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RECENT METHODS IN MANAGEMENT OF LOWER LIMB COMPARTMENT SYNDROME

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ABSTRACT

Background: Compartment syndrome (CS) is the clinical condition characterized by raised pressure within a "non-expandable" anatomical compartment, which is surrounded by fascia and bone. CS is a severe complication caused by bleeding or edema and it can occur following fractures or soft tissue trauma, burns and reperfusion injury following acute arterial obstruction. Although its incidence is relatively low, clinical awareness of this complication, early recognition and appropriate treatment with fasciotomies are of paramount importance to minimize the risk of irreversible damage and permanent disability. **Objective:** The aim of this work is to put some spotlights on compartmental syndrome in lower limb as regard recent modalities in diagnosis and treatment of established acute compartment syndrome. **Patient and Methods:** This is a prospective study included 30 patients who were admitted between April 2017 and April 2018, with lower limb compartmental syndrome requiring surgical treatment, admitted or referred to Al- Hussein University Hospital, Department of Vascular Surgery. 30 patients with were suspected to have acute compartment syndrome. In Nine patients with suspected acute compartment syndrome, the primary tissue pressure measurement at admission in one compartment was below (20mmHg). Two patients was diagnosed as acute compartment syndrome of leg by clinical examination. In 17 patients, the diagnosis of acute compartment syndrome was made based on clinical examination and compartment pressure measurements. In Two patients positive symptoms and signs was present while compartment pressure measurements revealed tissue pressure at (20mmHg). The measurement was reported after 4 hours and increased to (30 mmHg). **Results:** The functional results according to Rorabeck was 11 out of 19 patients had acceptable results (57.8 %) and 8 out of 19 patients had unacceptable results (42.1 %). Superficial infection in

the wound of fasciotomy was present in 17 patients (80.9%) that were managed by daily dressing. Deep infection was happened in two patients (9.5%) who required serial debridement and removal of necrotic muscle until skin closure by delayed primary skin closure. Three patients had persistent pain (14.2%). 14 patients had persistent numbness (66.6%). While three patients improved within 4 weeks. Eight patients had persistent sensory deficit (38%).Three patients had persistent motor weakness (14.2%) and three patients had major amputations (14.2%). **Conclusion:** The diagnosis of acute compartment syndrome depends on clinical examination and measurement of compartment pressure, which is preferred to be by continuous monitoring for at least the first (12 hours). Adequate fasciotomy within reasonable time first (12 hours) by single or double incision is the treatment of choice of this syndrome however the rate of re-operation still high and the complication is warranted.

KEYWORDS: compartment syndrome, diagnosis, proper fasciotomy.

INTRODUCTION

Compartment syndrome (CS) is the clinical condition characterized by raised pressure within a non-expandable anatomical compartment, which is surrounded by fascia and bone.[1]

CS is a severe complication caused by bleeding or edema and it can occur following fractures or soft tissue trauma, burns and reperfusion injury following acute arterial obstruction.[2]

Although its incidence is relatively low, clinical awareness of this complication, early recognition and appropriate treatment with fasciotomies are of paramount importance to minimize the risk of irreversible damage and permanent disability.[3]

Finally, CS is one of the more common sources of medical litigation, with significant malpractice liability.[4]

Regarding the lower extremity, compartment syndrome is most commonly seen in the leg, but it can also occur in the foot, thigh, and gluteal region.[2]

The earliest publication regarding this clinical entity is attributed to Richard von Volkmann in 1888.[5]

It was Hildebrand in 1906 who first introduced the term "Volkmann's ischemic contracture," to describe the result of any untreated compartment syndrome. He suggested that ischemic contracture might be the end-result of elevated tissue pressure. In 1909, Thomas, reviewing the literature of Volkmann's ischemic contractures, found fractures to be the main causative factor.[6]

Other predisposing causes included arterial injury, embolus, and tight bandaging. Rowlands, in 1910, suggested that reperfusion of a limb after a prolonged ischemia could result in the development of acute compartment syndrome (ACS).[7]

