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Conservative Management of Compartment Syndrome with Corticosteroids: An experience from India

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Abstract

Background: Acute compartment syndrome (ACS) is a rare condition characterized by increased pressure in the closed compartments of the limbs resulting in ischemic tissue necrosis. Most of the patients present following limb fractures. Apart from surgical options like fasciotomy, conservative management with corticosteroids have shown to be useful. We conducted this study to understand the changes in intra-compartment pressures in ACS after regular monitoring following corticosteroids treatment. **Material and methods:** Consecutive patients of ACS following closed fractures lower limb fractures of tibia or fibula from June 2021 to February 2022 were included. The intra-compartment pressure was measured using a manometer at the time of presentation and after 3, 6, 12, 24, 48, 72 and 96 hours of treatment with tab Deflazacort 6 mg x 1 tab x tds. The efficacy of treatment was assessed on basis of changes in intra-compartmental pressure and improvement in clinical signs and symptoms

of ACS. **Results:** The study included 30 patients, most (63.3%) suffering from fracture of proximal tibia or fibula (36.7%), presenting with ACS. Mean age was 32.4± 8.6yrs and most (53%) were males. We observed a significant change (p-value<0.05) in the intra-compartment pressures from baseline to 3hrs, 24hrs, 48hrs, 72hrs and 96hrs after corticosteroid treatment. None of these patients suffered from ischemic necrosis or any other complication of ACS. **Conclusion:** Our results suggest that timely diagnosis of ACS in patients with lower limb fractures and early initiation of conservative management with corticosteroids can be a mainstay of treatment in these patients. This conservative approach can avoid surgical intervention and reduce the cost of management.

Words in Abstract: 264

Key words: compartment syndrome; corticosteroids; compartment pressure

Introduction

Compartment syndrome is characterized by increased pressure of the closed compartment resulting in diminished microcirculation of the tissues. It is a rare, acute limb and life-threatening surgical emergency. It happens when extreme tissue pressure develops and rises in a closed muscular compartment. The tissue perfusion is reduced because of raised pressure within an osteofascial compartment, thus leading to ischemia, that can lead to tissue necrosis.

The incidence of compartment syndrome is more in young males, mainly below 35 years of age, with the mean age being 30yrs in males and 44yrs in females. Two-third of the patients usually have associated fractures, with the rate being 1–7.3 per 100,000, annually. Acute compartment syndrome (ACS) is a clinical diagnosis that requires an early intervention. 5 “P” found to be associated with ACS are; Pain, Pallor, Paresthesia, Paralysis, and high intra-compartment Pressure. Other early signs are tingling, numbness, and paresthesia.[1] The diagnosis should be timely and early as delayed treatment may result in loss of limb.[2] The standard treatment of this condition is fasciotomy. However, fasciotomy is often associated with infection of muscles, that leads to amputation of limb in later stages. There are reports of mortality following fasciotomy, suggesting that fasciotomy is not a good treatment modality. Corticosteroids are potent anti-inflammatory agents having a capability of reducing edema. The present study was conducted to assess the role of corticosteroids in managing compartment syndrome.

Materials and Methods

The prospective study was undertaken in Trauma Centre, Sir Sunderlal Hospital, Banaras Hindu University, Varanasi, from June 2021 to February 2022. The study included patients of closed fractures of tibia and fibula with positive clinical signs and symptoms of compartment syndrome. After the approval by the institutional Ethical Committee, nature of study was explained to the participant after which a written consent was obtained. Participants giving their consent for the study were included. Patient with other comorbidities, polytrauma, open factures or under sedation were excluded.

The patients were given tab Deflazacort 6 mg x 1 tab x tds. An indigenously built manometer was used to measure inter-compartment pressure which was measured at the time of presentation and after 3, 6, 12, 24, 48, 72 and 96 hours of treatment.

