

Chapter 11

Management of Missed Compartment Syndrome



Douglas W. Lundy and Jennifer L. Bruggers

Much has been written about acute compartment syndrome, and a recurring theme throughout the literature is that “the treating physician should never miss the diagnosis.” Early diagnosis and treatment is a well-recognized factor that is integral to optimal outcomes after acute compartment syndrome. Unfortunately, many surgeons who are specialized in trauma care will see patients who present with a missed compartment syndrome. These patients may have had slowly evolving symptoms that persisted longer than the treating surgeon was aware in retrospect, or they may present with clear-cut missed compartment syndrome. In these situations, surgeons are faced with difficult treatment decisions and uncomfortable conversations with patients.

There are several reasons why a patient may appear with a delayed presentation of acute compartment syndrome. Unfortunately, many surgeons are often accused of medical negligence in these situations. Some patients may appear with a clinical picture that is unclear and have a slowly evolving compartment syndrome. Patients with perceived poor pain tolerance or a history of excessive opioid use may present with an acute compartment syndrome that can be difficult to diagnose. Poor communication with staff who fail to understand the alarming signs of compartment syndrome may also result in delayed diagnosis and subsequent treatment of acute compartment syndrome.

At times, compartment syndrome can be challenging to diagnose, and the signs and symptoms of this condition may be somewhat insensitive [1]. Ulmer [2] performed a meta-analysis of clinical studies of compartment syndrome patients and found that “the positive predictive value of the clinical findings was 11% to 15%, and the specificity and negative predictive value were each 97% to 98%.” In response to these findings, he stated that “the clinical features of compartment syndrome are more useful by their absence in excluding the diagnosis than they are when present

D. W. Lundy (✉) · J. L. Bruggers
Resurgens Orthopedics, Atlanta, GA, USA
e-mail: lundydw@resurgens.com; bruggersjl@resurgens.com

in confirming the diagnosis.” Surgeons can often rest on this truth when they suspect that the patient is at risk for compartment syndrome but has not yet fully developed the condition. We can more reliably state that “it isn’t there” than we can say “it absolutely is there”.

Unfortunately, closed claim reports have documented cases of missed compartment syndrome where the treating surgeon seemed negligent in addressing the increasing signs and symptoms manifested by the patient. Although there are certainly situations when delayed recognition of the diagnosis may possibly be understandable, some cases just seem unexplainable. It is incumbent on the treating surgeon to anticipate acute compartment syndrome and be responsive when clear signs and symptoms present. O’Toole et al. [3] demonstrated that even highly trained orthopedic trauma surgeons in their Level I trauma center can have significantly different thresholds in diagnosing compartment syndrome. Recognizing that the diagnosis may be unclear and that delays in diagnosis may occur even in good systems, we should endeavor to make this unfortunate reality as rare as possible.

The hallmark symptom associated with acute compartment syndrome is “pain out of proportion.” Patients who are sedated and intubated on ventilator support, head injured with a low GCS, or paralyzed from the spinal cord or other injury may be unable to communicate that they have severe pain, and the chance of missing the diagnosis of compartment syndrome increases significantly in these situations. Surgeons must communicate with staff to be very wary of acute compartment syndrome in “at-risk” patients and be vigilant for the signs of this condition. Clinical examination, to include increased pressure in the compartment upon palpation, pallor, and pulselessness, must be reported immediately to the surgeon. Recognizing that pulselessness and pallor may indicate that damage to the limb has exceeded the window for salvage, it is still extremely important for this finding to be communicated to the treating surgeons so that expedited treatment decisions can be considered. Certainly, no one wants to hear these findings as the first communication that a compartment syndrome is present, but the surgeon must consider the best options for the patient if this is the case.

Certain fracture patterns may forewarn the surgeon that the patient has an increased chance of developing a compartment syndrome, and the surgeon should have increased awareness of these factors in the patient that is difficult to assess. Auld et al. [4] found that AO/OTA type C forearm fractures were more likely to develop compartment syndrome than type A or B fractures. This study affirms the adage that extremities with fracture types associated with higher-energy injuries (such as comminuted patterns) also sustain increased energy in the soft tissue component, increasing the subsequent risk for acute compartment syndrome. Stark et al. [5] showed that medial tibial plateau fracture dislocations have a higher rate of compartment syndrome than the Schatzker VI tibial plateau fracture. Orthopedic surgeons should be extra vigilant when treating patients with injury patterns that are well-known to be associated with compartment syndrome.

An interesting injury pattern is the foot compartment syndrome associated with severe calcaneal fractures. Some surgeons believe that the treatment of foot compartment syndromes may in fact be worse than the sequelae of the syndrome.