In 1914, Murphy reported that impeding of venous flow due to intramuscular hemorrhage, which increases intra-compartmental pressure and was the first to suggest that a fasciotomy might be effective for the prevention of Volkmann's contracture.[8]

Jepson in 1926 was the first to perform a fasciotomy for a compartment syndrome.[9]

The pathophysiology of compartment syndrome has been defined as an insult to normal local tissue homeostasis resulting from the increased tissue pressure within a confined tissue space. Increased pressure is generated secondary to an increase of the content of the compartment and/or a decrease of the intra-compartmental space.[3]

The main causes for the development of CS secondary to decreased size of the compartment is the external application of constrictive casts or dressings, or the firm closure of fascial defects especially in the anterior compartment of the leg. On the contrary, an increase of the intracompartmental content is seen in case of bleeding or edema within the compartment. The former is mainly associated with fractures, vascular injuries, extravasation of arthroscopic fluids or coagulopathy, whereas the latter with post ischemic and post-traumatic swelling, increased capillary permeability and reperfusion phenomenon.

Regardless of etiology, distortion of the relation between intra-compartmental volume, space and pressure interfere with the circulation, leading to the development of CS initially with venous obstruction within a closed space and decreased capillary blood flow, and ultimately with local tissue necrosis caused by oxygen deprivation.[3]

Diagnosis of compartment syndrome include

- History and Clinical examination
- Intra-Compartmental Pressure (ICP) Measurement
- Urine analysis and urine myoglobin (Rhabdomyolysis).
- Prothrombin Time and Partial Thromboplastin Time (PT/PTT) (Deep Venous Thrombosis).
- D-dimer level (Deep Venous Thrombosis).
- CBC with differential (Infection, osteomyelitis).
- Complete metabolic panel (Metabolic derangements, acidosis, hypercalcemia, hyperkalemia).
- Thyroid Stimulating Hormone (TSH) (Thyroid myopathy).
- Erythrocyte Sedimentation Rate (ESR) (Infectious rheumatologic).

Elevation of serum CPK in isolated compartment syndrome reflects the amount of muscular damage.

- Lactate dehydrogenase (LDH).
- X-rays of the extremity
- A bone scan will help rule out stress fracture periostitis, and malignancy of the lower extremity.
- Ultrasound to visualize blood flow (hematoma, deep venous thrombosis, vascular entrapment).
- CT scan and MRI to rule other significant causes of chronic lower leg pain.
- Thallous chloride scintigraphy with single photon emission computed tomography (SPECT).
- Measurements of the surface hardness of the compartment.
- Transcutaneous oxygen measurements.
- Measurement of mechanical impedance.
- Scintigraphy with Tc-99 m.
- Thallium stress testing.
- Nerve conduction studies[10]
- Direct Nerve Stimulation[11]
- Laser Doppler flow measurements[3]
- The near-infrared spectroscopy (NIRS).[12]
- Fiber optic devices using near-infrared (NIR)[13]

- Magnetic resonance imaging (MRI).[14]

PATIENTS AND METHODS

This is a prospective study included 30 patients who were admitted between April 2017 and April 2018, with lower limb compartmental syndrome requiring surgical treatment, admitted or referred to Al- Hussein University Hospital, Department of Vascular Surgery. Were subjected to clinical evaluation at time of admission. Duplex US was done as a routine investigation. Those patients with suspected acute compartment syndrome on top of one or more of the following criteria which the material of this study:

1. High energy trauma or polytrauma
2. Orthopedic surgery like IM nailing
3. Prolonged limb compression
4. 2nd and 3rd degree burns.
5. Intra-arterial drugs like drug abusers.
6. Major vascular bleeding and bleeding disorders.
7. Differential pressure level (DP) of 30 mmHg or less in case of ICP monitoring.
8. Deep Venous Thrombosis (DVT) with phlegmasia cerulea dolens.

For all these patients the following data was collected

Personal history

History of present illness

Past medical history

General examination

Local examination of the leg: Inspection for skin condition (bullous, wound, burn, ecchymosis) and soft tissue swelling localized edema, deformity, shortening. Local examination of sensation over planter, dorsal and lateral aspect of the foot.

