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# Acute compartment syndrome of the contralateral thigh following reconstructive shoulder surgery done for multidirectional shoulder instability in lateral decubitus position

John T Cronin , John G Skedros

Department of Surgery,  
Intermountain Medical Center,  
Murray, Utah, USA

**Correspondence to**  
Dr John G Skedros;  
jskedrosmd@uosmd.com

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## SUMMARY

A man in his early 40s had revision reconstructive surgery on his left shoulder while in a right lateral decubitus position. The prolonged surgery (7 hours) caused acute compartment syndrome (ACS) in the contralateral (right) thigh. Moderate pain and swelling of the contralateral thigh ('well limb') was first noted in the recovery room. After progression to severe swelling and numbness in his right toes, fasciotomies of the right thigh were performed, confirming ACS. Thirteen months later he returned to his prior work without lower extremity discomfort or limitations, and he reported a good result from the revision shoulder surgery. Non-traumatic ACS of a well limb is a rare complication of surgery performed in the lateral decubitus position. We suggest that moving the patient temporarily, or to a new position (eg, beach chair), should be considered when the duration of surgery approaches 4.5 hours.

## BACKGROUND

Non-traumatic acute compartment syndrome (ACS) can result from prolonged surgery in an otherwise normal limb ('well limb').<sup>1</sup> This complication is usually the result of patient positioning and prolonged surgery.<sup>2</sup> The occurrence of non-traumatic ACS in a well limb has been reported after various types of orthopaedic and general surgeries that were prolonged and were done in various positions, including supine, prone, lithotomy, hemilithotomy, tuck, knee-chest and lateral decubitus (also known as 'lateral position').<sup>1-8</sup>

We report the case of a healthy patient who developed ACS of the thigh after a 7-hour shoulder surgery that was done in the lateral decubitus position. [Table 1](#) lists cases found in our literature review (PubMed and Google) where ACS occurred in a well limb after diverse types of surgeries done in the lateral decubitus position (without use of a tourniquet<sup>9</sup>). The surgeries performed on these patients were all prolonged, ranging from 4.5 to 13.1 hours, with an average of 8 hours (SD = 2.5 hours). All but one patient developed ACS in a contralateral limb. Our case of ACS of the contralateral thigh after prolonged shoulder surgery is also listed in [table 1](#). We could not locate any prior reports of this complication occurring after a shoulder surgery done in the lateral decubitus position. Important aspects of our patient's surgery that contributed to its long duration are detailed below.

## CASE PRESENTATION

The patient is a healthy man in his early 40s with no prior shoulder problems who had a left shoulder dislocation from a ground-level fall in a restaurant kitchen where he worked as a cook (worker's compensation claim). The initial left shoulder surgery included arthroscopic anterior and posterior labrum repairs with suture anchors and capsular plications. This index surgery was not successful in the short term because of episodes of multidirectional subluxations. The patient then suffered recurrent episodes of multidirectional dislocations after another ground-level fall.

The patient was then referred to one of us (JGS) for revision shoulder surgery, which was 10 months after the initial surgery. He was diagnosed with post-traumatic multidirectional instability, and MRIs showed a large posterior Hill-Sachs lesion and anterior and posterior capsulolabral tears. The revision surgery was performed on 30 October 2018 in the right lateral decubitus position ([figure 1](#)). The patient was placed on a padded operating room table (7.62 cm thick) with two additional layers of polymer gel padding (2.54 cm total thickness) to cushion his dependent (right side) trunk and limbs. A deflatable bean bag had been placed beneath the gel padding. With the patient in this position, arthroscopic debridement was done initially, and an arthroscopic Remplissage procedure for the large Hill-Sachs lesion was planned.<sup>10</sup> However, this was converted to an open Remplissage because the Hill-Sachs lesion was larger than anticipated (was found to be 'engaging') and optimal visualisation was also obscured by bleeding.<sup>11</sup> The time spent attempting to perform the posterior reconstruction arthroscopically increased the duration of surgery by approximately 45 min. Anterior reconstruction was done with an open Latarjet procedure.<sup>12</sup> An attempt to place two screws into his relatively small coracoid resulted in a partial fragmentation of the coracoid apex, which added 30 min to the duration of surgery. An acellular dermal matrix patch (GraftJacket, Wright Medical, Memphis, Tennessee, USA) was used to augment the significant deficiency (thinning) of the ligaments spanning the anterior glenohumeral joint.<sup>13-15</sup> This unplanned step added approximately 45 min to the duration of surgery.

