

# Delayed Presentation of Compartment Syndrome of the Proximal Lower Extremity After Low-Energy Trauma in Patients Taking Warfarin

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Compartment syndrome is a well-known phenomenon that occurs after injuries to the lower extremities. Clinicians are easily alerted to its presence in the leg after tibial fracture when the patient presents with firm muscular compartments and significant pain that increases with passive stretching of the ankle or the digits of the foot. However, making the diagnosis without a clear history of significant trauma and an easily reproducible physical examination is difficult. Confounding variables (eg, patient comorbidities, medication profiles) become especially important in the elderly population. These patients usually have multiple medical problems being treated with medications. Anticoagulants, warfarin in particular, dramatically impair elderly patients' ability to recover from minor trauma. As demonstrated in this report, continued intramuscular bleeding can progress to compartment syndrome in patients with very limited physiologic reserve.

We describe the cases of 3 patients who developed compartment syndrome after sustaining very low-energy trauma while anticoagulated with warfarin for chronic cardiac conditions.

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## CASE REPORTS

### Case 1

A man in his mid-70s who was treated with warfarin for atrial fibrillation developed left gluteal pain secondary to a fall from a standing position 6 days before presentation to our facility. He was able to ambulate after the fall but developed incapacitating buttock pain over several days and then presented to the emergency department. Physical examination revealed a firm left gluteus with ecchymosis over an area of more than 10 cm<sup>2</sup> (Figure 1). Flexion and adduction of the left hip increased discomfort. Sensation over the plantar surface of the left foot was diminished, but the motor function of the sciatic nerve was intact. Hemoglobin level was 13.5 g/dL, hematocrit was 39.8%, and international normalized ratio (INR) was 3.11. Radiographs of the pelvis and hip revealed no fractures. Pressure in the gluteus maximus compartment, as measured with a handheld manometer (Stryker, Kalamazoo, Mich), was 62 mm Hg; systolic blood pressure (SBP) was 110 mm Hg, and diastolic blood pressure (DBP) was 62 mm Hg.

The patient was diagnosed with subacute, posttraumatic gluteal compartment syndrome and was taken to the operating room for fasciotomy, irrigation, and débridement of the gluteal compartments with intraoperative reversal of the coagulation profile using fresh-frozen plasma to an INR of 2.2. He required 3 surgeries for débridement of devitalized muscle of the gluteus maximus, medius, and tensor fascia lata ending with a subtotal myomectomy of the gluteus maximus. At the discretion of his internist, this patient was anticoagulated with low-molecular-weight heparin (LMWH) after the index procedure. He was closed primarily after the final surgery, and at 18-month follow-up he was ambulatory without use of an assistive device, with normal sensation, and with full motor function of the sciatic nerve distally.

### Case 2

A man in his early 60s who was anticoagulated with warfarin for a cardiac procedure developed right thigh pain after bumping into a desk 8 days before presentation. The pain was mild for a few days but then worsened until he could no longer ambulate and presented to our facility. Physical examination revealed a tense anterior compartment; the



**Figure 1.** Large area of ecchymosis associated with gluteal compartment syndrome.

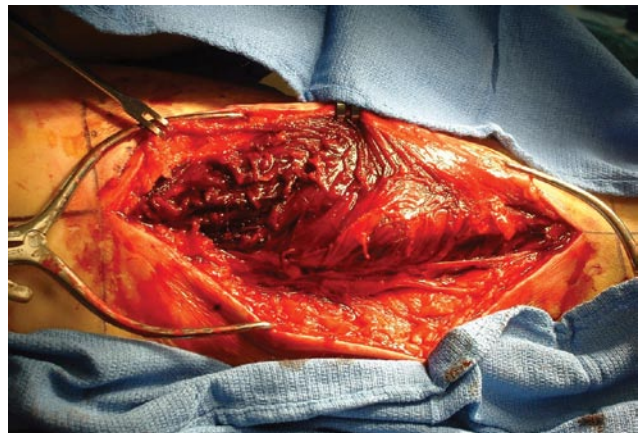
medial and posterior compartments were soft. Passive knee flexion brought significant discomfort. Motor function and sensation were intact throughout the right lower extremity, and the patient was able to actively contract all muscle groups despite his discomfort. He had SBP of 130 mm Hg, DBP of 90 mm Hg, and stable hemoglobin (13 g/dL) and hematocrit (36.5%). INR was 3.31. Anterior thigh compartment pressure was 54 mm Hg, and medial and posterior thigh pressures were 13 mm Hg, as measured with a handheld manometer (Stryker, Kalamazoo, Mich).

The patient was diagnosed with posttraumatic anterior thigh compartment syndrome. His coagulation profile was improved with fresh-frozen plasma (to an INR of 2.5) before surgical fasciotomy, irrigation, and débridement of the right thigh. Muscle necrosis and intramuscular hematoma were evacuated from both the rectus femoris and the vastus lateralis. This patient ultimately required 2 more débridements before definitive closure. He had resumed warfarin treatment before his first clinic follow-up 10 days after his final procedure and had been treated with LMWH in the perioperative period. At 6-month follow-up, he was ambulatory using a cane and was progressing in physical therapy.