Rosenthal et al. [6] found that the compartment syndrome patients in their series of calcaneal fractures had “toe clawing, permanent loss of function, persistent pain, muscle atrophy, contracture, painful warts, weakness, and sensory disturbances.” They found that the patients with compartment syndrome reported functional outcomes that were significantly worse than those without compartment syndrome and that the Sanders III and IV fractures were the most likely to develop compartment syndrome. The pain associated with calcaneal fractures can be severe, and the surgeon should be aware that a compartment syndrome may exist in these situations. The surgeon should communicate the risks and benefits of fasciotomy with the patient and family so that they can make an informed decision regarding treatment.

Increased pressure to palpation in the compartment is a poor and inconsistent method to diagnose compartment syndrome, but this manifestation may be one of the very few clinical indicators left in the insensate or uncommunicative patient. Shuler and Dietz [7] examined the accuracy of orthopedic surgery resident’s ability to estimate compartment pressures through palpation of the affected extremities. They found that the positive predictive value was 70%, and the negative predictive value was 63%. Although palpation of the limb and estimating pressure is not an ideal method for diagnosing compartment syndrome, there are situations when this sign may be the best that we have. Garner et al. [8] suggested that serial exams of the firmness of the compartments may be more sensitive in assessing for compartment syndrome, and they advocated that this may be a useful test in certain situations.

Advances in technology have not provided innovative and reliable methods to detect acute compartment syndrome. Shadgan [9] found that serologic studies are ineffective in the diagnosis of this condition. They found that creatinine kinase, myoglobin, and fatty acid-binding protein are elevated in injured patients as well as those in acute compartment syndrome, and these tests are insensitive in this regard. Wieck et al. [10] analyzed the ability of a polarographic probe to detect compartment syndrome by measuring differences in the partial pressure of oxygen in an animal model, but this has not been tested in human patients. This technology may have clinical application in the future.

Although most orthopedic trauma surgeons agree that the diagnosis of acute compartment syndrome should be based on the clinical presentation of the patient, the use of intracompartmental pressure measurements may be useful when assessing the insensate or obtunded patient. Collinge et al. [11] performed a survey of the Orthopedic Trauma Association and found that these assertions are widely accepted. Intracompartmental pressure may be considered as a part of the assessment of compartment syndrome, but these measurements should not stand alone as the sole decision point for treatment decisions. Intracompartmental pressure measurements are often unnecessary in the awake and alert patient, but they may provide valuable information in patients who cannot assess their pain and actively interact with the surgeon regarding decision making.

Indwelling pressure catheters providing constant measurement of compartment pressure have been shown to be ineffective in accurately diagnosing acute

compartment syndrome. Harris et al. [12] found that 18% of their patients with indwelling catheters had a recorded Δp less than 30 mm Hg. None of these patients ever manifested a compartment syndrome, and none were treated with fasciotomy. The overall incidence of acute compartment syndrome in their study was 2.5%, and performing fasciotomy based only on reported increased pressure measurements would have been unindicated. Likewise, Prayson et al. [13] found in their study that 84% of patients had a Δp measurement less than 30 mm Hg and that 58% of patients had at least one measurement less than 20 mm Hg. None of the patients in their study developed a compartment syndrome. Ho et al. [14] measured the pressure in all four compartments of the leg at the beginning of surgery and immediately after reaming the tibia. They found that 23% of the patients had $\Delta P < 30$ mm Hg, yet none of them ever manifested clinical signs of compartment syndrome nor needed fasciotomy.

There are situations when a surgeon may accept a patient in transfer that has developed a compartment syndrome while in transit or still in the care of the referring physician. This can be extremely challenging since the surgeon often has no good information concerning when the compartment syndrome began and how far along the patient has been in the current condition. This is especially challenging in the uncommunicative or insensate patient. The surgeon has the dilemma of having to predict the future without the benefit of meaningful information about what has transpired. It is paramount in these situations for the surgeon to thoroughly communicate with the patient and family regarding the issues at hand and the risks of all decision pathways.

Consistent vigilance is required since recognition of a developing compartment syndrome is critical in performing fasciotomy within the acceptable window of time. In the era of resident work-hour restrictions and the proliferation of midlevel providers, it is understandable how communication errors can increase the likelihood of a delayed diagnosis of compartment syndrome. Garner et al. [8] describe an algorithm that could improve communication in treatment teams, thus decreasing the risk of missing a compartment syndrome. Their first step was to identify patients “at risk” and ensure that all members of the treatment team were aware of the concern for compartment syndrome. The second step was for the on-call resident or midlevel provider to perform compartment checks on the patient every 2–4 hours, and this person was tasked with communicating the findings to the team. The “compartment check” consisted of subjective pain assessment, reviewing the analgesic requirements since the last check and assessing the compartment fullness by palpation, passive stretch of the muscles, and a full neurologic and pulse examination.