The most substantial prolongation of surgery was caused by something that was very unexpected. As the surgery progressed, the surgeon experienced



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**Table 1** Cases of non-traumatic well-limb acute compartment syndrome after prolonged surgery in lateral decubitus position

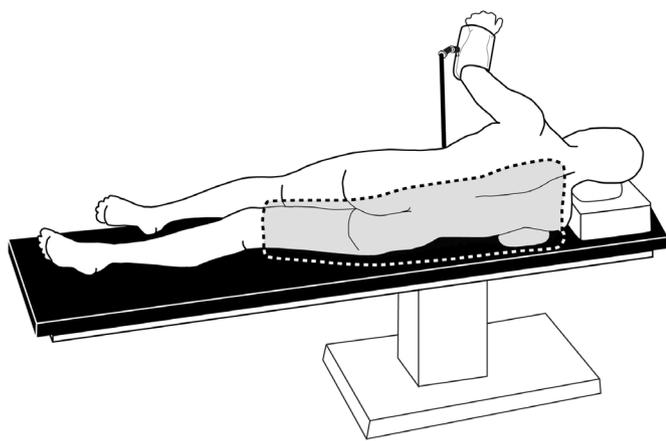
Reference	Patient age, sex	Surgical procedure	Patient positioning	Procedure duration (hours)	Symptoms	Compartment pressure (mm Hg)	Time to fasciotomy	Fasciotomy site(s)	Outcome
McLaren <i>et al</i> <sup>7</sup>	59, M	Acetabulum fracture repair	RLD	5	Swelling, respiratory distress, metabolic acidosis	60	56	Left thigh, proximal medial	Muscle excision, 4 months of dialysis
Nambisan and Karakousis <sup>6</sup>	20, M	Thoracic spine osteoblastoma excision	LLD	9	Pain, swelling, motor, dysfunction	NA	24	Left shoulder	No long-term deficits
Warner <i>et al</i> <sup>2</sup>	27, F	Right hemipelvectomy (osteosarcoma)	LLD	13.1	Pain, swelling, motor, dysfunction	60	8	Left hand	Persistent motor and sensory loss
	36, M	Right craniotomy for hypothalamic glioma	LLD	6.3	Pain, motor, dysfunction	80	32	Left forearm and hand	Arterial thrombosis in left forearm
Cascio <i>et al</i> <sup>3</sup>	58, M	Left elbow excision of malignant histiocytoma	LLD	9	Pain, swelling, motor, dysfunction	55	14	Left leg	Persistent peroneal nerve palsy
	17, M	Right peroneal nerve graft	LLD	10.75	Pain, swelling, motor, dysfunction	31	13	Left thigh	No long-term deficits
Rohde and Goitz <sup>40</sup>	35, M	Left scapula, glenoid, and clavicle fracture repair	RLD	8	Pain, swelling, decreased sensation, motor, dysfunction	41 (lateral), 43 (posterior)	36	Right deltoid	No long-term deficits
Ulutaş <i>et al</i> <sup>41</sup>	56, M	Right nephrectomy	LLD	6	Pain, swelling	NA	~108	Left gluteal area	Chronic haemodialysis
Wijesuriya <i>et al</i> <sup>42</sup>	20, M	Right distal humerus fracture repair	LLD	4.5	Pain, swelling, motor, dysfunction	85	1.5	Left deltoid	No long-term deficits
Borenstein <i>et al</i> <sup>4</sup>	36, M	Left humerus fracture repair	RLD	7.5	Pain, swelling, blistering, sensory loss, motor, dysfunction	29 (anterior), 37 (lateral), 60 (posterior)	48	Right deltoid	Chronic pain, muscle wasting
Farrell <i>et al</i> <sup>43</sup>	42, M	Left tibia repair with serratus anterior free flap	LLD	7	Pain, swelling	NA	NA	Left deltoid	Muscle wasting, weakness, numbness
Current case	42, M	Left shoulder reconstruction	RLD	7	Pain, swelling, sensory loss	NA	14	Right thigh	No long-term deficits

Obtained from various sources.<sup>2-4 6 7 40-43</sup>

F, female; LLD, left lateral decubitus; M, male; NA, not available/not known; RLD, right lateral decubitus.

transient episodes of radiating dominant (right) upper extremity pain and paresthesias that reduced his efficiency in completing the surgery in a timely fashion. This added approximately 60 min to the duration of surgery. Consequently, our patient's surgery was prolonged by about 3 hours.

