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Original Article

Compartment Syndrome and Its Validation in Skeletal Injuries

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ABSTRACT

Background: Compartment syndrome, a potential limb-threatening condition in acute traumatic situations following different modalities of injury, may lead to irreversible damage or even life risk later. Its differential time-bound clinical presentation with added observer bias on available invasive and noninvasive diagnostic modalities influences the decision-making and undue delay for early intervention toward limb salvage procedure.

Results: Thirty-two patients were included in our study with mean age of 36; males (18; 56.3%) were more injured than females (14; 43.8%) and left limb (17; 53.1%) was more involved than right (15; 46.9%). Mean calf muscle measurement of total injured limb with relation to immediate time was 39.9 cm, after 1 hour was 40.69 cm, after 2 hours was 41.06 cm, and after 3 hours was 41.40 cm; 95% confidence interval was found to be statistically significant. Three patients (9%) underwent emergency decompression fasciotomy, with an average mean of 41.4 cm for injured limbs against 38.5 cm in control limb.

Conclusion: Compartment syndrome is an acute emergency with potential irreversible damage when undiagnosed. Bias on diagnosis evolves around observer skills and clinical invasive and noninvasive methods, with differential statistical results pertaining to its decision-making for emergency fasciotomy.

Keywords: Compartment syndrome, Inch tape, Decompression and fasciotomy

INTRODUCTION

Compartment syndrome is a condition in which there is increased pressure within the body, in the anatomical regions of paired bone areas commonly like the forearm and leg, resulting in insufficient blood supply to tissues within that space. It is a potential limb-threatening condition in acute traumatic situations with differential time-bound clinical presentation of individual symptoms, and observer bias on available invasive and noninvasive diagnostic modalities influences the decision-making for limb salvage procedures and its sequelae.[1,2] In this study, we aim to predict the chances of impending compartment syndrome in acute leg fractures by a noninvasive method using an inch tape only for circumferential measurement on hourly basis around the maximum swelling area of the traumatized limb.

MATERIALS AND METHODS

This study was conducted at our hospital, from June 2018 to January 2020. It was a prospective, observational case-control and single-blind study. Study population includes all acute closed lower-limb fractures presenting to our emergency department within 6 hours of the injury.

Inclusion criteria

All acute closed single-leg fractures (like isolated tibia or both tibia and fibula fracture) presenting within 6 hours of injury were included in the study. A simple inch tape calibrated in centimeters was used to measure the circumference of the fractured limb at maximum swelling site; measurement starting from immediate time (as and when patient arrived at emergency department) to next 3 hours was performed on timely basis, keeping the opposite noninjured limb calf girth measurement as control.

Exclusion criteria

Cases with bilateral lower-limb fracture, open-leg fractures with or without neurovascular injury, post amputee and pediatric leg injuries, neuromuscular limb fracture, ipsilateral ankle and tibial plafond fractures, knee dislocations, polyskeletal trauma, and previously operated limb with or without implant in situ were excluded.

Randomization

Simple randomization was done by fracture pattern on X-rays and the opposite noninjured limb was kept as control limb. Institutional review board acceptance and informed consent from all patients were obtained. Statistical analysis was done with *Statistical Package for the Social Sciences* software at the research facility center.

RESULTS

In our study of total 32 patients, 18 (56%) were male and 14 (43%) female, with average mean age of 36 years, statistically not being significant. Left legs (17; 53%) were found to be more involved than right ones (15; 46%). Injured limb measurement on hourly basis with mean average ranged from 39.99 to 41.40 cm, against an average of 38 cm for the control limb. A repeated-measures analysis of variance determined that mean injured limb circumferential measurement differed significantly across time with $p < 0.001$, and post hoc pairwise comparison using the Bonferroni correction showed an increase between the initial and sequential assessments on hourly basis for maximum of 6 hours, which was statistically significant ($p < 0.001$; Tables 1–3). Three patients (9%) underwent decompression and fasciotomy, with their mean of 42.3 cm against an average mean of 38.5 cm for control limb.

Table 1: Timing and measurement of injured leg by inch tape (in centimeter).

