REVIEW ARTICLE

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Acute lumbar paraspinal compartment syndrome: a systematic review

William Alexander, Nelson Low and George Pratt
Department of Plastic Surgery, Monash Health, Melbourne, Victoria, Australia

Key words
fasciotomy, lumbar, paraspinal compartment syndrome, rhabdomyolysis.

Correspondence
Mr William Alexander, Department of Plastic Surgery, Monash Health, 135 David Street, Dandenong, VIC 3175, Australia.
Email: willalexandersemail@gmail.com

W. Alexander MBBS; **N. Low** MBBS, FRACS (Plastics); **G. Pratt** MBBS, FRACS (Plastics).

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Abstract

While still a rare entity, acute lumbar paraspinal compartment syndrome has an increasing incidence. Similar to other compartment syndromes, acute lumbar paraspinal compartment syndrome is defined by raised pressure within a closed fibro-osseous space, limiting tissue perfusion within that space. The resultant tissue ischaemia presents as acute pain, and if left untreated, it may result in permanent tissue damage. A literature search of 'paraspinal compartment syndrome' revealed 21 articles. The details from a case encountered by the authors are also included. A common data set was extracted, focusing on demographics, aetiology, clinical features, management and outcomes. There are 23 reported cases of acute compartment syndrome. These are typically caused by weight-lifting exercises, but may also result from other exercises, direct trauma or non-spinal surgery. Pain, tenderness and paraspinal paraesthesia are key clinical findings. Serum creatine kinase, magnetic resonance imaging and intracompartment pressure measurement confirm the diagnosis. Half of the reported cases have been managed with surgical fasciotomy, and these patients have all had good outcomes relative to those managed with conservative measures with or without hyperbaric oxygen therapy. These good outcomes were despite significant delays to operative intervention. The diagnostic uncertainty and subsequent delay to fasciotomy result from the rarity of this disease entity, and a high level of suspicion is recommended in the appropriate setting. This is particularly true in light of the current popularity of extreme weight lifting in non-professional athletes. Operative intervention is strongly recommended in all cases based on the available evidence.

Introduction

von Volkmann first described compartment syndrome and ischaemic muscle necrosis in 1881.[1] Compartment syndrome has subsequently been described in many anatomical areas, and most frequently involves the upper and lower extremities. Lumbar paraspinal compartment syndrome is a relatively new entity, with only a handful of cases described since Carr *et al.*'s initial description in 1985.[2]

Compartment syndrome is best defined as increased pressure within a non-distensible or unyielding fibro-osseous space, resulting in impaired blood flow and hence tissue perfusion in that space. Diminished perfusion leads initially to ischaemic-type pain, and subsequently to reversible and then irreversible damage to the tissues within the compartment. The resultant oedema and swelling results in a viscous cycle, triggering further ischaemic insult.

The patient with compartment syndrome presents with pain disproportionate to the severity of injury, and intensified upon passive stretch of the muscles within the involved compartment. Paraesthesia may follow, and later signs may include paralysis, absent distal pulses and, rarely, pallor. It is clear that these signs are easier to determine in the extremity as opposed to the paraspinal region.

Subsequent to the initial insult, symptoms develop within 48 h, and as the syndrome progresses, tissue damage results in a biochemical cascade of events. Injured myocytes release enzymes such as creatine kinase (CK) and myoglobin, and while these are a direct correlate of the degree of injury, they can also cause acute tubular necrosis. This kidney damage can be seen as rising serum creatinine. Rhabdomyolysis occurs as a secondary insult from compartment syndrome and can be managed with aggressive hydration, urine alkalinisation and fluid deficit restoration.

Compartment syndrome, left untreated, can cause irreversible muscle and nerve damage, including debilitating contractures. Early recognition and intervention can interrupt this cascade of events and prevent permanent sequelae.

The aim of this study was to systematically review the available literature regarding acute lumbar paraspinal syndrome, with a view to defining best management of this rare condition.

