Delayed Presentation of Compartment Syndrome of the Thigh in a Previously Undiagnosed Factor VII-Deficient High School Football Athlete

A Case Report

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Abstract

Case: We describe a case of delayed presentation of compartment syndrome in the anterior aspect of the thigh in a high school athlete. The patient had sustained a blow to the thigh 8 days prior to presentation, and had continued to practice football in the setting of undiagnosed coagulopathy. He presented with severe thigh pain and the inability to contract the thigh muscles.

Conclusion: A high index of suspicion for compartment syndrome is indicated for patients with disproportionate pain, especially in the setting of relatively minor trauma. Underlying coagulopathy should be investigated in patients with compartment syndrome because there is a high incidence of bleeding disorders in this population.

Compartment syndrome of the thigh is a relatively rare condition that traditionally has been described as a result of high-energy trauma associated with fracture of the femur, gunshot wounds, crush injury, and reperfusion injury[1,2]. There are limited reports in the literature of thigh compartment syndrome from closed blunt traumatic injury[3-5] or exercise[6-8]. We report a case of delayed presentation of compartment syndrome of the thigh after blunt trauma and continued exercise in a patient with a previously undiagnosed coagulopathy.

The patient and his parent were informed that data concerning the case would be submitted for publication, and they provided consent.

Case Report

A healthy 16-year-old Caucasian male high school football athlete presented with 3 days of worsening thigh pain. He had sustained a direct blow to the anterior aspect of the thigh from another player's knee during a football game 8 days prior to presentation. He initially had noted pain to the thigh, but no ecchymosis or swelling, and this quickly had resolved. He had returned to play with renewed pain and had last participated in practice 3 days prior to presentation. That evening, he had noticed worsening pain and swelling in the thigh. The pain escalated to the point that he had difficulty walking and required the use of a crutch. Two days prior to admission, he presented to an outside emergency department. Radiographs were negative for fracture, and he was discharged home. The subsequent day, he presented to a different emergency room, and computed tomography (CT) was performed. A large thigh hematoma was visualized (Fig. 1), and he was transferred to our emergency department.

Upon presentation, the patient was admitted by the pediatric surgery department for serial compartment examinations. The clinical condition became worse, and the orthopaedic surgery department was consulted. On evaluation, there was substantial fullness of the anterior aspect of the thigh compartment, decreased knee range of motion (0° to 20°), extreme pain with passive flexion of the knee, grade 1 of 5 quadriceps motor strength and the inability to contract the thigh muscles, and decreased sensation to light touch over the anterior aspect of the thigh. Distally, he had normal sensation to light touch in all distributions of the foot, and grade 5 of 5 gastrocnemius-soleus complex, tibialis anterior, and extensor and flexor hallucis longus motor strength. The pedal pulses were palpable and symmetric with the uninjured side. He had severe pain with even minor movements of the lower extremity. On laboratory evaluation, hemoglobin levels were normal, and prothrombin time (PT) and activated partial thromboplastin time (aPTT) were mildly elevated. The pain did not improve, despite an extensive

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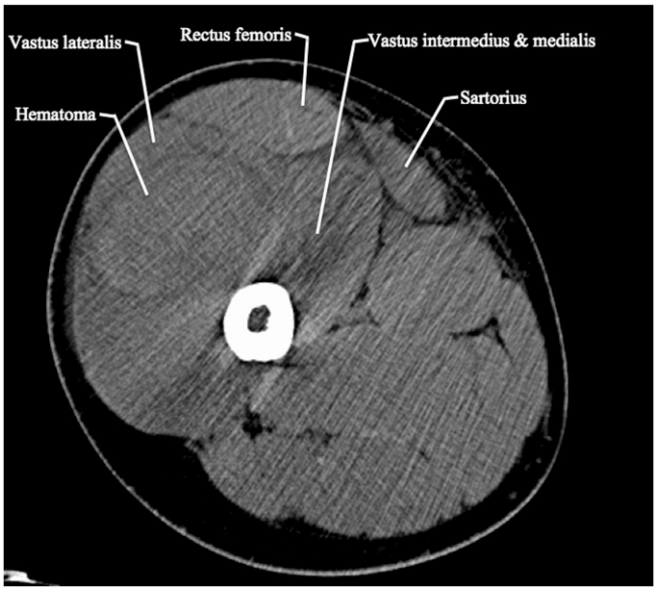

