



Etiology, Diagnosis and Management of Acute Compartment Syndrome: A Simple Review

**Yazeed Ali S. Albalawi^{1*}, Reema Ibrahim A. Albaltan²,
Turki Abdullah A. Alzahrani³, Ahad Mohammed Almutairi⁴,
Meshael Alawi Almatari⁵, Yasser Sultan M. Almuthhin⁶,
Zahraa Abbas A. Kassarah¹, Wejdan Mohammed K. Alhujayri¹,
Habib Yousef Aldabbab⁷ and Turki Abdullah A. Alahmadi⁸**

¹Medical, Tabuk University, Saudi Arabia.

²Medical, Qassim University, Saudi Arabia.

³Medical, Baha University, Saudi Arabia.

⁴Medical, Unizah College of Medicine, Saudi Arabia.

⁵Medical, ISNC, Saudi Arabia.

⁶Medical, Al jouf University, Saudi Arabia.

⁷Medical, King Faisal University, Saudi Arabia.

⁸Medical, Taibah University, Saudi Arabia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i42B32435

Editor(s):

(1) Dr. Paola Angelini, University of Perugia, Italy.

Reviewers:

(1) Patricia Haas, Federal University of Santa Catarina, Brazil.

(2) Bülent Bayraktar, Bayburt University, Turkey.

Complete Peer review History: <https://www.sdiarticle4.com/review-history/72504>

Review Article

Received 20 June 2021

Accepted 27 August 2021

Published 01 September 2021

ABSTRACT

The study aimed to summarize the updated evidence regards, Etiology, Diagnosis and Management of Acute compartment syndrome. Acute compartment syndrome (ACS) is a condition in which pressure builds up inside a closed osteofascial compartment, impairing local circulation. Early diagnosis and treatment are credited with the best outcomes following Acute Compartment Syndrome. The severity of compartment syndrome varies from mild to severe. Fasciotomies should be performed very soon if the patient have acute compartment syndrome. The treatment of late

compartment syndrome (delayed or missing diagnosis) is more problematic. Long duration of acute compartment syndrome without treatment can cause irreversible damage that's why early intervention is a must, non-operative measurement is preferred if possible, to prevent any surgical complications, however if surgery is needed it must be performed with Two-incision fasciotomy being the most used method.

Keywords: Severity of compartment syndrome, diagnosis, management, acute compartment syndrome.

1. INTRODUCTION

Acute compartment syndrome is a condition in which pressure builds up inside a closed osteofascial compartment, impairing local circulation. Acute compartment syndrome can lead to ischemia and, eventually, necrosis if not treated promptly [1]. Any increase in interstitial pressure in a closed osseo-fascial compartment might cause it. Ischemic damage can be irreparable in as little as six hours, resulting in long-term illness and even death [2].

Early diagnosis and treatment are credited with the best outcomes following Acute Compartment Syndrome (ACS) [3]. The removal of any constricting dressings or casts is the first step in treatment, as is preventing hypotension and optimizing tissue circulation by keeping the limb at heart level. If symptoms continue, surgical decompression of all affected compartments is required as soon as possible [4].

The presence of compartment pressures more than 30 mmHg indicates the presence of compartment syndrome. Having a high ICP for 6–8 hours causes irreparable soft tissue damage [5].

Fasciotomies should be performed very soon if the patient have acute compartment syndrome. The treatment of compartment syndrome (delayed or missing diagnosis) is more problematic [6].

The Appropriate Use Criteria (AUC) for the Diagnosis and Management of Acute Compartment Syndrome (ACS) were created by the Major Extremity Trauma and Rehabilitation Consortium and the American Academy of Orthopaedic Surgeons [7].

Objectives: The study aims to summarize the updated evidence regards, Etiology, Diagnosis and Management of Acute compartment syndrome.

2. METHODOLOGY

Study Design: Simple review article.

Study duration: Data was collected during the period from 1 June – 29 July, 2021.