Immediately following surgery, the patient reported pain in his right lateral thigh. In the recovery room, manual palpation revealed moderate swelling of that region, but there were no distal sensory, motor or perfusion deficits. Over the next 8 hours,



**Figure 1** Drawing of a patient in the lateral decubitus position that was used for our patient's surgery. The patient was placed on gel padding, beneath this was a deflatable bean bag and beneath that was 7.62 cm thick foam pad (shown in black). The position of the deflatable bean bag is indicated by the dotted line along the patient's trunk and thighs.

the right thigh pain and swelling progressively worsened, and mild numbness became manifest in his right foot. These findings were consistent with ACS.<sup>16 17</sup> All compartments of his right leg remained soft. At 12 hours after the surgery a peripheral blood sample was obtained and revealed elevations in creatine kinase (CK: 14 651 unit/L; normal range: 56–356) and CK-MB (CK-myoglobin: 60.5 ng/mL; normal range: 0.0–5.0). The elevated CK levels were consistent with evolving compartment syndrome, but could also be attributed to muscle perturbation from the shoulder surgery. The electrolytes, BUN (blood urea nitrogen) and creatinine were within normal limits at that time, and remained normal over the following 2 weeks. The patient's blood pressure, heart rate and urine output remained normal. He had no evidence or history of coagulopathy<sup>18</sup> and there were no episodes of hypotension during or after the shoulder surgery. At 14 hours after the left shoulder surgery, fasciotomies of the right thigh compartments were done through a lateral incision.<sup>17 19</sup> Compartment pressures were not measured. The bulging of muscles through the lateral fasciotomy incision confirmed the diagnosis of ACS.<sup>20</sup> The muscles appeared viable and contracted normally to electrical stimulation from a conventional Bovie electrocautery device.<sup>17</sup> The CK levels normalised 10 days later.

The lateral thigh incision was closed 2 weeks later, and lower extremity strength and sensation rapidly improved. There were no significant sequelae from the thigh compartment syndrome. Thirteen months later he returned to work as a cook in the same restaurant kitchen where he had been injured. The seemingly prolonged return to work reflected the duration of rehabilitation that the patient felt was necessary to regain shoulder strength and motion to return safely to his prior job. At that time, he reported 'no problems' with the right thigh or leg, and a 'good result' from the left shoulder surgery.

## TREATMENT

The patient had surgical fasciotomies of his right thigh.

## OUTCOME AND FOLLOW-UP

The patient recovered uneventfully after surgical fasciotomies of his right thigh compartment syndrome.

## DISCUSSION

Non-traumatic ACS of a well limb that occurs as a result of surgical positioning is a rare complication and is typically the result of prolonged increased pressure within a closed space, which subsequently impairs tissue perfusion.<sup>1 2 5 16 21 22</sup> The *sine qua non* of ACS is more specifically the elevation of compartment pressures above diastolic perfusion pressures resulting in tissue ischaemia.<sup>21 23</sup> However, as in our case, the measurement of compartment pressures is not deemed necessary when clinical findings were clear.<sup>16 17</sup>

Well-limb ACS can also occur as the result of prolonged immobilisation from sedation caused by substance abuse.<sup>24 25</sup> Other risk factors for non-traumatic ACS—which our patient lacked—include systemic hypotension, type 1 diabetes, anticoagulation medication, wrapping/splinting limbs too tightly and some cases of intense exercise history.<sup>5 18 26–30</sup> Our patient also did not have medical problems that could increase the risk of ACS, including hypothyroidism, nephrotic syndrome, viral or drug-induced myositis, systemic capillary leak syndrome and other rare metabolic disorders.<sup>31–34</sup> The only apparent risk factors that he had for ACS were the duration of the surgery,<sup>12</sup> elevated body weight<sup>3 35 36</sup> and surgical positioning.<sup>1–3 5 35 36</sup>