The manometer used the Whiteside's' technique which employs the following materials - i) One mercury manometer, ii) Two plastic intravenous extension tubes, iii) Two 18-gauge needles, iv) one 20-cc syringe, v) one three-way stopcock, vi) one bottle of bacteriostatic normal saline (Fig 1).[3] The extremity to be measured was cleaned and sterility prepped. Sterile saline was drawn into the 20 ml syringe, which was attached to the three-way stopcock. A single intravenous extension tube was attached to the stopcock and a second 18-gauge needle was attached to its other end. The third unused portion of the stopcock was closed off temporarily. The 18-gauge needle at the end of the extension tube attached to the stopcock was then inserted into the bottle of the saline. Saline was then aspirated without the bubbles into approximately half the length of the extension tube. The three-way stopcock was turned to close off this tube so that the saline was not lost during transfer of the needle. The second extension tube was then connected to the three-way stopcock at its remaining open part and its other end was connected to the manometer. The saline-containing needle was then inserted into the muscle of the extremity to be tested. The stopcock was then turned so that the syringe was opened to both extension tubes, forming a T-connection with a free column of air extending from behind the column of saline into the syringe as well as into the manometer.

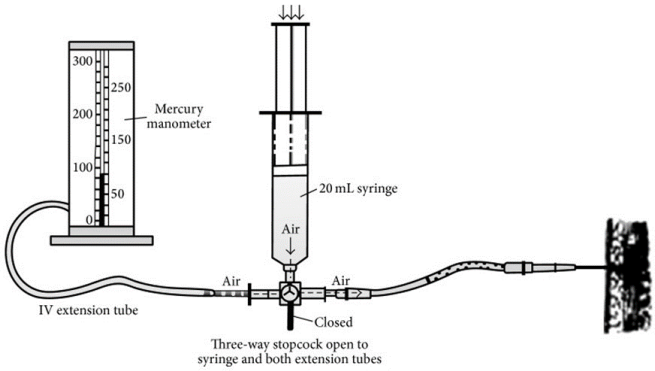

Fig 1. Manometer device for monitoring intra-compartmental pressure

Pressure was increased in the system gradually by slowly depressing the plunger of the syringe while watching the column of saline. As the plunger was depressed, the saline meniscus was altered from a convex configuration to a flat configuration, when the air pressure in the system equals the interstitial pressure in the patient's examined tissue.

The manometer reading at this time was the tissue pressure in mm Hg. Precautions were taken not to depress the syringe plunger too rapidly or placing the needle into the tendon, as these may give a false high reading. A new needle was used for each measurement in order to assure accuracy.

Efficacy of the corticosteroid treatment was assessed on basis of changes in intra-compartmental pressure and improvement in clinical signs and symptoms.

Results

The present study was carried out with enrolment of 30 patients having closed tibia and fibula fractures, with signs and symptoms of compartment pressure. Two-third of the patients (63.3%) suffered from fracture shaft tibia fibula (20% proximal 1/3, 20% middle 1/3, 20% distal 1/3 and 3.3% segmental) followed by 36.7% suffering with fracture of the proximal tibia.

Most of the patients (36.7%) patients were of 31-40yrs age group and only 10% were younger than 20yrs of age. The mean age of patients was 32.4± 8.6yrs. Out of 30 patients, 53% were males and 47% were females. The mean Systolic BP was 135.6±17 and diastolic BP was 86.1±9 with a mean pulse rate of 94.8±15.4 and mean SPO2 of 98.6±1.2. Table 1 shows the blood pressure, pulse rate and SPO2 in all patients. Table 2 shows the mean and range of the compartment pressures measured by the manometer at various time points.

It was observed that a significant change (p-value<0.05) was observed in relation to compartment pressure from baseline to 3hrs, 24hrs, 48hrs, 72hrs and 96hrs after corticosteroid treatment. An insignificant change (p-value>0.05) in compartment pressure was seen from baseline to 6hrs, and 12hrs. Fig 2 and 3 show the presentation and post-treatment outcome in two patients with fracture of proximal tibia.