Palpation for coldness, pain on passive stretch of the foot in dorsiflexion and plantarflexion, flexion and extension of the knee, tenderness over each muscle compartments. Examination of peripheral circulation (Dorsalis pedis, posterior tibial artery), capillary refilling, and temperature. Measurement of the calf circumference (15 cm below knee joint space) at lime of admission.

X ray was done (Anteroposterior and lateral views) of the affected leg and for any other site where fractures was suspected.30 patients with were suspected to have acute compartment syndrome.

In nine patients with suspected acute compartment syndrome, the primary tissue pressure measurement at admission in one compartment was below (20mmHg). The tissue pressure measurement was repeated within 4 hours the values of these measurements were also below (20mmHg) and the associated clinical picture of acute compartment syndrome was improved. (No surgery was done).

Two patients was diagnosed as acute compartment syndrome of leg by clinical examination without measuring the compartment pressure, had surgical decompression of the anterior compartment only.

In 17 patients, the diagnosis of acute compartment syndrome was made based on clinical examination and compartment pressure measurements revealed high tissue pressure in one compartment at or above (30mmHg) fasciotomy was done immediately in all four Compartments.

In Two patients positive symptoms and signs of acute compartment syndrome was present while compartment pressure measurements by needle manometer technique revealed tissue pressure at (20mmHg). The measurement was reported after 4 hours and increased to (30 mmHg) and the clinical picture of acute compartment syndrome was manifested. fasciotomy was done immediately in all four compartments.

Acute compartment syndrome was diagnosed clinically in all patients. Tissue pressure measurements in nine patients were not high above level of (30 mmHg), in 17 patients was co-incident with clinical picture and high/above level of 30 mmHg.

In two patients tissue pressure was below (30mmHg) but after four hours increased to (30mmHg) and tissue pressure was not measured in two patients. Fasciotomy was done to the four compartments of the leg by using either two-incision technique or modified single technique in the operative room under spinal anesthesia. The modified single incision is made from fibular neck to the lateral malleolus and in two-incision technique the lateral skin incision is made over the interval of the anterior and the lateral compartments midway between the fibula and the anterior crest of the fibula to decompress these two compartments.

In addition, the medial incision is made two centimeters from the medial crest of the tibial shaft.

The time between admission to hospital and transfer to the operating, room for surgical decompression (fasciotomy) ranged between 4 and 14 hours. After fasciotomy, the patients were examined for stretch pain, numbness, sensory and motor deficit.

Re-operation for Skin closure by delayed primary sutures in seven patients or skin graft in 14 patients and evaluation of the wound condition ranged between 5 and 10 days.

Patients were kept, in hospital until the skin condition was good, after discharge the patients were followed up every two weeks for the first 2 months, and then every four weeks for 4 months. In each visit, patients were clinically examined for stretch pain, numbness, sensory and motor function. In the last visit, patients were examined for calf circumference.

Functional evaluations of patients were rated as acceptable, unacceptable according to.[15] Acceptable result was a leg with normal function, with no residual neurological and/or motor deficit, which no required further reconstructive surgery.

Unacceptable result implied some persistent neurological and/or motor squeals, which lead to further reconstructive surgery being required. Inpatient time between admission and discharge from hospital ranged between 20 and 32 days.

RESULTS

In this study, there were three females (17.5%) and 14 males (82.5%). The youngest: patient was 20 years old and the oldest was 80 years old (Fig.1)

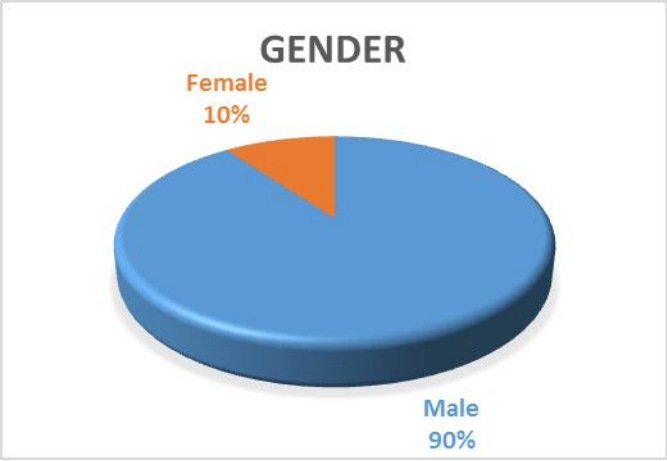

Fig. 1: Gender distribution among studied patients.