Data collection: Medline, Google scholar, EMBASE and PubMed database searches was performed for articles about the most important recent developments regards, Etiology, Diagnosis and Management of Acute compartment syndrome, published in English around the world. The keyword search headings included "Severity of compartment syndrome, Diagnosis, Management, Acute compartment syndrome", and a combination of these was used. References list of each included study will be searched for further supportive data.

Pathophysiology and Etiology: Acute compartment syndrome develops when pressure builds up inside a closed osteofascial compartment, impairing local circulation. It is the result of decreased perfusion within a compartment [8]. Any increase in interstitial pressure inside an osseo-fascial compartment can cause it. The differential between capillary perfusion pressure (CPP) and interstitial fluid pressure (IFP) determines tissue perfusion [4]. acute compartment syndrome is considered a surgical emergency since it might progress to ischemia and finally necrosis if not treated properly [1].

When fluid enters a fixed volume compartment, such as by bleeding, tissue and venous pressures rise. When the CPP is exceeded, capillary collapse occurs, resulting in muscle and nerve ischaemia. When the compartment size reduces (e.g. external compression) due to an increase in intracompartmental pressure and a drop in the arteriolar pressure, the CPP falls similarly [4].

To explain the pathophysiology of ACS, numerous theories have been presented: The pressure differential between these vessels

which called (arteriovenous gradient) affects blood circulation from high-pressure arteries to low-pressure veins. When such arteriovenous gradient is reduced, the rates of oxygenated arterial blood delivery and deoxygenated venous blood drainage decrease. This causes fluid to extrude into the third compartment, generating tissue oedema and an increase in ICP. This creates a vicious cycle, leading to the collapse of the vascular supply, resulting in ischaemia and irreversible necrosis [5,9].

A compartment syndrome can have a variety of causes:

- Burns
- Coagulopathies such as Bleeding disorders (hemophilia), or with heparin or other co-agulants.
- Infection, Traumas
- Iatrogenic Arterial line placement, closure of fascial defects, embolectomy, fracture reduction, intravenous line infiltration, orthopedic surgery, prolonged operating room positioning, prolonged tourniquet use, tight casts and splints, tight dressings
- Overuse syndromes: Exercise, weight lifting
- Miscellaneous such as Cardiac catheterization, ergotamines, intra-arterial drug injections, immobility, intravenous infiltration, nephrotic syndrome, reperfusion injury, tetany, venous occlusion [10].

Tibial shaft fractures are the most common cause of all ACSs, accounting for 2-9 percent of all cases. After the leg, the forearm is the next most common site, however it can affect practically any compartment: arm, thigh, foot, buttock, hand, and abdomen. The aetiology of ACS can also be linked to poor patient posture in unconscious individuals for long periods of time. [10-19].

Causes of Compartment Syndrome in Children That Aren't Traumatic Even though it is less prevalent, it's crucial to know that it can happen even if there are no fractures. Iatrogenic infiltration or failure to remove a phlebotomy tourniquet were the most common causes, with four cases resulting in amputation [20].

Incidence: The most prevalent site for compartment syndrome is in the anterior compartment of the leg. The tibialis anterior muscle, the deep peroneal nerve, and the tibial

artery are all found in this compartment. The forearm, thigh, buttock, shoulder, hand, and foot are among places where acute compartment syndrome can be detected. It can also appear in the abdomen, although it is more frequent in the limbs [1,21-24] in a study looked at the frequency of ACS The commonest site was found to be the leg (44, 59%) followed by the forearm (15, 20%) [3]. Sport events such football can be one of the main causes for ACS in legs [25.]

In the group that underwent delayed fasciotomies, or fasciotomies performed after initial evacuation, they had higher Muscle excision (25 against 11%), amputation (31 versus 15%), and mortality (19 versus 5 percent) [6] that's why early intervention is important.