Treatment

Orthopedic surgery residents are taught that compartment syndrome must be treated with fasciotomy. This is one of the few “always” statements in surgery, and violation of this rule is claimed to result in significant injury. The literature

suggests however that this adage may not apply in cases of missed or delayed treatment of compartment syndrome. The available literature on missed compartment syndrome consists of retrospective case reports or series, and prospective randomized trials would be ethically inconceivable. Nonetheless, the available literature suggests that in certain situations, a missed compartment syndrome that has evolved past the acute injury phase may be treated nonoperatively in certain patients.

The surgeon must try to establish how long the ischemia has been present and how much damage is presumed to be present in the compartment. This determination is an extremely challenging process, and no one can consistently determine the clinical outcome in these cases. Nevertheless, an understanding of how long the ischemic injury has been occurring is very important in determining whether fasciotomy may prevent further damage or if that same procedure will begin the process toward amputation of the limb. All too often, a clear determination of ischemia time is impossible to determine, and the surgeon must make the best decision possible based off of limited and flawed data.

Glass et al. [15] performed a systematic review of the limited literature regarding missed lower extremity compartment syndrome. They identified nine studies that comprised 57 patients with missed compartment syndrome. They graded these studies as either “low” or “very low” quality. All but one patient in these reported series had emergent fasciotomy, and the subsequent amputation rate was alarming. They summarized that of the 63 limbs in the 56 patients that were managed surgically, 21 amputations were eventually required, and two patients died. The authors described the decision to perform emergent fasciotomy in cases of missed compartment syndrome as an act that “commits the surgeon to an amputation should the extent of muscle necrosis be unfavorable.”

The same authors [15] performed a retrospective review of missed compartment syndrome at their facility commenting that this is a “rare and complex problem.” They found ten cases of missed compartment syndrome resulting from delayed presentation, clinical error, or depressed consciousness that masked the presenting symptoms. They similarly had poor outcomes from surgical management of the first six cases, and anecdotally they managed the next four without surgery. All four of these cases were in individuals with compartment syndrome that affected one or two of the four compartments of the leg. All four of these patients seemed to fare better than the patients that had been treated with fasciotomy.

A reasonable question is “if there is significant ischemic damage in the compartment that leads to necrosis, how can nonoperative treatment be an option for these patients?” Glass et al. [15] stated that “ischemic damage depends on the magnitude of pressure, muscle mass, and metabolic requirements, the duration of delay does not correlate linearly with the pathological sequelae observed.” Surgeons should carefully evaluate the patient and monitor for signs of sepsis or renal injury from evolving necrosis in the compartments. If there is concern that the load from ischemic damage is beyond the level that can lead to a satisfactory outcome without surgery, the surgeon must immediately perform fasciotomy and debridement understanding that this decision may lead to amputation.

The authors also stated that the decision to monitor missed compartment syndrome in lieu of fasciotomy should only be considered in the lower extremity. They advocate that missed compartment syndrome in the upper extremity should be treated with emergent surgery. Missed compartment syndrome in the upper extremity “represent a different clinical entity where preservation of fine motor function is of paramount importance.”

Legal Issues

Unfortunately, missed compartment syndrome does occur, and it is a leading cause of medical liability claims filed against orthopedic surgeons [1]. Patient care must always be the center of our efforts and attention, but one cannot ignore the prevalent threat of medical liability litigation and the tremendous impact that it has on medical providers. While we must endeavor to always do what’s best for patients, a consideration of the medicolegal risks is appropriate.

Bhattacharyya and Vrahas [16] examined 19 closed claims on 16 patients who sued their physician claiming negligence in the treatment of their acute compartment syndrome. The physician was victorious in 10 of the 19 claims, and all 3 of the claims that went to trial were found in favor of the physician. Not surprisingly, poor physician-patient communication and increasing time to fasciotomy more likely resulted in an indemnity payment. In their study, they found that fasciotomy within 8 hours of presentation of symptoms resulted in a successful defense.

It is vital for orthopedic surgeons to clearly document their findings and their thought processes when treating patients with suspected compartment syndrome. Defense attorneys prefer clear chart notes that elucidate that the surgeon was considering the possibility of acute compartment syndrome and their workup to rule in or rule out the diagnosis. While these chart notes can also be extremely helpful to communicate with other physicians and staff caring for the patient, they are extremely valuable in a medical liability defense years later.

Summary

An untreated compartment syndrome can be a devastating condition that can cause loss of limb or even life. Unfortunately, the diagnosis of compartment syndrome can be delayed or completely missed, and there are limited studies in the literature providing insight for treatment decisions. In certain cases, missed compartment syndrome may be monitored carefully by splinting the lower extremity in the functional position and observing the patient’s metabolic and renal response to the injury. If there is concern for significant muscle necrosis, fasciotomy and debridement may be required, but this can often lead to amputation. Surgeons should endeavor to be hypervigilant to avoid missing a compartment syndrome in their patients.

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