### Case 3

A woman in her mid-80s had comorbidities that included hypertension, diabetes, chronic renal insufficiency, and atrial fibrillation, for which she was prescribed warfarin. She presented to our facility 4 days after a fall from bed on waking. Over those days, her right thigh became progressively more painful until she could not ambulate, even with a walker. Evaluation in the emergency department was significant for a firmly tense, swollen anterior thigh and an INR of 4.87. Intracompartmental pressure (Stryker, Kalamazoo, Mich) measurement of the thigh demonstrated an anterior compartment pressure of 93 mm Hg with SBP of 135 mm Hg and DBP of 58 mm Hg.

The patient was also diagnosed with subacute, posttraumatic anterior thigh compartment syndrome. Her anticoagulation was reversed with fresh-frozen plasma to an INR of 1.85, and she underwent fasciotomy and débridement of



**Figure 2.** Débridement of intramuscular hematoma and ischemic muscle from the vastus lateralis.

the anterior compartment of the right thigh, which produced a large intramuscular hematoma in the vastus lateralis with active arteriole bleeding (Figure 2). Ischemic muscle was débrided, and blood coagulated. The patient had initiated mobilization from bed and had made slow progress with physical therapy over several days. Her postoperative course included anticoagulation with LMWH on day 4 under the direction of her internist. Unfortunately, this patient expired of cardiopulmonary arrest 6 days after surgery.

### DISCUSSION

Compartment syndrome is defined by an increase in pressure within a confined space. This increase in pressure leads to decreased circulation, resulting in ischemia and necrosis to the contents of the compartment.<sup>1</sup> Compartment pressure over 30 mm Hg, or within 30 mm Hg of the patient's DBP, raises concern for ischemia to the affected extremity.<sup>2</sup> Total ischemia time of 8 hours causes irreversible changes to the muscle and nerve.<sup>2,3</sup> Neurologic deficits in the affected extremity are a harbinger of potentially irreversible injury and are an ominous sign for full functional recovery of the extremity.<sup>2</sup>

Gluteal compartment syndrome (GCS) is an uncommon condition that is usually associated with drug overdose and immobilization for a prolonged period—causing compression of the gluteal compartments.<sup>4</sup> Few cases of GCS have been reported, because of the large space, good blood supply, and large muscle mass involved. As described by Owen and colleagues,<sup>5</sup> the gluteal compartment is confined by the fascia lata of the thigh, which splits into 2 layers that surround the gluteus maximus posteriorly and the tensor fascia lata anteriorly. Between the gluteus maximus and the tensor fascia lata, the combined fascia overlies the gluteus medius and minimus, which then function as 3 separate compartments.<sup>5</sup>

Recently, the optimal position for needle placement to measure compartment pressures has been defined. David and colleagues<sup>6</sup> outlined the neurovascular anatomy of the compartments to define the landmarks for safe needle placement to measure gluteal compartments using whole cadaveric pelvis models. The prime position

for needle placement in the gluteus maximus is over the proximal and inner quadrant of the respective buttock, 2 cm inferior and lateral to the posterior superior iliac spine. Placement of the needle to measure the tensor fasciae lata should be 2 cm anterior and 3 cm distal to the tip of the greater trochanter. The compartment of the gluteus medius and minimus should be measured with the needle placed 2 cm inferior to the iliac crest over the middle third of the iliac wing.<sup>6</sup> These landmarks are valuable for the obtunded patient who is unable to cooperate with a physical examination.

The 3 compartments of the thigh (anterior, posterior, medial) are easier to access for measuring compartment pressures. The posterior aspect of the anterior compartment is defined by the lateral intermuscular septum, just posterior to the easily palpable fascia lata.<sup>7</sup> Measuring the posterior thigh compartment is easiest directly posterior in the femur and perpendicular to the bone in the sagittal plane. The anterior

may be too risky for the elderly because of their medical condition. On the other hand, nonoperative management is associated with continued medical morbidity, potential mortality, and a poorly functioning limb on recovery. Compartment release is crucial to maintaining the viability of soft-tissue structures, but there is concern about continued bleeding.

Given our cases, our recommendations are to reverse anticoagulation emergently with a preoperative goal INR of 2.0 to 2.5 and to perform fasciotomy and débridement as rapidly as possible. We are unaware of any prospective studies defining an ideal preoperative INR. In a retrospective review about the risks and recommendations for oral anticoagulation in surgical procedures, Torn and Rosendaal<sup>12</sup> noticed no correlation between preoperative INR and incidence of bleeding and thromboembolic events in their small subset of orthopedic procedures. However, in their series, there was a small increase in perioperative

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compartment offers a broad surface area of access anterior to the fascia lata and iliotibial band. The fascia of the medial compartment is thinner. Access to this compartment is gained in an area several centimeters distal and medial to the palpable femoral pulse.