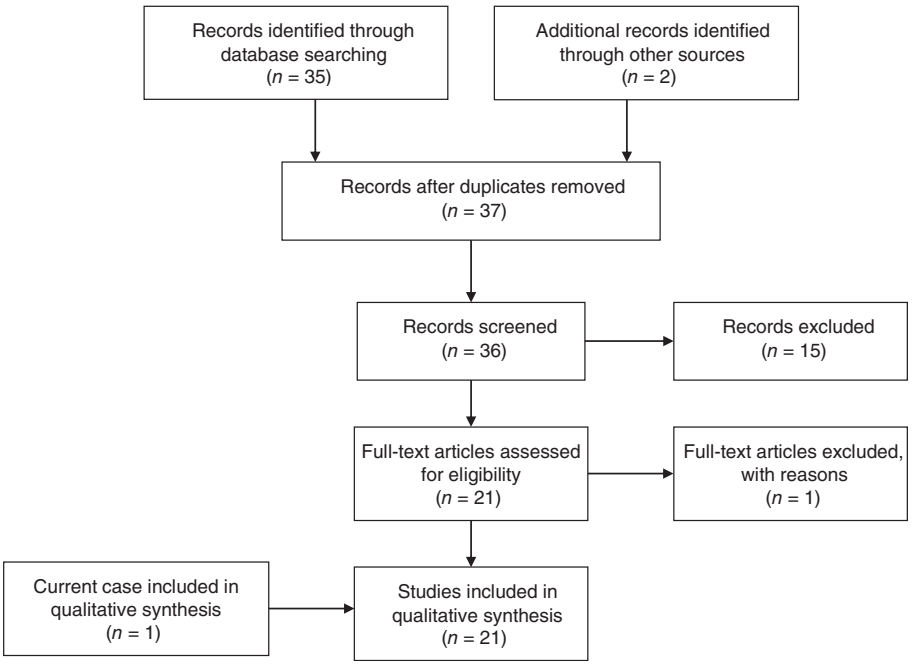

Fig. 1. Citation attrition diagram.

Methods

A PubMed search was conducted using the following title query: 'paraspinal compartment syndrome'. This search yielded 35 articles. Bibliographies of captured articles were examined to select articles not identified in PubMed (resulting in one further article). One author selected articles from the abstracts and obtained full articles for the review process. Articles selected were in English and were original articles describing one or more cases of acute lumbar paraspinal compartment syndrome. A total of 21 articles met the criteria (Fig. 1). Two articles in different journals by different authors seemingly describe the same patient.[3,4] The authors' current case was included in the systematic review. He provided written informed consent to be included in this study. A common data set was extracted from the articles, focusing on patient demographics, aetiology and clinical features of the disease process, and finally management and outcomes. No funding was involved in this investigation.

Results

A total of 21 articles met our criteria.[2–22] All studies were retrospective case reports, with two authors describing two cases.[8] The details of authors' case were included in the review. Table 1 summarizes the cases with respect to demography, aetiology, diagnostic criteria and outcomes.

Demography and aetiology

Nearly all cases were males (22/23), with an average age of 32.1 years (range 16–67 years). The preceding incident was most commonly not related to direct trauma to spinal muscles: weight lifting (12 cases, 52%), skiing (3, 13%), surfing (1, 4%) and non-specific exercises (1, 4%). Four cases were related to non-spinal surgery (17%), and one case was related to direct trauma (4%). No preceding event was found in one case. A total of 12 of the most recent 14 cases were caused by weight lifting.

Clinical findings

All patients presented with severe lower back pain, not controlled by opioid analgesia. Some patients reported radiation into the groin, and approximately half (12/23) had bilateral symptoms. Consistent clinical findings included pain resistant to analgesia, tenderness, paraspinal paraesthesia and the absence of motor signs. Straight leg raise testing was typically negative, and some authors report absent bowel sounds, although this is not consistent across the literature. This is likely a secondary ileus related to rhabdomyolysis.

