)

Sex	Group A (n=30)		Group B (n=30)	
	No. of Patients	Percentage	No. of Patients	Percentage
Male	25	83.0	26	87.0
Female	5	17.0	4	13.0
Total	**30**	**100.0**	**30**	**100.0**

The age ranged from 20 to 50 in Group A and 23 to 47 in Group B. Mean age of patients included in Group A was 35.97±15.51 years and that of Group B was 35.30±12.29 years. Majority of patients 12 (40%) in both groups were in the age group 17-27 years (Table II).

Table II: Age distribution of patients in both Groups (n=60)

Age Range (years)	Group A (n=30)		Group B (n=30)	
	No. of Patients	Percentage	No. of Patients	Percentage
18-27	12	40.0	12	40.0
28-37	7	23.0	8	27.0
38-47	3	10.0	3	10.0
48-57	3	10.0	2	7.0
>57	5	17.0	5	16.0
Total	**30**	**100.0**	**30**	**100.0**

Group A: Mean±SD 35.97±15.51
Group B: Mean±SD 35.30±12.29
P >0.05

The total duration of hospital stay in Group A was 10.47±5.01 days where as in Group B it turned out to be 10.40±5.05 days (Table III).

Road traffic accidents were observed to be the major cause of injury in Group A 27 (90%) and 28 (93%) in Group B (Table IV).

Table III: Comparison of hospital stay of patients between two groups (n=60)

	Group A (n=30)	Group B (n=30)	P value
Mean±SD	10.47±5.01	10.40.±5.05	P >0.05

Table IV: Mode of injury of patients in both groups (n=60)

Mode of Injury	Group A (n=30)		Group B (n=30)	
	No. of Patients	Percentage	No. of Patients	Percentage
Fall from stairs/height	1	3.0	2	7.0
Fall of heavy weight over both legs	1	3.0	0	0
Road traffic accident	27	90.0	28	93.0
Fight	1	4.0	0	0
Total	**30**	**100.0**	**30**	**100.0**

Middle 1/3 of tibial shaft was fractured in 18 (60%) and 21 (70%) in Group A and Group B respectively followed by distal 1/3 of tibia which was fractured in 10 (33%) in Group A and 7 (23%) in Group B (Table V).

Table V: Different diagnosis of patients in both groups (n=60)

Diagnosis	Group A (n=30)		Group B (n=30)	
	No. of Patients	%	No. of Patients	%
Fracture proximal 1/3rd of tibia	2	7.0	2	7.0
Fracture middle 1/3rd of tibia	18	60.0	21	70.0
Fracture distal 1/3rd of tibia	10	33.0	7	23.0
Total	**30**	**100.0**	**30**	**100.0**

The comparison of preoperative compartment pressure in Group A patients and Group B patients showed pressures of 11.87±3.45mmHg (ranged 5-20mmHg) and 12.43±3.53mmHg (ranged 8-18mmHg) respectively (Table VI).

Table VI: Comparison of preoperative compartment pressure in mmHg between two groups (n=60)

	Group A (n=30)	Group B (n=30)	P value
Mean±SD	11.87±3.45	12.43±3.53	P >0.05

Postoperative pressures in patients undergoing reamed intramedullary nailing were 19.60±4.36mmHg (ranged 10-25mmHg) whereas those with un-reamed nailing showed 16.37±3.79mmHg (ranged 8-22mmHg). The difference was statistically significant (p <0.05) (Table VII).

Table VII: Comparison of postoperative compartment pressure in mmHg between two groups (n=60)

	Group A (n=30)	Group B (n=30)	P value
Mean±SD	19.60±4.36	16.37±3.79	P <0.05

Preoperative diastolic blood pressure in group A patients was 78.77±8.37mmHg ranged from 65-95mmHg and in group B patients was 77.50±7.28mmHg ranged from 65-90mmHg. Postoperative diastolic blood pressure in group A patients was 77.13±9.05mmHg ranged from 60-95mmHg and in group B patients was 80.97±10.37mmHg ranged from 50-110mmHg (Table VIII). The difference was statistically significant (p <0.05)

Table VIII: Comparison in preoperative and postoperative diastolic blood pressure in mmHg between two groups (n=60)