The patients in our report were anticoagulated with warfarin, which over days allowed hemorrhaging to continue into intermuscular compartments. Warfarin is highly bioavailable orally and reaches peak blood concentration approximately 90 minutes after administration.<sup>8</sup> It circulates bound to plasma proteins with a half-life of 36 to 42 hours, affecting the procoagulant properties of factors II, VII, IX, and X.<sup>8</sup> Proven risk factors for bleeding while on therapeutic warfarin include age over 75 years and INR higher than 3.0.<sup>9</sup> There is cause for significant concern in the elderly, as these patients often have significant comorbidities that increase surgical risk.

However, this same population also has very little physiologic reserve and poorly tolerates the large load of catabolites and acidosis produced by dead and dying muscle of compartment syndrome in the large compartments of the lower extremities.<sup>4</sup> In a series by Schwartz and colleagues,<sup>10</sup> 7 of 17 patients diagnosed with thigh compartment syndrome after trauma went on to develop myoglobinuria and renal failure, and only 1 patient with acute renal failure survived. Some authors have suggested decompressing and débriding compartments even in the clinical scenario of a delayed presentation of a patient with the diagnosis of compartment syndrome and renal failure due to myoglobinuria.<sup>11</sup>

This then is the dilemma for the orthopedic surgeon. Fasciotomy and débridement constitute ideal treatment but

complications for all types of procedures considered when patients' INR was higher than 3.0.<sup>12</sup> This coincides with the previously mentioned risk factors for bleeding when using therapeutic warfarin.<sup>9</sup> The patient's overall condition may require continued intraoperative reversal of anticoagulation with a goal of complete reversal of warfarin therapy. Perioperative anticoagulation with LMWH is used for treatment of comorbidities until warfarin therapy can be reinstated.<sup>11,13</sup>

## CONCLUSIONS

Compartment syndrome of the larger muscular compartments of the lower extremity—caused by bleeding in the presence of anticoagulation—is an extremely difficult problem to treat. This scenario usually occurs in elderly patients with multiple comorbidities that complicate the treatment course. The condition may evolve over days, as the compartment fills with hematoma, while the patient's overall clinical picture is unclear. Prompt reversal of anticoagulation with fresh-frozen plasma, and with vitamin K if necessary,<sup>13</sup> is an essential step before definitive surgical treatment. Customary fasciotomy and débridement of the involved muscular compartments are vital to arresting continued myonecrosis, which would add cytokines and catabolites to the clinical milieu.

## AUTHORS' DISCLOSURE STATEMENT AND ACKNOWLEDGMENTS

The authors report no actual or potential conflict of interest in relation to this article.

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## REFERENCES

1. Schmalzried TP, Eckardt JJ. Spontaneous gluteal artery rupture resulting in compartment syndrome and sciatic neuropathy. *Clin Orthop*. 1992;(275):253-257.
2. Whitesides TE, Heckman MM. Acute compartment syndrome: update on diagnosis and treatment. *J Am Acad Orthop Surg*. 1996;4(4):209-218.
3. Whitesides T, Harada H, Morimoto K. Compartment syndromes and the role of fasciotomy, its parameters and techniques. *Instr Course Lect*. 1977;26:179-196.
4. Hill SL, Bianchi J. The gluteal compartment syndrome. *Am Surg*. 1997;63(9):823-826.
5. Owen CA, Woody PR, Mubarak SJ, Hargens AR. Gluteal compartment syndrome: a report of three cases and management utilizing the wick catheter. *Clin Orthop*. 1978;(132):57-60.
6. David V, Thambiah J, Kagda FH, Kumar VP. Bilateral gluteal compartment syndrome. A case report. *J Bone Joint Surg Am*. 2005;87(11):2541-2545.
7. Tarlow SD, Achterman CA, Hayhurst J, Ovadia DN. Acute compartment syndrome in the thigh complicating fracture of the femur. A report of three cases. *J Bone Joint Surg Am*. 1986;68(9):1439-1443.
8. Ansell J, Hirsh J, Poller L, Bussey H, Jacobson A, Hylek E. The pharmacology and management of the vitamin K antagonists: the seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy [published correction appears in *Chest*. 2005;127(1):415-416. dosage error in text]. *Chest*. 2004;126(3 suppl):204S-233S.
9. Levine MN, Raskob G, Beyth RJ, Kearon C, Schulman S. Hemorrhagic complications of anticoagulant treatment: the seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest*. 2004;126(3 suppl):287S-310S.
10. Schwartz JT Jr, Brumback RJ, Lakatos R, Poka A, Bathon GH, Burgess AR. Acute compartment syndrome of the thigh. A spectrum of injury. *J Bone Joint Surg Am*. 1989;71(3):392-400.
11. Shaw CJ, Spencer JD. Late management of compartment syndromes. *Injury*. 1995;26(9):633-635.
12. Torn M, Rosendaal FR. Oral anticoagulation in surgical procedures: risks and recommendations. *Br J Haematol*. 2003;123(4):676-682.
13. Jaffer AK. Anticoagulation management strategies for patients on warfarin who need surgery. *Cleve Clin J Med*. 2006;73(suppl 1):S100-S105.

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*This paper will be judged for the Resident Writer's Award.*

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