Laboratory and radiographic findings

All cases had markedly elevated CK (average 58 687 U/L in those tested). In those managed conservatively, the CK continued to rise for a short period of time; however, in the fasciotomy group, the CK dropped post-operatively. There were inconsistently also elevations in aspartate aminotransferase, alanine transaminase), lactate and occasionally white cell count.

In those cases where intracompartment pressure was measured, the findings were greater than the known normal parameters (average 73.7 mmHg in those tested; normal: 3.1–7.95 mmHg[23]). This measurement was typically done with the patient in the prone position.

Both computed tomography (CT) and magnetic resonance imaging (MRI) modalities were used in the reviewed cases, and proved useful in the diagnosis. The consistent findings on CT are swelling of the paraspinal musculature, whereas the MRI typically revealed paraspinal oedema (best seen with T2-weighted images).

Table 1 Systematic review case details

Author	Year	n	Sex	Age	Aetiology	Uni-/ Bilateral	Loss of lordosis	Tenderness	Paraspinal sensory loss	AST	CK	CT/MRI	ICP (mmHg)	Management	Follow-up (duration) and outcome
Carr et al.[2]	1985	1	M	24	Skiing	Bi	+	+	–	365	5465	+	NA	Conservative	1/12: Ongoing pain
DiFazio et al.[6]	1991	1	M	27	Skiing	Bi	NA	+	+	565	60 000	+	L: 80; R: 70	Conservative	4/12: Ongoing pain with activity
Sava et al.[19]	1999	1	F	43	Direct trauma	Uni	NA	NA	+	NA	10 581	–	NA	Fasciotomy (day 7)	NA
Osamura et al.[15]	2000	1	M	67	Aortic bypass	Uni	NA	+	+	190	7975	+	NA	Conservative	7/12: Ongoing mild discomfort
Kitajima et al.[12]	2002	1	M	25	Surfing	Uni	NA	+	+	196	21 440	+	L: 14.7	Fasciotomy (~48 h)	2/12: Pain-free full activity
Ferreira et al.[7]	2003	1	M	55	Aortic bypass	Bi	NA	+	+	NA	25 000	+	NA	Conservative	3/12: Ongoing pain with strenuous activity
Khan et al.[11]	2005	1	M	35	Skiing	Bi	+	+	+	804	48 550	+	L: 26; R: 44	Fasciotomy (12 h)	1/12: Playing sport without pain
Haig et al.[8]	2007	2	M	57	Aortic bypass	Bi	NA	+	+	NA	NA	+	NA	Conservative	NA
			M	34	Gastric bypass	Bi	NA	+	+	NA	NA	–	NA	Conservative	NA
Minnema et al.[14]	2008	1	M	32	Weight lifting	Uni	+	+	+	608	72 820	+	R: 108	Fasciotomy (~48 h)	2/52: Pain-free motion
Karam et al.[10]	2010	1	M	23	Weight lifting	Bi	NA	+	NA	NA	77 400	+	NA	Conservative + HBO	4/12: Pain with exertion
Wik et al.[22]	2010	1	M	30	Weight lifting	Bi	NA	NA	+	NA	82 000	+	L: 20; R: 150	Conservative	2/12: Significant pain with movement
Paryavi et al.[16]	2010	1	M	20	Weight lifting	Bi	+	–	–	504	72 516	+	L: 78; R: 26	Fasciotomy (~10 h)	1/12: Pain-free movement
Calvert et al.[4]/ Allerton et al.[3]	2012	1	M	25	Weight lifting	Uni	NA	+	–	NA	60 800	+	L: 20; R: 7	Conservative + HBO	2/52: Ongoing pain
Chavez et al.[5]	2013	1	M	25	Weight lifting	Uni	+	+	+	NA	42 000	–	NA	Conservative	Day 5: Ongoing pain
Mattiassich et al.[13]	2013	1	M	30	Weight lifting	Uni	NA	+	+	NA	33 000	+	L: 47; R: 3–10	Fasciotomy (~67 h)	3/12: Pain-free sport + skiing (minor paraspinal paraesthesia)
Rha et al.[17]	2014	2	M	30	Weight lifting	Bi	NA	+	NA	632	67 200	+	NA	Fasciotomy (~8 h)	6/12: Pain-free exercise
			M	31	Weight lifting	Bi	NA	NA	NA	'elevated'	'elevated'	+	NA	Fasciotomy (~6 h)	6/12: Pain-free exercise
Rogers et al.[18]	2014	1	M	45	Idiopathic	Bi	NA	+	+	1026	178 000	+	L: 150; R: 120	Fasciotomy (~24 h)	2/52: Resolution of symptoms
Hoyle et al.[9]	2015	1	M	24	Weight lifting	Uni	NA	+	NA	'normal'	4949†	+	NA	Conservative	6/52: Reduced ROM, paraspinal muscle wasting
Schreiber and Ward[20]	2015	1	M	17	Weight lifting	Uni		NA	+	1330	116 000	+	NA	Fasciotomy (~18 h)	4/12: Pain-free exercise
Vanbrabant et al.[21]	2015	1	M	16	Exercise	Uni	NA	+	+	647	81 840	+	L: 20; R: 125	Fasciotomy (~4 days)	3/12: Pain-free exercise
Authors' case	2017	1	M	23	Weight lifting	Uni	+	+	+	NA	52 470	+	R: 100	Fasciotomy (~36 h)	3/12: Pain-free exercise