Fig 2. A 42-year male, teacher by profession, suffered fracture of proximal tibia following a fall from bike. A and B show swelling and blisters in the right leg prior to corticosteroid administration. C and D show the recovery following corticosteroid treatment

Fig3. A 35-year male, shopkeeper by profession, suffered fracture of proximal tibia following a collision between bike and car. A shows swelling of lower leg prior to corticosteroid treatment. C and D shows the recovery following corticosteroid treatment.

Discussion

The incidence of acute compartment syndrome (ACS) is estimated to be 7.3 per 100,000 in males and 0.7 per 100,000 in females, with the majority of cases occurring after trauma. In the present study most patients of ACS were of 31-40yrs age group (mean age 32.43±8.59yrs) and were males (53.3%).

Shadgan B et al. also reported that in their cohort, 772 (69%) were males (mean age 39.6± 15.97 years) and the rest were women (mean age 45.08 ± 19.04 years), with age group of 35-45yrs.[4] It has been advocated that ACS occurs more commonly in males younger than 35, which may be due to a larger relative intra-compartmental muscle mass and increased likelihood of being involved in high-energy trauma.[5]

Aya K et al. mentioned that male gender, age, and lifestyle choices such as alcohol and smoking conferred increased risks. These variables may assist physicians in identifying at-risk patients who may benefit from increased monitoring, and potentially prevent the high morbidity associated with this condition.[6]

Chronic, acute on chronic, and rarely ACS has been recognized in athletes and soldiers who undergo rigorous training, which is due to an increase in volume of muscle in the tight fascial compartment, or repeated trauma. The pressure within that compartment can further increase because of compromise of the microvascular circulation which leads to an accumulation in tissue fluid both intracellularly and extracellularly.[7]

Compartment syndrome is a rare occurrence in the upper limb, a fact attributed to a more compliant fascia and also because the compartments freely communicate with the shoulder girdle, allowing further distribution of oedema and therefore pressure.[8] The incidence of compartment syndrome of the foot is around 6% in patients with foot injuries due to motorcycle accidents, while the incidence of compartment syndrome of the lower leg seems even lower (e.g., 1.2% after closed tibial diaphyseal fractures).[9] Ischemia causes capillary wall damage and a vicious cycle of events result in permanent nerve and muscle dysfunction.

Proximal tibia fractures with compartment syndrome present a challenge for orthopedic surgeons. More often than not these patients are subjected to multiple surgeries and are complicated by infection osteomyelitis and poor rehabilitation.[10]

We observed that out of 30, maximum patients (63.33%) suffered from fracture of shaft tibia fibula (20% proximal 1/3, 20% middle 1/3, 20% distal 1/3 and 3.33% segmental) followed by 36.67% suffering with fracture proximal tibia. Sharma N et al. observed that proximal tibia fractures were more common in males with age range 22-61 years.[10] Similar to our study, Park S et al. classified tibial fractures into 3 groups (proximal, diaphyseal, and distal) based on the anatomic location of the fractures.[11] They observed that the rate of compartment syndrome was highest in the diaphyseal group (8.1%, $P < 0.05$) followed by proximal (1.6%) and distal (1.4%) groups. They

concluded that tibial fractures of the diaphysis are more frequently associated with development of compartment syndrome than proximal or distal tibial fractures.[11]

Burton AC advocated that perfusion within a compartment is only present when the diastolic blood pressure exceeds the intra-compartmental pressure.[12] During vasoconstriction or hypertension, perfusion ceases at even lower pressures. Although it is unclear at which pressure tissue damage occurs, clinical studies suggest a difference between diastolic and intra-compartmental pressure of less than 30 mm Hg as an indication for fasciotomy. In tibial diaphyseal fractures, this threshold detected all patients with compartment syndrome. When intra-compartmental pressure increases to within 10 mmHg to 30 mmHg of the patient's diastolic blood pressure, this indicates inadequate perfusion and relative ischemia of the involved extremity.[5]

The limitations of our study is a small sample size, suggesting that studies should be conducted on larger samples. We have not assessed the various etiological factors causing compartment syndrome. Thus, future studies should be conducted assessing relationship of compartment pressure with various risk factors. Further studies can be conducted to assess the optimum dosage of corticosteroids required to manage compartment pressure.

