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Acute compartment syndrome of the deltoid: a case report and systematic review of the literature

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Background: Deltoid compartment syndrome is a rare entity. The purpose of this study was to report a recent case and perform a systematic literature review.

Methods: Patient data were gathered from chart review and clinical encounters. For the review, the MEDLINE, Embase, and Ovid databases were queried for deltoid compartment syndrome cases. Seventeen articles reporting on 18 patients with deltoid compartment syndrome were included.

Results: Including our patient, 9 of 19 patients (47.4%) presented with compartment syndrome limited to the deltoid. Most patients presented with additional affected compartments, most commonly in the ipsilateral arm (7 of 19, 37%). Isolated deltoid involvement often resulted from iatrogenic injury; of 10 iatrogenic reports, 8 involved only the deltoid. Of 19 cases, 5 (26%) occurred in powerlifters, climbers, or anabolic steroid or testosterone injectors. In 13 of 19 cases (68%), the patients were men aged 18–36 years, and only 1 female case (5%) was reported. Prolonged recumbence owing to substance abuse was documented in 6 of 19 cases (32%).

Conclusion: Deltoid compartment syndrome is rare, with only 19 reported cases, including our patient. Men are more commonly affected, and isolated deltoid compartment syndrome occurs in about 50% of reported cases. More than half of cases are iatrogenic, secondary to prolonged lateral decubitus positioning, injections, and surgical interventions about the shoulder. Prolonged recumbence from intoxication is also a common etiology. Providers should be aware of and recognize deltoid compartment syndrome to facilitate urgent surgical management.

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Acute compartment syndrome is an orthopedic emergency, with potentially devastating morbidity and death. Without quick recognition and appropriate decompression, the patient is likely to have severe long-term sequelae.¹ Compartment syndromes of the lower legs and forearms are well documented and are presentations with which most orthopedic surgeons and emergency providers are familiar.¹⁹ However, compartment syndrome of the deltoid is rare and has been infrequently reported.² Currently, there

are 18 reported cases in the literature, with only 8 having isolated deltoid involvement.^{1,2,4–9,11–18,20}

We recently encountered the case of a patient who had isolated compartment syndrome of the right deltoid after being found lying down for an unknown period. The purpose of this study was to (1) present the encountered case and (2) perform a systematic literature review of deltoid compartment syndrome.

Methods

For the case report, we longitudinally gathered data from chart review and clinical encounters. For the systematic review, the MEDLINE, Embase, and Ovid databases were queried from database inception to May 14, 2020, using the following search terms: (deltoid OR shoulder OR (upper arm)) AND (compartment

Institutional review board approval was not required for this case report.