Fig. 1

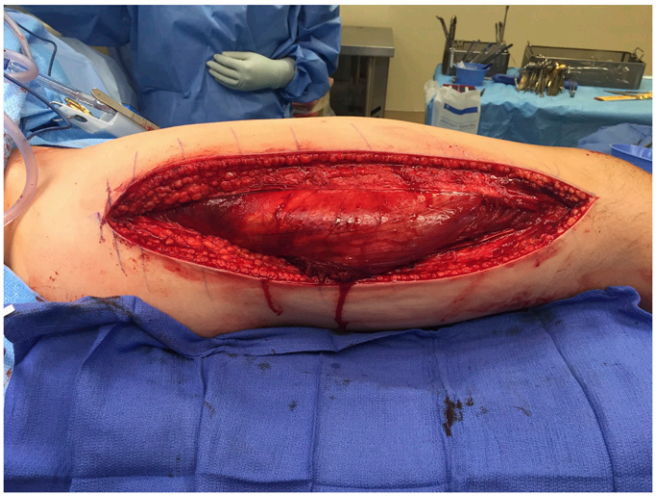

Fig. 2

Fig. 1 CT of the right lower extremity demonstrating a large hematoma in the anterior and proximal aspects of the thigh. **Fig. 2** Intraoperative photograph demonstrating a laterally based incision for decompression of the anterior compartment of the thigh, with visible bulging of the vastus lateralis through the incision.

amount of oral and intravenous medications. Based on clinical examination and imaging findings, the diagnosis of compartment syndrome was made. Because an operating room was available immediately, compartment pressure monitoring was deferred to prevent further delay of treatment. After discussing the risks of surgery and obtaining informed consent, the patient immediately was taken to the operating room for a right thigh fasciotomy.

We performed a standard lateral approach to the anterior compartment of the thigh. After incising through the iliotibial band, the bulging quadriceps muscle immediately extruded through the wound (Fig. 2). All of the muscle was thoroughly examined and was determined to be viable. The posterior and medial compartments were not released because of a low index of suspicion for their involvement, both clinically and intraoperatively. During surgery, the patient had an increased amount of oozing, but bleeding was controlled with electrocautery. The wound was left open and packed with wet-to-dry dressings. Postoperatively, the patient had immediate relief, and the pain was easily managed with oral medications.

Based on the slightly elevated PT and aPTT as well as intraoperative observation of increased bleeding, the hematology service was consulted; additional coagulopathy testing was initiated. The results of testing for the most common coagulopathies (factor VIII, factor IX, von Willebrand factor [vWF], and vWF antigen) were normal.

The patient was taken back to the operating room 2 days later for closure of the wound. The postoperative course was complicated by sanguineous oozing from the surgical wound, even after closure, and symptomatic anemia. Transfusion with 3 units of packed red blood cells (PRBCs) was performed over the next 2 days, without appropriate response of the hemoglobin levels. Additional testing for more rare forms of coagulopathy was performed, and the patient was found to have a deficient level of factor VII (14% of normal). Transfusion of recombinant factor VII was initiated in addition to 2 more units of PRBCs, and the hemoglobin levels and symptoms began to respond. By postoperative day 4, the hemoglobin levels had stabilized. Ultimately, he was discharged on a regimen of factor-VII replacement.

After discharge, the patient's course was complicated by a superficial methicillin-resistant *Staphylococcus aureus* surgical site infection. This was treated with surgical irrigation and debridement and oral antibiotics. After treatment, he had no additional complications. At the 2-month postoperative visit, he was doing very well, had regained full quadriceps strength equal to the contralateral side, and was walking without difficulty. At 1 year and 3 months postoperatively, he had no limitations, full quadriceps strength equal to the contralateral side, symmetric thigh circumference, and no limp. He elected to stop playing football because of the increased bleeding risk, and switched to basketball without limitations. He has since undergone elective removal of wisdom teeth and was given factor-VII replacement in the perioperative period. At 1 year and 5 months postoperatively, he was admitted to the hematology service for observation of a calf hematoma after a basketball game. He did not develop compartment syndrome, and the hematoma improved with rest, use of a compressive wrap, and administration of factor VII.