†Nine days post-onset of pain. AST, aspartate aminotransferase (U/L); CK, creatine kinase (U/L); CP, compartment pressure; CT, computed tomography; ICP, intracompartment pressure; MRI, magnetic resonance imaging (+, swelling of paraspinal musculature (CT/MRI), or increased signal in paraspinal musculature (MRI)); NA, results not available or not stated; ROM, range of motion.

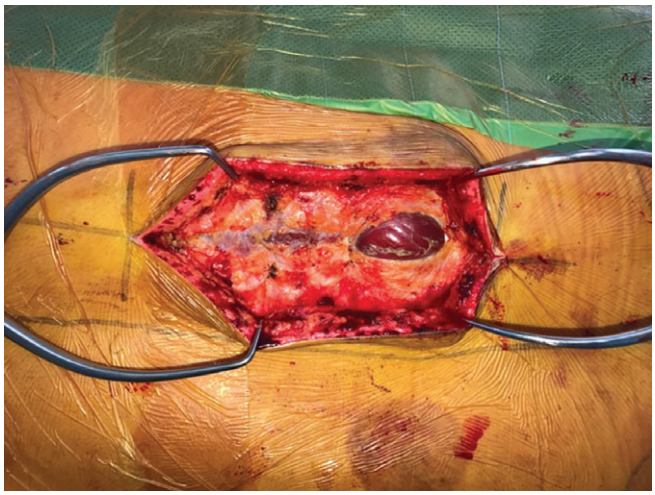

Fig. 2. Patient positioning and Wiltse incision markings, with partial release of compartment and eruption of bulging paraspinal musculature.

Management and outcome

Twelve of the described cases underwent fasciotomy, nine had purely medical therapy and the remaining two had medical therapy plus hyperbaric oxygen therapy. Figures 2–4 demonstrate the operative technique and surgical findings in the authors' case. There was non-standardized follow-up across the cases, and within those cases with reported follow-up (20/23), outcomes were measured from between 5 days and 6 months following discharge. These were described qualitatively with respect to pain at rest and with exercise, and the activities able to be performed by the patients.

All cases that were treated with fasciotomy reported good outcomes with respect to pain and function. Fasciotomy was performed up to 7 days following the onset of symptoms, but usually within 36 h. Approximately half of those who underwent fasciotomy were found to have irreversible myonecrosis, but this did not adversely affect the functional outcome in these patients. Two cases had minor ongoing paraspinal paraesthesia at 3 months post-discharge.