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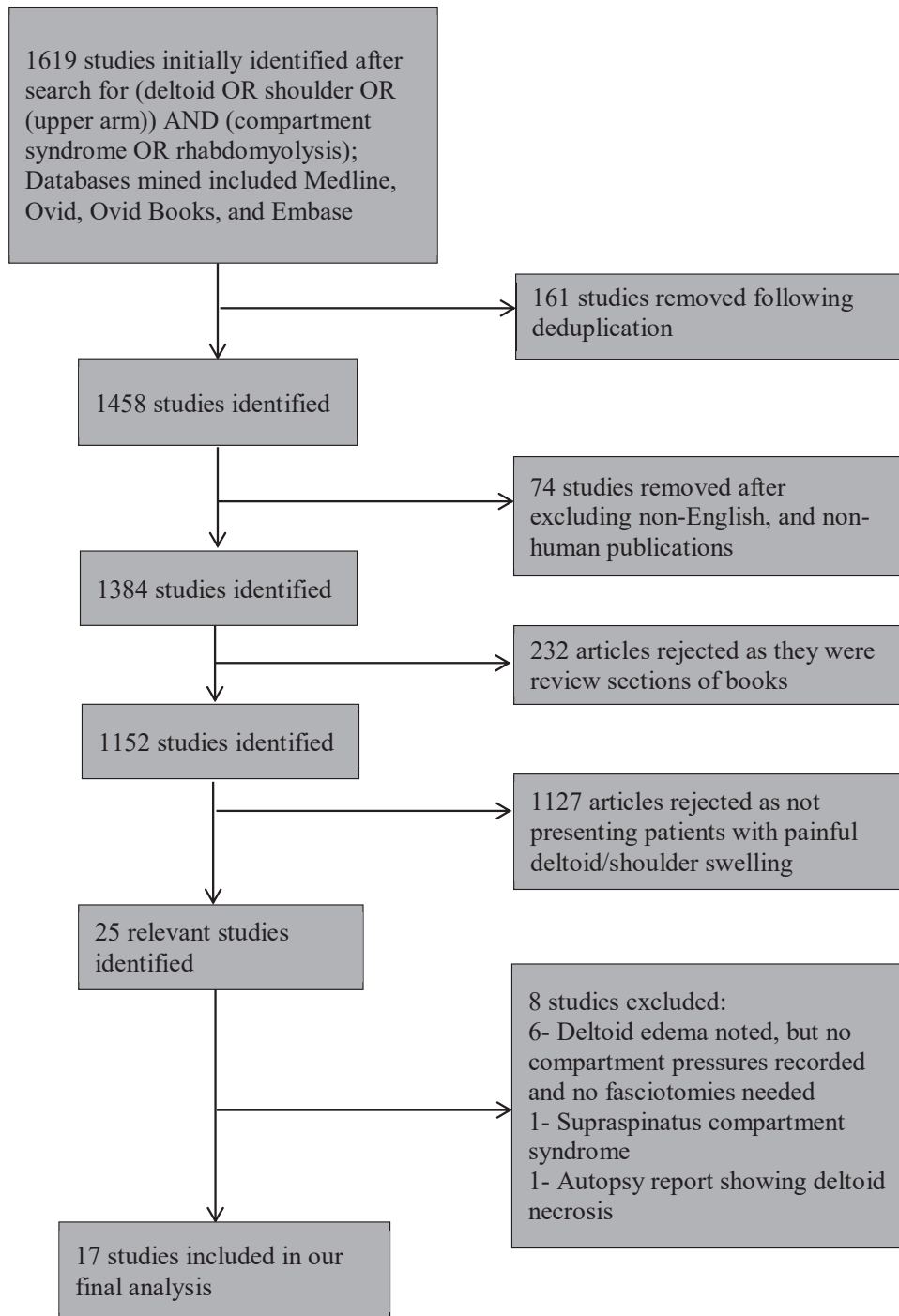


Figure 1 Study-selection flow diagram.

syndrome OR rhabdomyolysis). The initial search yielded 1619 reports. After duplicates were excluded, 1458 distinct articles were identified. After removal of non-English-language and nonhuman reports, there were 1384 studies. Book sections were excluded, resulting in 1152 studies. Abstracts were reviewed for clinical encounters of patients with signs or symptoms of a painful deltoid or shoulder swelling, which yielded 25 potential articles. Articles dealing primarily with deltoid rhabdomyositis, without documented compartment pressures and without the need for fasciotomy, were excluded. Reports presenting autopsy records without documented clinical symptoms prior to the patient’s death

were also excluded. Finally, articles reporting on compartment syndromes of the rotator cuff muscles without deltoid involvement were excluded. Ultimately, 17 articles reporting on 18 patients with deltoid compartment syndrome were reviewed for this report by 2 authors (J.P.S. and M.C.).^{1,2,4–9,11–18,20} The study-selection flow diagram is depicted in Figure 1.

Case report

A 53-year-old right hand–dominant man (body mass index, 34.5 kg/m²) with a medical history of polysubstance use, cirrhosis,