Discussion

Acute compartment syndrome is defined as the elevation of intracompartmental pressure to a high enough level and for an adequate duration that will cause tissue ischemia and necrosis[9,10]. Compartment syndrome is one of the true orthopaedic emergencies, and timely diagnosis is crucial[9,11,12].

TABLE I Most Common Inherited Bleeding Disorders*[25,26]

Deficient Factor/Disease Name	Inheritance	Prevalence in General Population	Laboratory Values		Treatment
			aPTT	PT	
vWF/von Willebrand disease	Types 1 and 2: AD Type 3: AR	1 in 100	+	–	Desmopressin Aminocaproic acid Tranexamic acid
Factor VIII/hemophilia A	X-linked	1 in 5,000	+	–	Factor-VIII concentrates
Factor IX/hemophilia B	X-linked	1 in 30,000	+	–	Factor-IX concentrates
Factor VII	AR	1 in 500,000	–	+	FFP, factor-VII concentrates, PCC
Factor V	AR	1 in 1,000,000	+/–	+/–	FFP
Factor X	AR	1 in 1,000,000	+/–	+/–	FFP, PCC
Factor XII	AR	1 in 1,000,000	+	–	FFP
Fibrinogen	AR	1 in 1,000,000	+	+	Cryoprecipitate
Prothrombin	AR	1 in 2,000,000	+	+	FFP, PCC
Factor XIII	AR	1 in 2,000,000	–	–	Cryoprecipitate/factor-XIII concentrates

*aPTT = activated partial thromboplastin time, PT = prothrombin time, AD = autosomal dominant, AR = autosomal recessive, FFP = fresh-frozen plasma, and PCC = prothrombin complex concentrates.

Many factors can confuse or delay diagnosis, including a delayed presentation, a lack of fracture or crush injury, an unusual anatomic location, and a lack of known coagulopathy or use of anticoagulation medications[1,2,10,13].

The most common locations for compartment syndrome are the tibia and the forearm; the thigh is less commonly involved[9,12,14,15]. The thigh comprises 3 (anterior, medial, and posterior) large osteofascial compartments that allow for a greater amount of swelling prior to neurovascular compromise[13]. For this reason, patients may present hours, or even days, after the initial injury with increased pain and swelling of the affected thigh.

Compartment syndrome of the thigh is largely a clinical diagnosis. Common symptoms include pain out of proportion to the injury, pain with passive stretching of the compartmental muscles, paresthesias in the distribution of the nerves in the compartment, and tenseness of the compartment[9,11]. The diagnosis can be confirmed with intracompartmental pressure measurements of >30 mm Hg, or a difference between diastolic blood pressure and compartment pressure of <30 mm Hg[9]. However, compartment pressures are not needed for diagnosis in the setting of unequivocal examination findings[9,13].

Treatment of compartment syndrome of the thigh remains controversial, but most authors have advocated for surgical release[2,3,6-8,13,16-18]. Studies have demonstrated worse functional outcomes in patients with associated femoral fractures, myonecrosis at the time of fasciotomy, and a time to decompression of >8 hours[16]. However, there are reports of patients with delayed presentation, exercise-induced compartment syndrome, or minor blunt-injury-induced compartment syndrome undergoing decompression outside of the 8-hour window without resulting limitations[3,7,18-20].

Compartment syndrome of the thigh may be associated with an underlying bleeding disorder. A literature review demonstrated that 21% of patients with compartment syndrome of the thigh had coagulation defects[2]. A similar case involving a patient with minor trauma and delayed presentation of thigh compartment syndrome led to a diagnosis of hemophilia B[21]. Diagnosis of coagulation disorders is critical for surgical optimization. In our patient, the diagnosis of a factor-VII deficiency was made after surgical intervention, and the patient continued to bleed until the factor ultimately was replaced.

Factor-VII deficiency is a rare coagulation disorder, with an incidence of 1 symptomatic individual per 500,000[22]. It is autosomal recessive, with no racial or ethnic predilection[23], and is often diagnosed by unexplained bleeding after surgical procedures[24]. Bleeding changes in patients with severe factor-VII deficiency are commonly manifested by epistaxis, menorrhagia, and/or intracranial bleeding episodes during the neonatal period. Hemarthroses, which are frequently seen in the more common factor-VIII and IX deficiencies, rarely cause problems in patients with factor-VII disorders[22,23,25-27]. When we examined further, we learned that our patient had a history of easy bruising and had had a large scalp hematoma after a minor snowboarding accident, which had persisted for months despite use of compressive wraps and drainage.