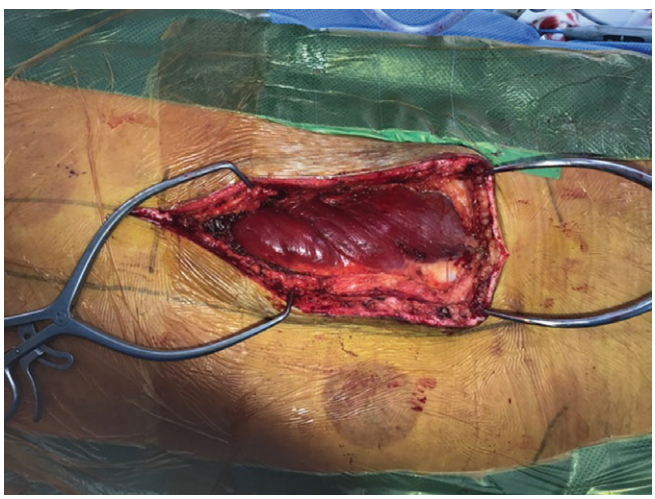

Fig. 3. The thoracolumbar fascia is released, with elevation and preservation of latissimus dorsi and the inferior edge of trapezius. Initial questionable viability of muscle within the compartment is noted.

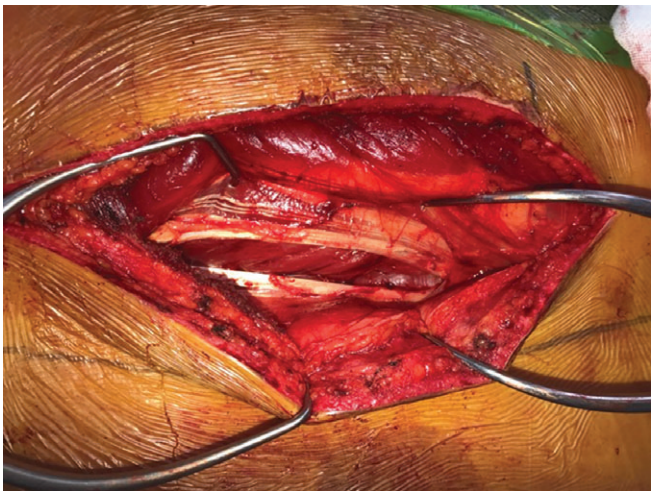

Fig. 4. Dissection proceeded through the paravertebral muscles to release each of longissimus, iliocostalis, spinalis and multifidus. After complete release, the intracompartmental muscles regained a healthy, pink appearance.

Of the 11 cases that were treated without fasciotomy, all had ongoing symptoms or functional restriction at their follow-up appointments. Hyperbaric oxygen therapy did not convey any demonstrable benefit compared to conservative management alone, in this small cohort.

Discussion

Lumbar paraspinal compartment syndrome was initially described in a 1985 case report of a young man with severe post-exertional back pain.[2] In that case, the diagnosis was proposed on the basis of myoglobinuria, elevation in serum CK and CT findings suggestive of ischaemia and necrosis. The authors subsequently demonstrated through pressure measurements in healthy volunteers and cadaveric dissection that the paraspinal muscles are ensheathed in a fascial envelope that is similar to other muscle compartments susceptible to compartment syndrome.

Anatomically, the compartment is enclosed by the thoracolumbar fascia on all but the medial side, where it bordered by the spinous processes, and interspinous ligaments.[24] This fascial compartment space behaves physiologically like a closed space, and the resting intracompartment pressures in healthy subjects have been reported between 3 and 7.95 mmHg, depending on position, rising transiently up to 25 mmHg during exercise.[2,23] The pressure measured in cases of compartment syndrome was 14.7–150 mmHg.

The aetiology of acute paraspinal syndrome can be classified into those due to direct trauma to the muscles, non-direct/atraumatic insult (i.e. weight lifting) or secondary to non-spinal surgery causing occlusion of blood supply.[25] The most common aetiology is non-direct or atraumatic injury, and this typically affects young males in the second or third decade of life. Particularly recently, weight lifting (including 'CrossFit') has accounted for the great majority of cases. This subtype of weight lifting is a high-intensity

exercise programme, which focuses on functional strength. It has gained popularity in the last decade, with just 13 'CrossFit' gyms in 2005, but over 10 000 in 2014.[26] This has been reflected in our results, with 13 of the last 14 reported cases linked to weight lifting.