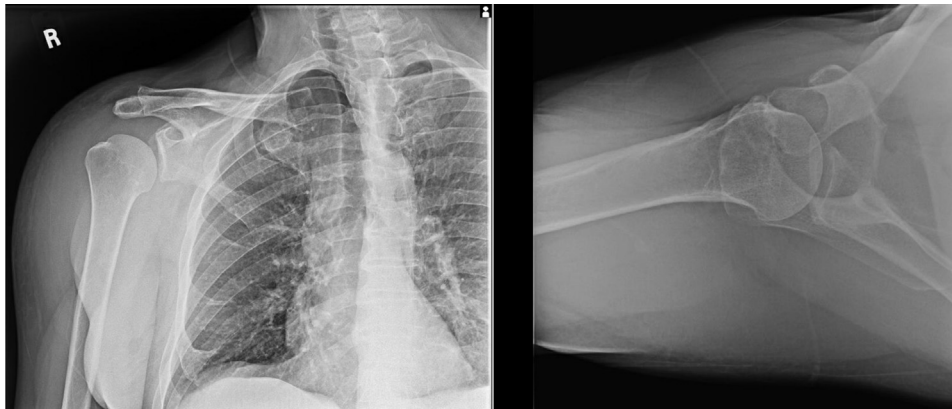


Figure 2 Anteroposterior (left) and axillary (right) radiographs of right (R) shoulder demonstrating no fracture or osseous abnormality.

chronic obstructive pulmonary disease, and bipolar disorder was brought to the emergency department by police after an extended period of lying on his right side. The patient was disoriented and was unable to provide a consistent or reliable history; therefore, it was unclear how long he had been immobilized. Chart review showed multiple admissions in previous months for alcohol, marijuana, and cocaine use, as well as suicidal ideation.

In the emergency department, the patient had hypertension (183/90 mm Hg), had tachycardia (112 beats/min), was febrile (38.3°C), and had tachypnea (34 breaths/min). Because of his hemodynamic status and confusion, a septic workup was initially undertaken by emergency physicians. This showed a normal white cell count of 10,200/ μ L, erythrocyte sedimentation rate of 14 mm/h, C-reactive protein level of 3.8 mg/dL, and lactate level of 1.9 mmol/L. The test result for severe acute respiratory syndrome coronavirus 2 (obtained because of the current pandemic) was negative, and blood cultures were obtained (with no growth on final culture). Laboratory values indicated rhabdomyolysis and myoglobinuria, with a creatine kinase level of 15,131 U/L. There was no detectable serum ethanol. A shoulder radiograph demonstrated normal osseous anatomy with soft-tissue swelling (Fig. 2). A computed tomography scan of the shoulder showed extensive soft-tissue edema of the deltoid without any focal fluid collections (Fig. 3). The patient was determined to be in alcohol withdrawal with a score of 15 on the Clinical Institute Withdrawal Assessment of Alcohol, Revised (CIWA-Ar) scale.

The patient’s orthopedic examination findings were notable for diffuse firmness in the right shoulder with a tense deltoid and

tenderness to palpation. He had no pain with small arcs of motion and had equivocal pain with shoulder abduction. He had full sensation and motor function in the extremity, as well as a palpable radial pulse. Given the high index of suspicion and ambiguous examination findings owing to mental status, compartment pressures were measured using a Stryker Intra-Compartmental Pressure Monitor System (Stryker, Kalamazoo, MI, USA). This recorded absolute pressures of 45 mm Hg in the middle compartment and 45 mm Hg in the anterior compartment of the deltoid (δ pressures of 50 mm Hg and 45 mm Hg, respectively). The extremity distal to the deltoid was soft and compressible. The patient was then brought to the operating room for deltoid fasciotomy.

The patient was positioned supine with a bump under the right shoulder. A 1-incision, lateral approach was performed superficially from the acromion toward the deltoid insertion on the humerus; this was approximately 15 cm in length. The subcutaneous tissue was edematous, and the underlying muscle belly was firm. The deltoid fascia was divided above the axillary nerve. The raphe and the superficial deltoid fasciae of the anterior and posterior compartments were divided. The muscle was noticeably decompressed. The wound was copiously irrigated. The muscle bellies were all able to be stimulated with electrocautery, although the inferior aspect of the deltoid appeared slightly dusky. The incision was intermittently covered with a negative-pressure wound vacuum and was reassessed in the operating room 48 hours later. The posterior compartment of the deltoid was found to be necrotic and was débrided, with a repeated negative-pressure wound vacuum application. The patient was again taken to the operating room 4



Figure 3 Computed tomography scans with intravenous contrast demonstrating edematous deltoid with no fluid collection. A, adipose; LP, left pleura; R, right; L, left.