Early recognition, intra-compartmental pressure monitoring and prompt treatment is the best solution to manage compartment pressure. Fasciotomy has been the mainstay of treatment, but many a times it is associated with a lot of morbidity. Effect of corticosteroids due to its potent edema reducing properties has been studied in compartment syndrome.[13, 14] Thus in present study we assessed the effect of corticosteroids in managing compartment syndrome. We observed the mean compartment pressure at baseline and various time intervals after treatment with corticosteroids.

Our findings show that corticosteroids are useful conservative alternative for treating compartment syndrome. They are safer and better alternatives than surgical management of compartment syndrome.

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Table 1. Vitals and recordings of compartment pressures in thirty patients of compartment syndrome

S.No.	Age	Sex	Vitals				Compartment pressures							
			Sys BP	Diast BP	PR	Spo_2	0hrs	3hr	6hr	12hr	24hr	48hr	72hrs	96hrs
1	18	M	110	78	110	98	36	34	34	30	28	26	16	14
2	22	F	112	98	120	100	36	34	32	32	30	24	18	16
3	39	F	120	100	70	97	38	38	36	34	30	22	14	12
4	45	F	132	99	76	97	40	38	38	36	34	27	16	12
5	43	M	134	80	86	100	42	42	38	36	34	28	16	12
6	42	M	150	76	98	99	40	42	40	38	36	30	22	18
7	39	M	156	74	110	99	42	40	40	38	34	30	22	20
8	30	M	160	80	106	98	44	44	42	40	36	30	22	20
9	28	M	129	88	112	97	38	38	40	36	30	24	18	14
10	29	F	138	100	118	100	38	36	32	32	28	22	14	12
11	17	F	146	90	76	98	46	44	34	34	32	22	16	14
12	22	F	120	94	78	99	44	42	40	40	36	30	24	18
13	33	F	150	75	84	99	40	40	42	36	30	28	16	14
14	39	F	146	77	94	100	36	34	32	30	28	22	18	14
15	40	M	142	99	86	99	38	34	30	30	28	22	16	12
16	45	M	138	94	112	97	36	32	30	32	24	20	16	14
17	41	M	130	93	82	100	38	34	30	30	28	20	12	12
18	37	M	128	85	88	97	36	38	36	34	30	22	18	16
19	32	M	166	88	84	97	40	38	36	32	34	22	14	12
20	28	M	146	80	78	100	42	40	38	32	30	24	16	14
21	25	F	128	75	100	99	44	42	40	40	34	24	18	14
22	24	F	122	77	108	99	40	36	36	30	22	20	18	16
23	19	F	110	80	112	98	40	34	34	34	30	22	16	14
24	22	M	116	90	118	97	36	32	32	30	30	22	16	12
25	30	M	170	92	88	100	44	42	40	40	38	28	20	14
26	31	M	160	94	80	99	42	40	38	36	36	26	18	16
27	35	M	146	96	98	98	44	40	40	38	30	26	22	20
28	45	F	120	75	100	97	38	34	34	30	24	20	18	16
29	37	F	122	77	102	100	36	34	34	32	30	23	18	14
30	36	F	120	80	70	100	38	34	34	30	26	22	12	10

Table 2. Mean values of compartment pressure at different time intervals

Descriptive analysis	0HRS	3HR	6HR	12HR	24HR	48HR	72HRS	96HRS
Mean	39.7333	37.6667	36.0667	34.0667	30.6667	24.2667	17.3333	14.5333
Std. Deviation	3.05053	3.67971	3.69467	3.54219	3.94211	3.30030	2.94001	2.62262
Minimum	36.00	32.00	30.00	30.00	22.00	20.00	12.00	10.00
Maximum	46.00	44.00	42.00	40.00	38.00	30.00	24.00	20.00