Examination of the durations of the surgeries listed in [table 1](#) (including our case at 7 hours) shows that the shortest surgeries were 4.5 and 5 hours. It is useful to consider the durations of surgeries that were complicated with postoperative well-limb ACS when the patient was in the *supine* position. Compared with the lateral decubitus position, the supine position is about 20–25 times more commonly used for orthopaedic and general surgery cases, which is an estimate obtained from the medical database at Mayo Medical Center, Rochester, Minnesota over a 10-year period (1 July 1989 to 30 June 1999).<sup>2</sup> Using data from that 10-year period, Warner *et al*<sup>2</sup> reported cases of postsurgical ACS of well limbs of five patients who had surgery in the *supine* position, and the durations of these surgeries were 3.2, 4.6, 7.0, 10.6 and 15.7 hours. These data and also data from all patients who had undergone an index (ie, initial) surgical episode and, within 5 days, a subsequent fasciotomy were also tabulated. Excluded cases included ACS that occurred in traumatised limbs or limbs that were subject to ischaemia from vascular surgical procedures. Overall, 485 of the 499 214 patients (0.1%) underwent a fasciotomy for ACS. There was no apparent pre-existing cause for compartment syndrome in 13 patients (2.7%). Of these 13 patients, the two that were in the lateral decubitus position are listed in [table 1](#); these 2 patients from the Warner *et al* study occurred in 19 422 patients (1 per 9711). In contrast, ACS developed at a much lower rate in the supine position (5 of the 462 204 patients in a supine position (1 per 92 441)). In contrast, ACS developed in 6 of 52 319 patients in the lithotomy position (1 per 8720). (Although the lithotomy position is rarely used for orthopaedic surgeries,<sup>37</sup> it must be noted that Warner and coworkers likely lumped hemilithotomy (commonly used in orthopaedic surgery) and lithotomy positions into ‘lithotomy positions’. To clarify this, we attempted to contact all authors of that study and their institution but we were unable to obtain

any additional information.) The most noteworthy characteristic of all 13 patients was their relatively long surgical procedures, ranging from 3.2 to 15.7 hours, with an average duration of 7.2 hours. In contrast, the average duration of procedures for all patients during this 10-year study period was 2.7 hours.

In a case report, Clarke *et al*<sup>1</sup> described an obese man in his 50s who was in the hemilithotomy position for 6.25 hours for surgical reconstruction of acute right tibia and femur fractures. That patient developed ACS of the contralateral (left) leg. They stated that “identifiable risk factors based on case reports and various studies of well-leg compartment syndrome include increased body mass index, operating time above 4 hours, and intraoperative hypotension resulting in decreased peripheral arterial pressures.” Our examination of the 10 references in their case report did not reveal any data, or implied or explicit suggestion/opinion, supporting this recommended 4-hour cut-off time. In contrast, in an overview of postoperative ACS occurring from *various positions* (lithotomy, lateral decubitus, supine, prone and beach chair), Halvachizadeh *et al*<sup>38</sup> suggest that >5 hours of surgical time is a significant risk factor for this complication. This cut-off is consistent with data from several reported surgical cases (all longer than 4.5 hours) where well-leg ACS occurred during the *hemilithotomy position* used for intramedullary nailing of contralateral femur fractures.<sup>39</sup> Based on these findings and cases of well-limb ACS in patients who had surgery in the *lateral decubitus position* (shortest duration at 4.5 hours, [table 1](#)), we suggest that when surgical time approaches 4.5 hours measures should be taken to reduce the chance of ACS in the lateral decubitus position. These measures might include temporarily stopping surgery and repositioning the patient (eg, turning from lateral to supine or beach chair) and possibly continuing the remainder of surgery in that new position (eg, completing the posterior reconstruction first so that the anterior portion can be done later in the beach chair position). Also, massaging and/or manual moving of the dependent limbs that are at greatest risk would be recommended. Enhanced methods for padding should also be considered when initially positioning the patient.<sup>25</sup>

## Learning points

- ▶ Non-traumatic acute compartment syndrome of contralateral or ipsilateral limbs is a rare complication of orthopaedic and general surgeries performed in the lateral decubitus position.
- ▶ If prolonged surgery is anticipated (>4 hours) extra padding should be applied around the patient.
- ▶ If surgery goes beyond 4.5 hours, measures should be taken to reposition the patient and/or move the patient’s dependent limbs.

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Case reports provide a valuable learning resource for the scientific community and can indicate areas of interest for future research. They should not be used in isolation to guide treatment choices or public health policy.

#### ORCID iDs

John T Cronin <http://orcid.org/0000-0001-7726-6374>

John G Skedros <http://orcid.org/0000-0002-2352-980X>

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