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Original Work

Evaluation of acute compartment syndrome of extremities in emergency room: a case series of 32 children

Ajai Singh[Ψ], Sabir Ali, Rajeshwar N Srivastava

Department of Orthopedics, King George's Medical University, Lucknow, India

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The aim of this study was to analyze the clinical signs of diagnosis, treatment and follow-up of the pediatric population presenting with acute compartment syndrome in the emergency room at an Institutional Level II trauma center. The study is a prospective case series. Thirty-two samples were selected from Institutional Trauma Centre, King George's Medical University, Lucknow, between January 2005 and December 2010. Children presenting with clinically suspected acute compartment syndrome were studied. These were divided into two age related groups: Group A (children < 14 years) comprising of 12 children and Group B (14 or > to 18 years) comprised of 20 children. Patients' demographics, diagnosis, treatment, follow-up and complications were analyzed. Acute compartment syndrome represents a surgical emergency. The clinical signs predict and corroborate with acute increases in compartment pressure effectively.

KEY WORDS: ***Acute compartment syndrome; Raised compartment pressure; Acute compartment syndrome in children; Acute compartment syndrome and fasciotomy***

INTRODUCTION

Acute compartment syndrome (ACS) was first described by Volkmann in 1881[1]. The management of ACS in adults is well discussed and described, but only a few studies were conducted involving children with ACS[2]. ACS is a diagnostic dilemma in small children, who may not have the ability to provide clinical information, resulting in a delay in the diagnosis and management[3]. The early diagnosis of ACS is a vital factor, which determines the prognosis. The outcome of ACS is determined by the duration of ischaemia, the pressure in osteofascial compartment and causes of increased compartment pressure. If the diagnosis and management is delayed, then this may lead to extensive muscular and neurovascular damage or myoglobinaemia resulting in acute renal failure.

The aim of the study was to evaluate ACS in children in the emergency department at a level II institutional trauma center, so that better evidence of the diagnosis, treatment and outcome of children with ACS can be obtained.

[Ψ]**Correspondence at:** Professor, Department of Orthopedics, King George's Medical University, Lucknow, India; Mobile: +9415022557; Email: as29762@gmail.com

MATERIAL AND METHODS

Approximately 16,000 children and adolescents below 18 years of age were treated since January, 2005 to December, 2010 at level II institutional trauma center. Thirty-two (0.2 percent) children and adolescent who presented with suspected ACS in any anatomical region were included in this prospective case series. All those whose parent / attendant gave written informed consent were included in the study. According to their age, these patients were divided into two groups: Group A (age < 14 years) and Group B (age 14 to 18 years: adolescent). The groups cutoff at the age of 14 years was chosen by us because closure of the epiphyses happens in most humans between the ages of 12–16 years[3].

Patients' demographic records (age, sex, mode of injury, date of injury, the period between the injury and admission, type of injury (bone/soft tissue), the period between admission and definitive treatment, etc. were noted. Other relevant information like adopting diagnostic measures, type of bony immobilization, wound management, numbers of surgical procedures until definitive closure of the wound, the outcome of fasciotomy, total hospital stay, complications if any, and final clinical outcome at the discharge or at the end of 30 days

(whichever may be earlier) were also recorded. The average follow up was 16.9 months (range 9 – 22 months).

All fasciotomies performed were based on diagnosis of ACS made on clinical signs. The clinical signs or symptoms that we used are as follows: significant trauma, tight extremity on palpation, excessive pain sensation, pain on passive stretching, sensory loss and requirement of increased analgesia. All fasciotomies were single incision open type, which were made under sterile conditions in operation theatres under general or regional anaesthesia. Primary closure of fasciotomy was not done in any of the cases. Intra-compartmental pressure measurement was not done in any of the cases studied. Histological examination of muscle tissue was done in all cases to confirm the histological changes with time.

RESULTS

Out of all 32 children (male: 21 and female: 11), twelve children were included in Group A and the rest twenty patients in Group B. Group A: the mean age of twelve children included in this group was 6.9 years (range 2-12 years); out of these nine males were of mean age 9.8 years (2-12 years) and 3 females with mean age of 5.3 years (3-8 years). Nine of twelve (75 percent) sustained the injury while playing (low velocity trauma). Further, no children with ACS, suffering from diabetes mellitus were found in our study. The most common region of injury and traumatic ACS was the forearm (n=8: 66.7 percent) followed by the leg in 3 (25 percent) cases. There was one (8.3 percent) case involving the foot. Group B consists of 20 adolescents aged 14-18 years (mean age – 16.8 years) females (n=6) with mean age 14.6 years (14-16 years) and males (n=14) with mean age 15.3 years (14-18 years). All sustained injury due to road traffic accident (2 wheeler-2wheeler accident). Eighteen (90 percent) developed ACS in the leg and one (5 percent) each in hand and foot. All children and adolescent were having fractures as a cause of ACS. The mean time from injury to admission was 26.1 hours (range 6-72 hours) in group A, while in group B mean time was 28.6 hours (8-36 hours).