The mean age of the patients is 52.5 years, male: female is (4:1) that the mostly affected were middle-aged males (Fig. 2).

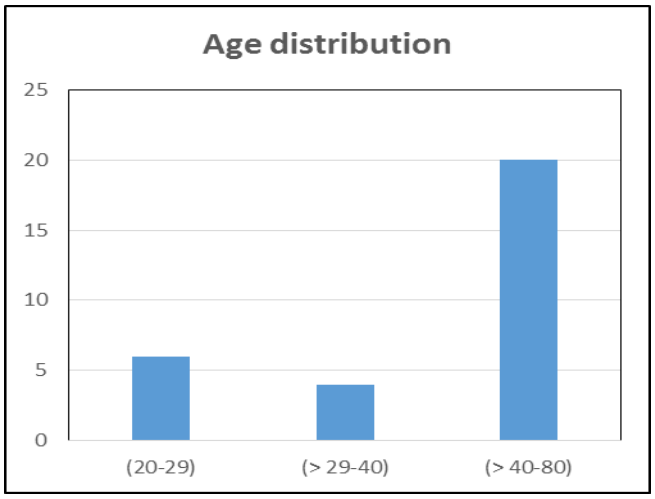

Fig. 2: Age distribution among studied patients.

Mechanism of trauma was mainly car accidents, gun shoot, and DVT. (Fig. 3).

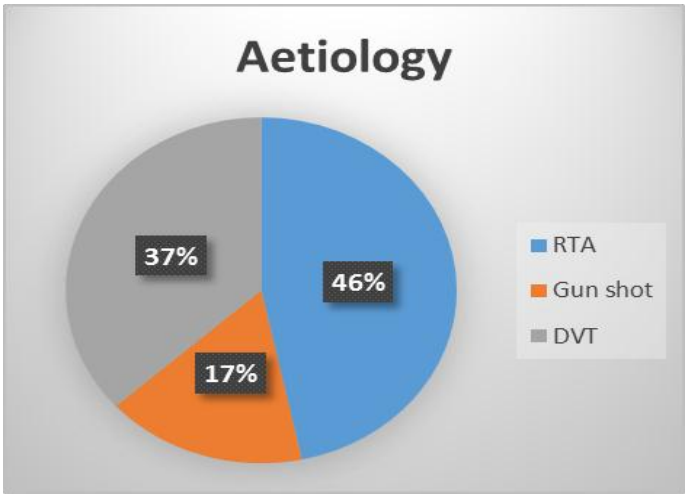

Fig. 3: Aetiology of disease.

The diagnosis of acute compartment syndrome was made primary based on positive clinical examination (Symptoms and Signs) in all patients. The most common presenting symptoms were increasing pain in the leg over the affected compartment and numbness in the foot and toes.Lab investigation was done for all cases. The most important among these investigations are CPK and LDH, which were done pre and post-operatively. The table below shows Mean ± SD for each. (Fig. 4).

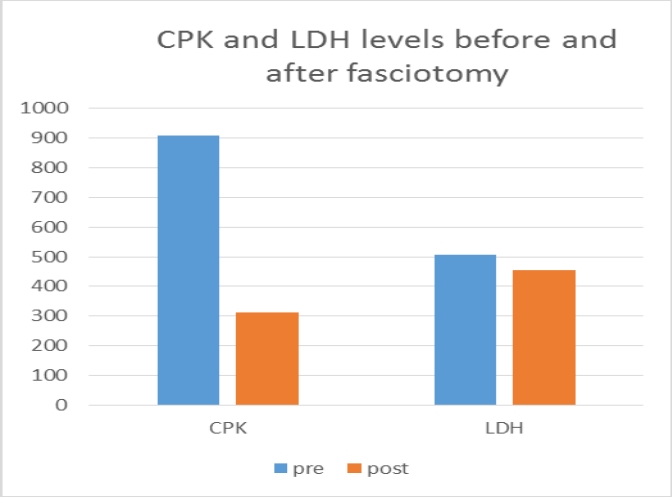

Fig. 4: CPK and LDH levels before and after fasciotomy.