According to Scottish study the annual incidence is 3.1 per 100 000 people on average (7.3 per 100 000 men and 0.7 per 100 000 women). The most prevalent cause of ACS is a tibial diaphysis fracture. Tibial fracture is linked to around 36% of all ACS occurrences. Blunt soft-tissue injury is the second most common cause, accounting for 23.2 percent of all ACS cases in the Scottish series [26].

Diagnosis: Acute compartment syndrome is a clinical diagnosis in most cases. Intracompartmental pressure (ICP) > 30 mmHg, on the other hand, can be utilised as a diagnostic threshold. A single normal ICP value, however, does not rule out acute compartment syndrome [1] also even though several publications claim that the Δp threshold at which surgical intervention is needed is between 30 and 45 mmHg, hypotensive individuals with ICPs greater than 20 mmHg have also a high risk of ACS [5].

More and more studies have shown that pressures greater than 30 mm Hg can be tolerated without causing harm, and it has been proposed that the difference between diastolic and compartment pressure, rather than an absolute threshold, be used as an indication for fasciotomy (diastolic pressure minus compartment pressure <30 mm Hg) [27].

The traditional description of the ACS pain which is a severe pain that "disproportional to the damage or surgery" is used to make the diagnosis. it is not eased by medications or morphine [5], and it is exacerbated by passive compartment muscle stretching. However, pain may be absent in the late stages of ACS. When the diagnosis is in dispute, compartment

pressure monitors might be a useful tool [2]. Other findings with the pain includes the 5Ps, Paresthesia, Pallor, Paralysis, and high intra-compartment Pressure [5]. The symptoms also include Numbness, tingling, tenseness or hardness, localised motor or sensory impairments, or decreased pulse or capillary refill time [8] some studies suggest that physical examination is unreliable and cannot rule out the diagnosis. And they suggest that Measurement of intracompartmental pressures using a pressure monitor is the most reliable test [8].

Pressure monitoring can be done in a variety of ways, and the equipment used varies. The Whitesides needle manometer, a slit or wick catheter are all invasive options for monitoring pressure. The disadvantage of these devices was that they were quickly obstructed by blood and muscle clots. The STIC Monitor is a portable monitor that measures compartment pressure using a side port needle, a disposable saline flush syringe, and a digital read out manometer [27-31].

There have also been suggestions for non-invasive imaging approaches for detecting ICP. Near-infrared spectroscopy (NIRS), ultrasonic devices, and laser Doppler flowmetry are among them. NIRS analyses local soft tissue oxygenation around 2 to 3 cm below the skin's surface, and it could be used to monitor intracompartmental hypoxia in real time [5,32,33].

Management: The AUC for Diagnosis and Management of ACS was developed by recognizing clinical signs and symptoms that are common in individuals suspected of having an ACS in clinical practise. The majority of these indicators were clinically observable factors, such as symptoms or diagnostic test findings [7].

The removal of any constricting dressings or casts is the first step in therapy, as is preventing hypotension and maximizing tissue circulation by maintaining the limb at heart level. If symptoms continue, surgical decompression of all affected compartments is required as soon as possible [2].

Usage of Anesthetic agents: While regional anaesthetic can be beneficial to orthopaedic patients, long-acting nerve blocks and epidural anaesthesia can be harmful to patients who are at risk of developing compartment syndrome [6]

.In orthopaedic patients, regional anaesthetic possibilities include:

- epidural/spinal anesthesia
- peripheral nerve blocks (PNBs),
- continuous peripheral nerve blocks (CPNBs).
- Patient-controlled anesthesia (PCA) infusions [6]

Dense motor and sensory blockages can be avoided by using low dosages of local anaesthetics in combination with systemic opioid delivery. [6,34-37]. This method of administering and titrating epidural anaesthetic may avoid mask the acute discomfort of a developing compartment syndrome. In the setting of epidural anaesthesia that was titrated to the point of motor blockage, a number of case reports of gluteal compartment syndromes as well as lower leg compartment syndromes have been reported [6,38-40].