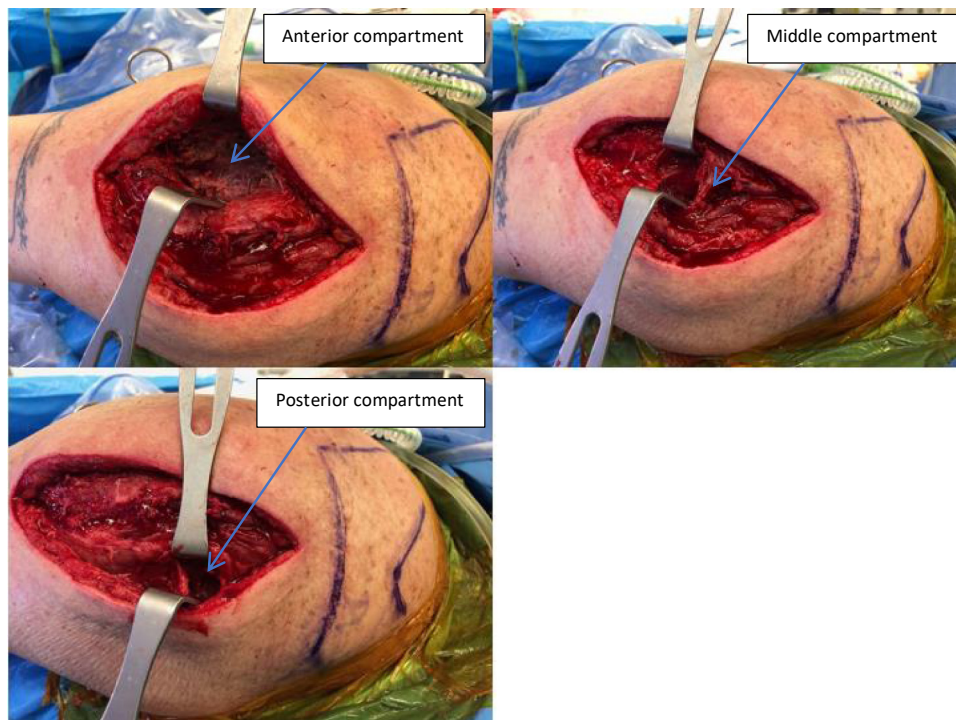


Figure 4 Intraoperative images of anterior (top left), middle (top right), and posterior (bottom) compartments of deltoid showing viable healthy musculature.

days later and was found to have healthy remaining muscle tissue throughout the deltoid (Fig. 4). The incision was closed primarily at that time, and the patient was discharged home.

Results and discussion

Deltoid compartment syndrome is a rare entity. The anatomy of the shoulder girdle decreases the risk of clinically significant swelling in the deltoid compartments. Anteromedially, the deep deltoid fascia is contiguous with the pectoralis fascia. The deltoid fascia also communicates with the infraspinatus fascia posteriorly and with the brachial fascia inferiorly.^{2,3} Moreover, the fascia of the deltoid is more compliant than that of the leg and forearm and is able to tolerate more muscular swelling without compartmental pressure changes.^{2,10} As such, amassing sufficient edema to cause intracompartmental pressures to reach the threshold of syndromic levels requires a severe insult. This report presents a case of isolated deltoid compartment syndrome in an obese male patient with polysubstance use who was found lying down for an unknown period and was ultimately treated with surgical intervention. His case required 3 operations, with the first to release the compartments, the second to débride a nonviable posterior compartment, and the third to obtain a final look and achieve primary wound closure.

In the systematic review, the selected studies demonstrated that the etiologies of deltoid compartment syndrome are varied and that patients often have multiple risk factors. Including our patient, fewer than half of reported patients presented with compartment syndrome limited to the deltoid muscle (9 of 19 patients, 47.4%).^{1,4–6,11,13,17,20} In the majority of cases, patients presented with additional affected compartments, most commonly in the ipsilateral arm (7 of 19 patients, 37%) and pectoralis (2 of 19 patients, 11%) (Table 1). This finding likely demonstrates the ability of the upper-extremity fascial planes to distribute tensile forces.³ Cases of isolated deltoid involvement were often the result of iatrogenic injury;