	Mean±SD (Group A)	Mean±SD Group B	P value
Preoperative diastolic blood pressure	78.77±8.37	77.50±7.28	P >0.05
Postoperative diastolic blood pressure	77.13±9.05	80.97±10.37	P <0.05

Preoperative delta P value [(diastolic blood pressure) – (compartment pressure)] in group A patients was 66.90±9.67mmHg ranged from 65-85mmHg and in group B was 65.07±7.27mmHg ranged from 55-80mmHg. Postoperative delta p value in group A was 57.53±10.67mmHg ranged from 40-85mmHg and in group B was 64.53±10.18mmHg ranged from 35-88mmHg (Table IX). The difference was statistically significant (p <0.05).

Table IX: Comparison in preoperative delta P and postoperative delta P in mmHg between two groups (n=60)

	Mean±SD (Group A)	Mean±SD Group B	P value
Preoperative delta P	66.90±9.67	65.07±7.27	P >0.05
Postoperative delta P	57.53±10.67	64.53±10.18	P <0.05

There was not even a single case in both groups which showed symptoms or signs of compartment syndrome.

Discussion

Acute compartment syndrome develops when an increase in the pressure within a closed muscle compartment impedes arterial perfusion. The resultant ischemia can have permanent and disabling sequelae. Early diagnosis and decompression of the compartment have been shown to be effective in preventing the soft tissue dysfunction that results from an untreated compartment syndrome.

Impending or early compartment syndrome can be diagnosed by accurate measurement of compartment pressure before the onset of irreversible significant changes.[25]

The study documents the compartment pressure changes in reamed and un-reamed intramedullary nailing for tibial fractures. The mean age in both study groups was 35.97±15.51 years and 35.30±12.29 years. The maximum number of patients in both groups were males 83% in group A and 87% in group B. This distribution can be explained as in our socioeconomic setup males spend more active life who remain outdoors more often for daily activities to earn their living and also in outdoor sports while females stay mostly indoor and are less involved in outdoor chores and sports.

Road traffic accidents were the major cause of injury in both study groups 90% in group A and 93% in group B.

The main reasons for the increased number of road traffic injuries are increasing in the number of motor vehicles, poor enforcement of traffic safety regulations, poor quality of roads and vehicles and inadequate public health infrastructures.[26,27]

This study showed the average hospital stay in group A was 10.47±5.01 and group B was 10.40±5.05. The postoperative compartment pressure in patients who underwent reamed intramedullary nailing was (19.60±4.36mmHg) and in patients who underwent un-reamed intramedullary nailing was (16.37±3.79mmHg).

The critical level of absolute tissue pressure has been variously reported as 30mmHg (Mubarak et al, Blick et al, Hargens et al) 40mmHg (Matsen et al, Koman, Hardaker and Goldner and Schwartz et al) and 45mmHg (Matsen, Winquist, and Krugmire).[28]

There was not even a single case in our study which leads to raised intra compartmental pressure up to the level considered critical for fasciotomy. These results matched with the study of McQueen, Christie, and Court-Brown who studies compartment pressures after reamed intramedullary nailing and they concluded in their study that intramedullary nailing does not increase the incidence of acute compartment syndrome in tibial fractures.[29]

The study showed the mean preoperative delta P values [diastolic blood pressure) – (compartment pressure)] were 66.90±9.67mmHg in group A patients and 65.07±7.27mmHg in group B patients and mean postoperative delta P values in group A patients were 57.53±10.67mmHg and in group B patients were 64.53±10.18mmHg.

The delta P values were greater than thirty millimeters of mercury preoperatively as well as postoperatively in both groups.

However, our study as well as the majority of international studies do not support this finding and in our study also there was not even a single case in both groups which showed raised compartment pressure up to the level considered critical for fasciotomy.

Conclusion

Compartment syndrome does not occur after reamed or un-reamed intramedullary nailing. Reamed intramedullary nailing raises the compartment pressure a few mmHg as compared to un-reamed nailing but this rise in compartment pressure does not reach the critical level. So both techniques are safe in regard to compartment syndrome.

It is concluded that reaming is not a significant cause in the development of compartment syndrome as endorsed by the study and many other international studies. It is recommended that incidence of fat embolism in our setup in reamed versus un-reamed nailing should be studied, to find out its incidence.

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