Injured limb measurement	Mean (cm)	Standard deviation	*p*-Value
Immediate measurement	39.9906	3.56772	<0.001
1-hour measurement	40.6969	3.51251	<0.001
2-hour measurement	41.0625	3.53943	<0.001
3-hour measurement	41.4031	3.49391	<0.001

DISCUSSION

Compartment syndrome following an acute fracture in the leg could be underdiagnosed or overdiagnosed and sometimes misdiagnosed. Possibilities of such situation arise due to varied factors like mode of injury, fracture pattern, transportation of injured person, tight splinting of limb, and anatomical musculature of the leg per se with presence of paired bones with interconnecting fascia and compartmentalization of leg muscles. Clinical biases include systemic and neurovascular assessment, invasive pressure measurement, drug intake, analgesics requirement, disproportionate pain, antiedema usage, and inter/intraobserver bias among clinical specialists.[3–7]

In our study, all acute closed leg fractures presenting to emergency department within 6 hours of injury only were included. Injured limb was immobilized on padded splint applied only to posterior aspect of leg and secured with roller bandage, leaving anterior aspect of leg exposed. Only a simple inch tape calibrated in centimeters was used to measure the circumference of the maximum swollen area of the injured leg, excluding the splint. Measurement was done on timely basis, from arrival time to the next 3 hours, and observed against the opposite limb kept as control. In our study, full circumference of leg at maximum swollen area was measured to include all compartments of leg irrespective of the knee and ankle position.

Table 2: Marginal means and confidence interval.

Time of reading	Mean (cm)	Standard error	95% confidence interval		*p*-value
			Lower bound	Upper bound	
Immediate measurement	39.991	0.631	38.704	41.277	<0.001
1-hour measurement	40.697	0.621	39.430	41.963	<0.001
2-hour measurement	41.062	0.626	39.786	42.339	<0.001
3-hour measurement	41.403	0.618	40.143	42.663	<0.001

Table 3: Pairwise comparison of time and its significance.

Time/factor	(J) factor	Mean difference (I–J)	Standard error	Significance	95% confidence interval for difference[b]	
					Lower bound	Upper bound
Immediate: 1	2	–0.706	0.068	0.000	–0.898	–0.514
	3	–1.072	0.080	0.000	–1.298	–0.846
	4	–1.412	0.091	0.000	–1.670	–1.155
1 hour: 2	1	0.706	0.068	0.000	0.514	0.898
	3	–0.366	0.032	0.000	–0.455	–0.276
	4	–0.706	0.048	0.000	–0.840	–0.572
2 hours: 3	1	1.072	0.080	0.000	0.846	1.298
	2	0.366	0.032	0.000	0.276	0.455
	4	–0.341	0.032	0.000	–0.430	–0.251
3 hours: 4	1	1.412	0.091	0.000	1.155	1.670
	2	0.706	0.048	0.000	0.572	0.840
	3	0.341	0.032	0.000	0.251	0.430

Note: Immediate as 1, 1 hour as 2, 2 hours as 3, and 3 hours as 4.

In our study of total 32 patients, males (18; 56.3%) were more than females (14; 43.8%), with mean age of 36 years. Left side (17; 53.1%) was more involved than right (15; 46%), which was statistically not significant. Mean measurements of injured limb with respect to time were found to be statistically significant. Pairwise comparison of measurements within time was statistically significant and multivariate analysis was significant with time effect ($p < 0.001$). Mean of the control opposite the noninjured limb was found to be 38.5 cm, which was measured on arrival only once; no further readings were taken. Three patients (9%) underwent decompression and fasciotomy with an average mean of 41.4 cm for injured limb against an average mean of 38.5 cm for the control limb, and was independent of timing and type of surgery, preoperative blood transfusion, tourniquet application, intraoperative tissue discoloration, suturing technique, vacuum dressing application, and its sequelae to sparing or amputation.[8–10] Surgical intervention period varied on an average of minimum 12 hours among surgically treated subjects, with measurement difference of 0.5 to 1 cm for mean injured limb and 1.5 to 3 cm for the control limb.

Limitations of our study include small sample size, early presentation to emergency department, independent fracture pattern and pain scoring, new Coronavirus Disease-2019 epidemic with minimal contact exposure protocol, and scarce and efficient usage of personal protective equipment kit on demand. This study signifies a very simple, effective, feasible, and noninvasive way of approaching a closed fractured leg for identifying the impending disaster and intervening at the earliest, with very minimal literature support to date.

CONCLUSION

Compartment syndrome is an acute emergency with potential irreversible damage when undiagnosed. Bias on diagnosis evolves around observer skills and available invasive and noninvasive methods, with differential statistical results pertaining to its decision-making for emergency fasciotomy. From our study, we would like to conclude that there is a strong predilection for developing compartment syndrome and further requiring emergency fasciotomy if the difference in circumferential measurement is of more than 2 cm when compared with control limb. We would recommend further studies, preferably randomized controlled trials, with bigger sample size to be more confident in predicting the development of compartment syndrome and further surgical management.

Conflict of interest

None.

Ethical approval

Obtained.

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