The most common sign was stretch pain, which is pain referred to the compartment on passive movement of the toes in dorsiflexion or plantar flexion of foot. Sensory deficit was present in 14 patients, diminished sensation in the first web space in 7 patients, sensory deficit on dorsum of foot in 3 patients, sensory deficit in lateral border of foot in two patients and sole of foot in two patients.

Those patients who had sensory deficit in one compartment except in one patient who had deficit in two compartments superficial and deep posterior compartments.

Frank motor weakness was observed in six patients.The positive clinical findings of acute compartment syndrome and percentage (before surgical interference) are shown in the following table and figure. **(Fig. 5).**

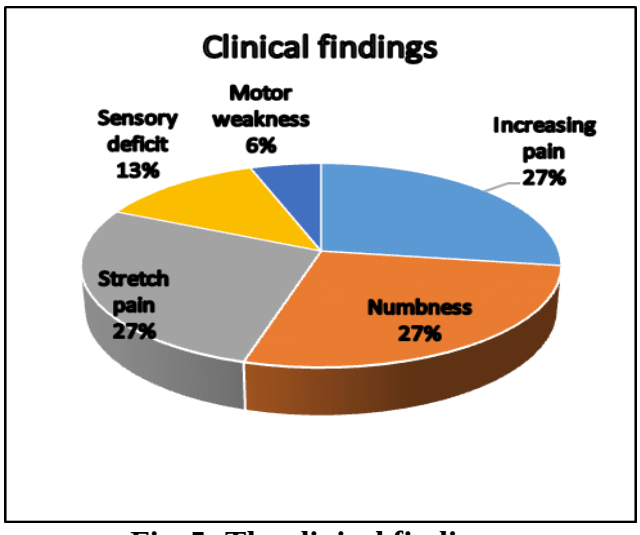

Fig. 5: The clinical findings.

The tissue pressure measurements were done in 28 patients who were at or above (30 mmHg) in 17 patients and the highest values of tissue pressure measurements in those 17 patients were recorded in the following table and figure. **(Fig. 6).**

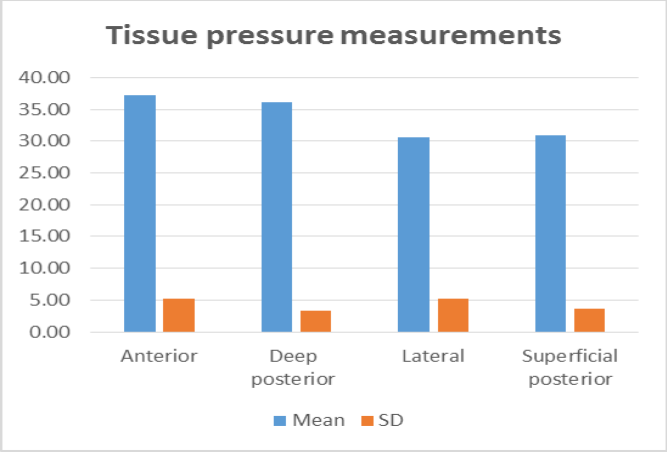

Fig. 6: Tissue pressure measurements.

In 17 patients both positive clinical picture and tissue pressure measurement of acute compartment syndrome was present, in nine patients the positive clinical picture did not correspond to tissue pressure measurement. These clinical pictures subsided without surgical interference. In addition, two patients diagnosed as acute compartment syndrome without tissue pressure measurement. Fasciotomy was done immediately for all four compartments except in two patients where fasciotomy done in the anterior compartment only. The functional results according to **Rorabeck** was 11 out of 19 patients had acceptable results (57.8 %) and 8 out of 19 patients had unacceptable results (42.1%). **(Fig.7).**