Most other coagulopathies would have presented with more rapid development of pain, swelling, and obvious bruising after similar blunt trauma, raising clinical suspicion. Factor-VII deficiency has been described as a chameleon disease because of its lack of direct correlation between plasma levels of factor and bleeding manifestations[23,25]. There are multiple reports of asymptomatic subjects with severe deficiency (levels <1%), and reports of severe hemorrhages with more mild deficiencies

(levels >10%)[23,28-30]. Factor VII is involved in the extrinsic pathway, and, theoretically, the intrinsic pathway should prevent bleeding in its absence; however, bleeding problems do occur in patients with factor-VII deficiency, particularly if the surgical dissection is of magnitude or if the trauma is complex and persistent. Perhaps this is because factor VII is not only involved in the activation of factor X, but may also interact with factors in the intrinsic pathway. Table I summarizes the most common congenital bleeding disorders.

Hemostatic control is relatively easy with factor-VII deficiency. Multiple methods, including use of recombinant factor VII, prothrombin complex concentrate, and fresh-frozen plasma, have been shown to be efficacious in the mitigation of abnormal bleeding, even in patients with severe factor-VII deficiency who undergo major surgery[24,25,31,32].

Clinicians must remain vigilant in the detection of compartment syndrome, even in uncommon locations. Knowledge of patient symptoms and clinical examination findings that are associated with compartment syndrome is crucial for timely diagnosis. Furthermore, an anticoagulation workup should be considered in the setting of compartment syndrome in unusual locations or when there have been unusual injury mechanisms. The incidence of undiagnosed coagulopathies in these patient populations is high and may affect outcomes[1,21]. A working knowledge of coagulation defects may affect postoperative care and prevent additional complications secondary to ongoing bleeding. ■

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References

1. Mithöfer K, Lhowe DW, Vrahas MS, Altman DT, Altman GT. Clinical spectrum of acute compartment syndrome of the thigh and its relation to associated injuries. Clin Orthop Relat Res. 2004 Aug;425:223-9.

2. Ojike NI, Roberts CS, Giannoudis PV. Compartment syndrome of the thigh: a systematic review. Injury. 2010 Feb;41(2):133-6. Epub 2009 Jun 24.

3. Colosimo AJ, Ireland ML. Thigh compartment syndrome in a football athlete: a case report and review of the literature. Med Sci Sports Exerc. 1992 Sep;24(9):958-63.

4. Mithöfer K, Lhowe DW, Altman GT. Delayed presentation of acute compartment syndrome after contusion of the thigh. J Orthop Trauma. 2002 Jul;16(6):436-8.

5. Lee AT, Fanton GS, McAdams TR. Acute compartment syndrome of the thigh in a football athlete: a case report and the role of the vacuum-assisted wound closure dressing. J Orthop Trauma. 2005 Nov-Dec;19(10):748-50.

6. McDonald LS, Mitchell RJ, Deaton TG. Bilateral compartment syndrome of the anterior thigh following functional fitness exercises: a case report. Mil Med. 2012 Aug;177(8):993-6.

7. Nau T, Menth-Chiari WA, Seitz H, Vécsei V. Acute compartment syndrome of the thigh associated with exercise. Am J Sports Med. 2000 Jan-Feb;28(1):120-2.

8. Kahan JS, McClellan RT, Burton DS. Acute bilateral compartment syndrome of the thigh induced by exercise. A case report. J Bone Joint Surg Am. 1994 Jul;76(7):1068-71.

9. McQueen MM, Duckworth AD. The diagnosis of acute compartment syndrome: a review. Eur J Trauma Emerg Surg. 2014 Oct;40(5):521-8. Epub 2014 Jun 3.

10. Mubarak S, Owen CA. Compartmental syndrome and its relation to the crush syndrome: A spectrum of disease. A review of 11 cases of prolonged limb compression. Clin Orthop Relat Res. 1975 Nov-Dec;113:81-9.

11. Matsen FA 3rd, Winquist RA, Krugmire RB Jr. Diagnosis and management of compartmental syndromes. J Bone Joint Surg Am. 1980 Mar;62(2):286-91.