In group A, the mean time from admission to fasciotomy was 13.7 hours (range 5.5 – 36 hours), whereas in group B, fasciotomy was performed at mean time 12.8 hours (6.5 – 24 hours). In group A, the eight fractures were treated by external fixators while rest four cases were fixed with K wires. In group B, eleven patients received intra-medullary nails, eight were managed by external fixators and in one patient K wires were used to fix the fracture (**Table 1**). The number of operations from fasciotomy to definite wound closure was 1.9 (range 1-4) in group A, while 2.4 (range 1-6) in group B. The mean hospital stay was 20.4 days (14-28 days) and 26.2 days (21-45 days) in group A and B respectively. There was no significant difference between the two groups on the above parameters. Split skin grafting was performed to close the fasciotomy wound in 29 (90.6 percent) cases and in the rest (9.4 percent) secondary fasciotomy was performed for the closure.

Table 1: Clinical data on injury, diagnosis and treatment

	Patient (n) Mean age(range)	Site of Injury n (%)	Mechanism of Injury	Mean time from Injury to admission	Diagnostics Time from admission to the fasciotomy	Type of fasciotomy	Mean Hospital stay
Group- A	Total (n=12) 6.9 (2-12)	Forearm 08 (66.7) Leg 03 (25) Foot 01 (8.3)	LVT = 09 HVT= 03	26.1 (06-72)	13.7 (5.5 -36)	External Fixator 08 K wires 04	20.4 (14-28)
Group-B	Total (n=20) 16.8 (14-18)	Leg= 18(90) Hand= 01 (5) Foot= 01 (5)	HVT= 20	28.6 (08-36)	12.8 (6.5-24)	Intra-Medullary Nails 11 External Fixator 08 K wires 01	26.2 (21-45)

Table 2: Clinical data of complications after the treatment

Complications	Superficial Wound Infection	Chronic Contracture	Contractures Development	Sensory Deficits	Chronic Osteomyelitis	Delayed Union
Group-A	05(15.6)	04(12.5)	04(12.5)	04(12.5)	00(0.0)	00(0.0)
Group- B	09(28.1)	02(6.2)	06(18.7)	06(18.7)	01(3.1)	01(3.1)

Superficial wound infection was the most frequent complication, developed in 14 (43.7 percent) patients. This superficial infection was controlled by local dressing and debridement. Chronic contractures were developed in 6 (18.7 percent) cases (4 patients in group A and 2 in group B). All these patients were manipulated under general anaesthesia followed by active assisted physiotherapy and corrective splints (**Table 2**). Ten (31.2 percent) patients, including the above-mentioned 6 patients with contractures developed residual sensory deficits in the extremities (4 patients in group A and 6 patients in group B). Chronic osteomyelitis and delayed union were seen in one (3.1 percent) patient each (both belonged to group B). Amputation was not required in any of our patients. We have not seen systemic complications in any of our patients.

DISCUSSION

Studies related to ACS in children are limited. To evaluate the children presenting in the emergency department at a level II institutional trauma center with clinical ACS, the present study was conducted to get better evidence of the diagnosis, treatment and outcome. It has been demonstrated that the most common cause of ACS is traumatic fracture[4].

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In this study, all cases had traumatic fractures as the cause of ACS. Any trauma and bleeding or oedema of any origin within a closed osteofascial compartment may increase the intra-compartmental pressure (ICP). This may lead to ischaemia to muscles and neurovascular structures[5]. Ischemia leads to the muscle membrane leaking fluids and electrolytes[6]. If this ICP remains elevated for a sufficient period, it will lead to decrease in capillary perfusion leading to compromised muscle function and survival along with neurological deficit[7]. Thus, early diagnosis and treatment is vital for a better outcome. In the present study, the mean time from to admission to fasciotomy was 13.7 hours and 12.8 hours respectively for group A and group B. The time difference (0.9 hours) between the two groups was not significant. In a study[3] of 24 cases, the difference between the two groups was 0.8 hours. As increase in ICP can occur as early as 02 hours, but does not often occur until 06 hours. This fact makes it necessary to monitor these patients at short intervals[8]. The exact time of appearance of the first symptom or start of first change could not be documented because of the delay of admission of these children.