of 10 reports with iatrogenic causes, 8 involved only the deltoid compartment.^{1,4,6,11,13,15,17,20} These cases included antegrade humeral intramedullary nailing, humeral intraosseous access, and multiple instances of insufficient padding in the lateral decubitus position. Previous reports have also noted that a large muscle mass—especially a rapidly expanding muscle mass owing to anabolic steroid use—is a likely risk factor for deltoid compartment syndrome.^{1,8} Our review supports this finding, as 5 cases occurred in powerlifters, professional climbers, or persons self-administering anabolic steroid or testosterone injections.^{2,11,14,16,20} In 13 of 19 cases (68%), the patients were men aged 18–36 years, and only 1 case (5%) has been reported in a female patient.^{1,2,4,8,9,11–13,15,16,18,20} Her case was notable as it was caused by an expanding hematoma rather than solely muscular edema.¹⁷

Prolonged recumbence owing to substance abuse was documented in 6 of 19 cases (32%), including our case report.^{5,8,12,18} As extended periods of pressure lead to tissue edema, positional dependence on the deltoid will lead to increased compartmental pressure.¹² Although the acutely treating orthopedist is incapable of preventing presentations from substance abuse, 3 included reports concerned deltoid compartment syndrome from prolonged intraoperative lateral decubitus positioning (3 of 19, 16%).^{1,5,13} Therefore, it is imperative to properly position and pad potential pressure points during orthopedic procedures, as well as to be cognizant of operative time.

Accurately identifying deltoid compartment syndrome is crucial to timely fasciotomy. Although direct compartment pressure measurement is not necessary to diagnose compartment syndrome, in patients who are in an altered state and unable to fully participate in an examination, we recommend obtaining quantitative compartmental pressures. Absolute compartment pressures > 30 mm Hg or within 30 mm Hg of diastolic pressure are appropriate thresholds to confirm suspected compartment syndrome.⁸ In patients in whom neighboring muscle compartments are also afflicted, opting for easily extensible approaches is recommended,

Table 1
Literature review summary

Article	Mechanism	Compartments involved	Deltoid fasciotomy technique	Findings	Outcome
Borenstein et al, ¹ 2015	Prolonged lateral decubitus positioning	Right deltoid	2 incisions: anterolateral and posterolateral	Nonviable posterior and middle deltoid compartments	Decreased function and chronic pain at 1 yr
Diminick et al, ² 1999	Fall into cement-ground pool while intoxicated	Left deltoid and posterior upper arm	3 incisions: extensile posterior, lateral, and anterior	Edematous, viable deltoid and triceps	Full recovery at 14 mo
Gaffney and Slabaugh, ⁴ 2009	Anterograde intramedullary nailing of segmental humeral fracture	Left deltoid	2 incisions: direct lateral and anterior	Edematous, viable deltoid	Full recovery at 3 mo
Harrison et al, ⁵ 2016	Prolonged recumbence owing to substance abuse	Left deltoid	Not reported	Edematous, viable deltoid	No reported follow-up
Klocker et al, ⁶ 2003	Revascularization after stenting of stenotic subclavian artery	Left deltoid	1 incision: anterolateral	Edematous, viable deltoid	Full recovery at 8 mo
Knapke and Truumees, ⁷ 2004	Intramuscular vitamin B ₁₂ injection	Right deltoid and posterior upper arm	1 incision: extensile posterolateral	Edematous, viable deltoid and partially nonviable triceps	Not reported
Kooner et al, ⁸ 2020	Prolonged recumbence owing to substance abuse	Right deltoid, right hand, and right gluteus	2 incisions: anterolateral and posterolateral	Partially nonviable anteromedial deltoid	Full recovery at 1 yr
Kumar et al, ⁹ 2003	High-voltage electrical burn	Right deltoid, right anterior upper arm, and right volar forearm	Not reported	Not reported	Not reported
Mofidi et al, ¹¹ 2002	Testosterone injections in martial artist	Left deltoid	1 incision: direct lateral	Partially nonviable deltoid	Full activity at 3 mo
Mubarak et al, ¹² 1978	Case 1 Prolonged recumbence owing to substance abuse	Deltoid, volar and dorsal forearm, and anterior thigh	Not reported	Not reported	Full shoulder function with Volkmann contracture Full recovery
	Case 2 Prolonged recumbence owing to substance abuse	Deltoid, anterior upper arm, gluteus, and tensor fascia	Not reported	Not reported	
Rohde and Goitz, ¹³ 2006	Prolonged lateral decubitus positioning	Right deltoid	1 incision: transverse saber-type	Edematous, viable deltoid	Full recovery at 1 yr
Saleem and van Doorn, ¹⁴ 2001	Revascularization after aortic dissection	Right deltoid and entire upper arm and forearm	1 incision: extensile anterolateral	Edematous, viable muscle throughout	Death on POD5 due to multiorgan failure
Seewoogoolam et al, ¹⁵ 2019	Quetiapine overdose	Left anterior deltoid and left pectoralis	2 incisions: extensile anterior	Edematous, viable muscle throughout	Partial residual weakness at 3 weeks
Tarkin et al, ¹⁶ 2009	Exercise induced in tree climber	Left deltoid and left pectoralis	1 incision: extensile anterior	Partially nonviable muscle	Full function at last follow-up Not reported
Thadikonda et al, ¹⁷ 2017	Humeral intraosseous access with suprathreshold INR	Left deltoid	2 incisions: anterolateral and posterolateral	Viable deltoid with hematoma formation	
Thorpe and Tarkin, ¹⁸ 2010	Prolonged recumbence owing to substance abuse	Right deltoid and right anterior thigh	2 incisions: anterolateral and posterolateral	Nonviable posterior deltoid	Full function at last follow-up
Wijesuriya et al, ²⁰ 2014	Prolonged lateral decubitus positioning	Left deltoid	1 incision: direct lateral	Edematous, viable deltoid	Full recovery at 6 mo
Current report	Prolonged recumbence owing to substance abuse	Right deltoid	1 incision: direct lateral	Nonviable posterior deltoid compartment	Discharged with no pain