12. McQueen M. Acute compartment syndrome. Acta Chir Belg. 1998 Aug;98(4):166-70.

13. Heidepriem RW, Frey SE, Robinson D, Tapscott WJ, Spence RK. Thigh compartment syndrome: diagnosis and surgical treatment. Vascular. 2004 Jul-Aug;12(4):271-2.

14. Court-Brown C, Heckman JD, McQueen MM, Tornetta P 3rd, McKee M, Ricci W. Rockwood and Green's fractures in adults. Lippincott Williams & Wilkins; 2015.

15. 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 Mar;71(3):392-400.

16. Mithoefer K, Lhowe DW, Vrahas MS, Altman DT, Erens V, Altman GT. Functional outcome after acute compartment syndrome of the thigh. J Bone Joint Surg Am. 2006 Apr;88(4):729-37.

17. Kanlic EM, Pinski SE, Verwiebe EG, Saller J, Smith WR. Acute morbidity and complications of thigh compartment syndrome: A report of 26 cases. Patient Saf Surg. 2010 Aug 19;4(1):13.

18. King TW, Lerman OZ, Carter JJ, Warren SM. Exertional compartment syndrome of the thigh: a rare diagnosis and literature review. J Emerg Med. 2010 Aug;39(2):e93-9. Epub 2008 Jul 2.

19. Patti BN, Pfefferle KJ, Myer T. Bilateral compartment syndrome of the thigh in a college football athlete: a case report. JBJS Case Connect. 2014;4(1):e12.

20. Winternitz WA Jr, Metheny JA, Wear LC. Acute compartment syndrome of the thigh in sports-related injuries not associated with femoral fractures. Am J Sports Med. 1992 Jul-Aug;20(4):476-7.

21. Jones G, Thompson K, Johnson M. Acute compartment syndrome after minor trauma in a patient with undiagnosed mild haemophilia B. Lancet. 2013 Nov 16;382(9905):1678.

22. Lapecorella M, Mariani G; International Registry on Congenital Factor VII Deficiency. Factor VII deficiency: defining the clinical picture and optimizing therapeutic options. Haemophilia. 2008 Nov;14(6):1170-5.

23. Mariani G, Bernardi F. Factor VII deficiency. Semin Thromb Hemost. 2009 Jun;35(4):400-6. Epub 2009 Jul 13.

24. Mariani G, Dolce A, Napolitano M, Ingerslev J, Giansily-Blaizot M, Di Minno MD, Auerswald G, De Saez AR, Tagliaferri A, Batorova A; STER (Seven Treatment Evaluation Registry). Invasive procedures and minor surgery in factor VII deficiency. Haemophilia. 2012 May;18(3):e63-5. Epub 2012 Feb 22.

25. Napolitano M, Siragusa S, Mariani G. Factor VII deficiency: clinical phenotype, genotype and therapy. J Clin Med. 2017 Mar 28;6(4):E38.

26. Chuansumrit A, Visanuyothin N, Puapunwattana S, Chaivisuth A, Rasmidat P, Charoenkwan P, Chiemchanya S. Outcome of intracranial hemorrhage in infants with congenital factor VII deficiency. J Med Assoc Thai. 2002 Nov;85(Suppl 4):S1059-64.

27. Lippi G, Franchini M, Guidi GC. Diagnostic approach to inherited bleeding disorders. Clin Chem Lab Med. 2007;45(1):2-12.

28. Perry DJ. Factor VII Deficiency. Br J Haematol. 2002 Sep;118(3):689-700.

29. Barnett JM, Demel KC, Mega AE, Butera JN, Sweeney JD. Lack of bleeding in patients with severe factor VII deficiency. Am J Hematol. 2005 Feb;78(2):134-7.

30. Khanna S, Schwartz MH, Ruggiero SL. Factor VII deficiency resulting in acute hemorrhage in orthognathic surgery: a case report. J Oral Maxillofac Surg. 2012 Jan;70(1):e92-4. Epub 2011 Aug 6.

31. Greene WB, McMillan CW. Surgery for scoliosis in congenital factor VII deficiency. Am J Dis Child. 1982 May;136(5):411-3.

32. Kim SH, Park YS, Kwon KH, Lee JH, Kim KC, Yoo MC. Surgery in patients with congenital factor VII deficiency: a single center experience. Korean J Hematol. 2012 Dec;47(4):281-5. Epub 2012 Dec 24.