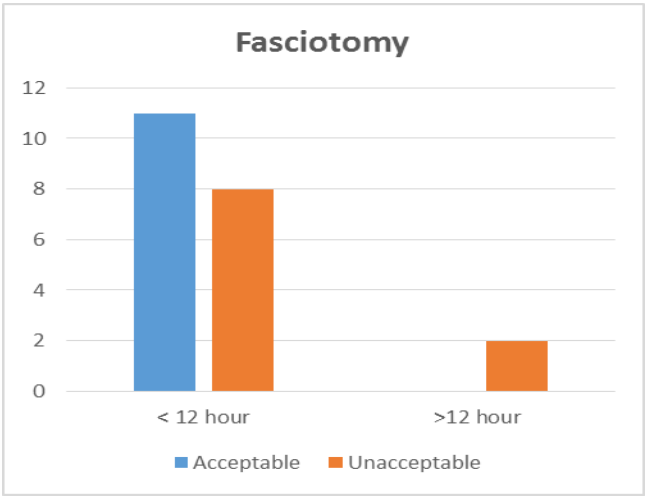

Fig. 7: The functional result in relation to the timing of fasciotomy.

After the surgical procedure, the patients were examined for pain, numbness, sensory and motor deficit.

The improvement after surgery of these clinical finding was shown in the following table and figure. (Fig. 8).

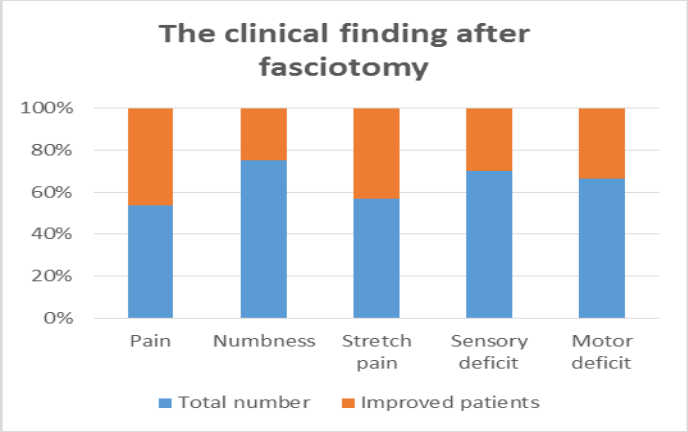

Fig. 8: The clinical finding after fasciotomy.

Complications

Delay in surgical decompression due to delayed transfer of the patient to hospital and delay in making the decision to getting the patient to the operating room for fasciotomy are the main cause of complications. Superficial infection in the wound of fasciotomy was present in 17 patients (80.9%) that were managed by daily dressing. Deep infection was happened in two patients (9.5%) who required serial debridement and removal of necrotic muscle until skin closure by delayed primary skin closure. Three patients had persistent pain (14.2%). 14 patients had persistent numbness (66.6%). While three patients improved within 4 weeks. Eight patients had persistent sensory deficit (38%).Three patients had persistent motor weakness (14.2%) and three patients had major amputations (14.2%). (Fig. 9).

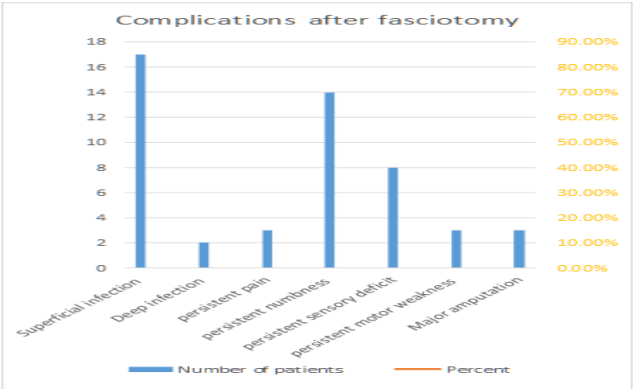

Fig. 9: Complications after fasciotomy.

DISCUSSION

This study is a prospective study of patients presented with acute compartment syndrome.