POD5, postoperative day 5; INR, international normalized ratio.

such as an anterior incision for combined deltoid and pectoralis compartment syndrome. For isolated deltoid compartment syndrome, 3 reports described 2-incision approaches.^{1,4,17} A 2-incision approach may allow for easier visualization of both the deltoid raphe and the axillary nerve branches; this may facilitate avoidance of denervation of the teres minor if posterior deltoid débridement is required.¹⁸ Five author groups reported a 1-incision approach, including us.^{6,11,13,20} With a single incision, there is no concern about the viability of a skin bridge under tension and there is a smaller defect if grafting is ultimately required. One author group used a transverse, saber-type 1-incision approach.¹³ Although their patient achieved a full recovery at 1 year, a transverse incision may place the supraclavicular nerves at higher risk of transection during the approach. Ultimately, the surgeon should use the approach with which he or she is most confident of successful deltoid decompression, as this is the major determinant of patient outcomes.

Limitations

This study does have limitations. It is a case report and literature review of a rare entity. As such, it is difficult to draw generalizable conclusions from only 19 reported cases. Because the cases discussed are all from small case series or reports, there are no comparison groups. The included studies all provide level IV evidence, and the treatment strategies documented are reliant on the treating surgeon’s individual practice. We are unable to calculate the statistical significance of any of the proposed trends and etiologies of deltoid compartment syndrome and are unable to perform a meta-analytical assessment.

Future directions

The documentation of an additional case and a review of this rare entity will provide surgeons with further treatment information if they were to encounter deltoid compartment syndrome in their

practices. Further study of deltoid compartment syndrome will be reliant on future documentation of cases. The rarity of this syndrome may make it challenging to design any comparative study of outcomes based on etiologies or incision choices.

Conclusion

Deltoid compartment syndrome is a rare entity, with only 19 reported cases, including our patient. It most commonly presents in men, and isolated deltoid compartment syndrome occurs in about 50% of reported cases. The other half of cases appear to be varied but essentially occur after prolonged recumbence in patients who are intoxicated. Providers should be aware of and recognize deltoid compartment syndrome to facilitate urgent surgical management.

Disclaimer

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