The clinical diagnosis of increased ICP is not easy. Pain (severe and out of proportion)[9], pallor paresthesia, paralysis and pulselessness[10] are the cardinal symptoms/signs of ACS. In small children who cannot communicate, patients in coma, uncooperative patients and patients under the influence of regional anaesthesia or deep sedation, the clinical signs can produce a higher percentage of false negative results than true positive patients[11]. It was also observed that pulselessness (of major vessels) is noted only at a late stage[12]. Ulmer *et al*[11] observed that likelihood ratio calculation found that the probability of ACS with only one clinical sign/symptom was approximately 25 percent, whereas the probability was 93 percent with the presence of three clinical signs/symptoms. Clinical diagnosis remains the most important factor in the management of ACS[8]. Our observations confirm the findings of one study[13], which concluded that despite its drawbacks, clinical assessment is still the diagnostic cornerstone of ACS. Compartment pressure measurement can confirm the diagnosis in suspected patients. In the present study, all the diagnoses were made on clinical symptoms and signs. We further agree with the observations[3] that the combination of a significant trauma, tight extremity on palpation, excessive pain sensations, pain on passive stretching, sensory loss and requirement of increase analgesia should give rise to a higher suspicion of increased ICP.

A retrospective analysis by Ferlic *et al*[14], concluded that clinical monitoring is fundamental in order to be able to surgically intervene as soon as possible when needed. Branco *et al*[15] demonstrated that the need for fasciotomy varied as per the injury mechanism and was needed in patients who sustained a combined arterial and venous injury. Choi *et al*[16] had also concluded that the poorly perfused hands are at high risk for vascular repair and compartment syndrome.

Compartment pressure measurement can be made by Wick technique modified by Mubarak *et al*[17] the simple needle manometry by Whiteside *et al*[18] infusion technique by Matsen *et al*[19] slit catheter technique modified by Barners *et al*[20] and side ported needle[21]. But ICP measurements are not always reliable or easily available. They do not necessarily show a true picture of pressure throughout the compartment. Thus, clinical diagnosis based on clinical signs holds good.[22-25]. Edrdos *et al*[3] observed that even if ICP measurements are helpful, it is primarily the clinical signs that lead to the decision to perform a fasciotomy. As ACS is a surgical emergency, in which high level of suspicion is needed, delay in fasciotomy is associated with significantly increased risks which may outweigh any potential benefits. We also performed fasciotomy based on clinical diagnosis only.

The adequate therapy of ACS, after removing of any external source of compression is the decompression of all involved compartments by an open technique[3]. The skin incision alone reduces the ICP by 5-9 mmHg[26]. The subcutaneous technique, used in chronic compartment syndrome, appears to be insufficient in ACS[21]. Like other studies[3,22] skin incisions were kept open after the fasciotomy in the present studies. The fasciotomy wound was closed by secondary suturing in 9.4 percent of our patients, while in the rest, partial thickness skin grafting was used for the same. Contrary to the present study, one study[3] reported direct secondary fasciotomy closure in 87.5 percent of cases, while split skin grafting in 12.5 percent of cases. We are of the opinion that open muscles in fasciotomy wound become edematous and that direct wound closure would further hamper the functional ability of those injured muscles.

Hoffineyer *et al*[27] found marked perifascicular and intra vascular oedema with dissociation of muscle fibers. In later stages, they found atrophy and hypertrophy of muscle fibers with lipid globules appeared in the tissue examined. In a series of 32 children, the authors found necrotic and partially necrotic tissue in the histological examination. In our study, we also observed patchy necrosis of muscle fibers with perifascicular oedema[3].

We observed ischemic contractures in about 18.7% of our cases. In a series of 24 children with acute compartment syndrome, chronic contractures were reported only in 4.2% cases[3]. The probable reason for the higher incidence of these contractures in our series could be poor compliance.

CONCLUSION

In the present study, we conclude that the diagnosis of ACS in children can be challenging. Repeated observation of clinical signs and the presence of three or more clinical signs suggestive of increased intra-compartment syndrome, and emergency fasciotomy are pivotal. Fasciotomy is a surgical emergency and should be performed in sterile conditions only. Timely intervention, prompt follow-up and compliance may avoid all long term and permanent complications.

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