Clinical findings of paraspinal compartment syndrome include severe, unrelenting pain following a typical antecedent. The patient is markedly distressed, and often unwilling to mobilize secondary to the pain. It is not uncommon for these patients to re-present after having been unsuccessfully discharged from a previous emergency department with analgesia only. Examination typically reveals unremarkable vital signs, but a tender, swollen lumbar paraspinal region. There is a loss of normal lumbar lordosis, and pain is typically exacerbated by stretch of the compartment (i.e. hip flexion). The patient may report radiation to the groin and may have absent bowel sounds secondary to ileus. Paravertebral sensory dysfunction is not uncommon, as the dorsal primary sensory branches pass through the paraspinal compartment. The remainder of the neurological examination is unremarkable.

An elevated CK is the consistent finding, and this responds rapidly to surgical decompression. Transaminase levels and white cell counts may also be useful in diagnosis. Intracompartment pressure measurement is the ideal test, providing direct information regarding the intracompartment pressure, with normal ranges well documented by previous literature.[23]

Whereas imaging is typically neither required nor recommended in the diagnosis of compartment syndrome in the extremities, it is very useful in this setting where, due to its rarity, there is diagnostic uncertainty and a lack of experience with the condition. MRI is the test of choice and showed striking features in all but one case where it was performed. These patients had paraspinal enhancement on T2-weighted images, indicating oedema within the compartment. CT scans were also useful, showing swelling of the paraspinal musculature. Both modalities also help to exclude alternate diagnoses such as abscess, tumour or fracture.

All patients with rhabdomyolysis should be aggressively treated with intravenous hydration and urine alkanization. This helps prevent the breakdown of myoglobin into toxic by-products within the kidneys, and subsequent acute renal failure. In addition, nephrotoxic drugs should be avoided.

Based on the available evidence, all patients should be treated with surgical fasciotomy. Obviously, the evidence presented is limited to single or double case reports, and the follow-up is not reported in a standardized or quantitative fashion. With that said, every patient managed conservatively reported ongoing pain or functional limitation. Conversely, every patient treated surgically reported good function without pain. The two patients managed with conservative therapy plus hyperbaric oxygen had similar outcomes to the group managed with conservative measures only. Interestingly, extended delays to theatre did not seem to adversely affect the functional outcome. The fasciotomy in our case was performed 36 h following the onset of symptoms, and other authors have described good outcomes despite delays of 2–4 days after the onset of symptoms.[13,14,21] In most cases, the muscle appeared dusky upon release but was viable, returning to a pink, healthy, contractile state by the end of the first procedure. Even in the cases where some dead muscle was found and debrided, the functional outcome was good.[12,13,16,17,20,21] Most authors, including ourselves, used either a unilateral or bilateral paramedian Wiltse incision,[27] and once through the lumbar fascia, released the subcompartmental individual muscle groups. The paramedian (rather than midline) incision is recommended as it allows for delayed soft tissue closure or grafting over a viable muscle bed.

Conclusion

Acute lumbar paraspinal compartment syndrome is an important differential in the young patient presenting with severe lower back pain. There has been an increase in incidence of this entity over the past 5 years, and this seems to correlate with the increasing popularity of weight lifting exercises such as 'CrossFit' in the non-professional athlete. Findings of a firm, tender compartment with paraspinal paraesthesia and poor response to analgesics should invoke suspicion. The diagnosis can be confirmed with raised serum CK, classical features on MRI (or CT) and a raised intracompartment pressure. All patients should be treated for rhabdomyolysis, but should also undergo emergent fasciotomy. The available evidence suggests even a significant delay to theatre is not a contraindication to fasciotomy. Patients can expect good outcomes from this condition if managed appropriately.

Conflicts of interest

None declared.

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