Fasciotomy:

Fasciotomy is indicated as an emergency procedure in the following situations:

- Patients with ICPs greater than 20 mm Hg are hypotensive.
- Patients with ICPs more than 30 mm Hg who are uncooperative or unconscious.
- Patients having positive clinical symptoms, compartment pressures greater than 30 mm Hg, and a duration of elevated pressure unknown or suspected to be longer than 8 hours [41].

Two-incision fasciotomy with anterolateral and posteromedial incisions is the most typical surgical technique to ACS of the leg. To access the anterior and lateral compartments, an anterolateral incision is performed between the tibial crest and the fibula. It runs from 5 centimetres below the fibular head to 5 centimeters above the lateral malleolus. The skin as well as the fascia should be freed. 2 cm posterior to the medial line of the tibia, a posteromedial incision is created. This incision is used to liberate the deep and superficial posterior compartments [42].

Single incision fasciotomy: Over the fibular axis, a single long incision is made, reaching 5 cm from the fibular head to 5 cm from the lateral malleolus. The fascia is identified, and anteriorly and posteriorly, full-thickness cutaneous flaps

are produced to access the anterior, lateral, and superficial posterior compartment fasciae. Longitudinal fasciotomies are used to decompress the three compartments. The posterior intermuscular septum is then lifted from the peroneal muscles until it reaches the posterolateral aspect of the fibula. To decompress the deep posterior compartment, the intermuscular septum is dissected along this insertion over its whole length [26].

Unfortunately, fasciotomies are linked to a high rate of morbidity, including the need for additional surgery for delayed wound closure, surgical reconstruction with skin grafting or vascularized flaps, cosmetic issues, pain and nerve injury, permanent muscle weakness, and chronic venous insufficiency [43].

Non-Operative Treatment: The foot compartment syndrome linked with extensive calcaneal fractures is an intriguing injury pattern. Some surgeons believe that treating foot compartment syndromes operatively is actually sometimes worse than the syndrome's consequences [44]. That's why simple treatment measures in ACS include loosening ace wraps, compression dressings, splints, and uni- or bivalving casts where safe and practical. Elevating an extremity to no more than the level of the heart aids venous drainage, decreases edema, and improves tissue perfusion. Furthermore, avoiding knee flexion and foot dorsiflexion will help to improve circulation throughout a leg and reduce ICP increases in the deep posterior compartment [45].

Tissue Ultrafiltration: In a new methods of treatment TUF is new method under investigations. The idea behind it that Compartment syndrome is caused by the accumulation of mass within a muscle compartment of relatively stable volume, which leads to an increase in intramuscular pressure, which in turn causes vascular embarrassment and metabolic abnormalities, which eventually lead to tissue death. The loss of related fluid mass within the compartment may lower compartment pressures if even tiny volumes of fluid are removed. Tissue ultrafiltration (TUF) was shown to have potential benefits in an animal investigation [46].

3. CONCLUSION

Acute compartment syndrome is one of the serious cases that is presented to the emergency

department, if not has been treated soon enough it can cause irreversible damage, in some cases even death. That's why early diagnosis and prober treatment is a must. The physical diagnosis of ACS is not of enough reliability, that's why measuring of compartment pressure is a must, different guidelines indicate that more than 30 mm Hg is enough of diagnosis, however different studies suggested that even less than that can suffer ACS that's why the newer guiltiness suggest using the diastolic pressure as another measurement for the patients with hypotension and the different between diastolic pressure and compartment pressure if more than mm Hg it indicates Acute compartment syndrome and prober treatment should be followed.

Long duration of acute compartment syndrome without treatment can cause irreversible damage that's why early intervention is a must, non-operative measurement is preferred if possible, to prevent any surgical complications, however if surgery is needed it must be performed with Two-incision fasciotomy being the most used method. Newer method are currently under development such as tissue ultrafiltration, we hope for the increase of such method to limit the need for operative surgeries and thus reduces its possible complications.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI: 10.1007/978-3-030-22331-1_17

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Peer-review history:

*The peer review history for this paper can be accessed here:
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