The mean age of the patients is 52.5 years, male: female is (9:1) that the mostly affected were middle-aged males.[1]

The commonest cause of acute compartment syndrome was polytrauma.[6]

The diagnosis of acute compartment syndrome depends on positive clinical finding (symptoms and signs) of acute compartment syndrome and compartment pressure measurements in 28 patients; two patient was diagnosed as acute compartment syndrome without tissue pressure measurement.[16]

In nine patients, the positive clinical picture did not correspond to tissue pressure measurement, the clinical manifestation of acute compartment syndrome subsided without surgical interference.

In this study, the most common presenting symptom was increasing pain and the most common sign was stretch pain and numbness in 30 patients. The presence of skin changes as ecchymosis and bullous was detectable after (5-7) hours from development of acute compartment syndrome indicated ischemia of the skin.[3]

Sensory deficit was important neurological sign present in 14 patients, while diminished sensation in the first web space in the terminal distribution of the deep peroneal nerve (7 patients) implied involvement of anterior compartment (50%), sensory deficit on dorsum of foot (3 patients) implied involvement of lateral compartment *(21.4 %)* and sensory deficit in lateral border of foot (two patients) or sole (2 patients) indicated elevated pressure in superficial or deep posterior compartments (14.2 %) with the same percent.[19]

This point to the acute compartment syndrome was more common in anterior compartment followed by deep posterior compartment.

Frank motor weakness was difficult to elicit in patients with acute compartment syndrome but this was observed in six patients.[20]

These clinical pictures was improved after surgical procedure, increased pain in the leg and stretch pain was improved in (86%) of the patients after the fasciotomy and motor weakness

in (50%), while sensory deficit was improved in only (43%) and numbness (33%) from the affected patients after the fasciotomy.[3]

The tissue pressure measurement in the four compartments was done by using the needle manometer technique in 28 patients; the highest value of pressure measured was (45 mmHg). The use of needle manometer technique was easy, available, low hospitals cost but allow intermittent monitoring of compartment pressure and it is difficult to know the exact time of the onset by using this technique.[18]

Continuous pressure measurements as (Wick, Slit Catheter, and Stryker Monitoring System) are much more reliable in following the progress of patients with an acutely swollen limb.[19,21]

Fasciotomy in the treatment of acute compartment syndrome of the leg is usually effective in preventing irreversible damage of muscle and nerves.[22,23]

11 out of 19 patients had acceptable results, the best results were achieved when adequate fasciotomy was performed in the first 12 hours in 19 patients, fasciotomy performed after 12 hours in (two patients) gave unacceptable results, fasciotomy done in that patient was inadequate because of single compartment was released, which is not recommended because hyperemia precipitate increased pressures in adjacent compartments.[24]

The complication observed after surgical decompression (fasciotomy) was deep infection (in two out of 19 patients) was happened which may be due to inadequate and delayed fasciotomy (small, single incision for one compartment after 12 hour from developed of acute compartment syndrome).[25]

Superficial infection was happened in the wound of fasciotomy in most patients that required daily dressing and close follow up of the wound condition.[25]

The deep infection incidence was low with adequate fasciotomy, which means with adequate fasciotomy (proper time and method) the rate of infection was decreased and that may reflect the degree of tissue necrosis.[25]

Persistent numbness, weak motion of the foot and sensory deficit was observed in most patients suffered from acute compartment syndrome regardless to time, method of

fasciotomy.[26,27,28]

Although the etiology, pathophysiology, and treatment of acute compartment syndrome are well described, very few studies have yet been published dealing with the outcome of this syndrome and the classification of the outcome to acceptable and unacceptable according to[15] is very limited.

SUMMARY AND CONCLUSION

Acute compartment syndrome is a clinical condition characterized by increase of pressure within a closed anatomic space. Patients presented with symptoms or signs of acute compartmental syndrome were included in this study. All patients were admitted or referred to Al-Hussein University Hospital, Department of Vascular Surgery.

The diagnosis of acute compartment syndrome depends on clinical examination and measurement of compartment pressure, which is preferred to be by continuous monitoring for at least the first (12 hours). Adequate fasciotomy within reasonable time first (12 hours) by single or double incision is the treatment of choice of this syndrome however the rate of re-operation still high and the complication is warranted.

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