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Case Report

Abnormal Thigh Swelling after Anterior Cruciate Ligament Reconstruction with Tourniquet

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Abstract

Background: Anterior cruciate ligament (ACL) reconstruction surgery is a common orthopedic procedure. Minimally invasive surgeries and arthroscopy are becoming more common, and tourniquets are utilized in these procedures to reduce bleeding and allow for improved tissue visualization.
Case Report: In this paper, we report a 32-year-old man who underwent the right knee ACL reconstruction using a tourniquet following trauma. He developed thigh swelling at the tourniquet site after surgery. Right thigh ultrasound and magnetic resonance imaging (MRI) indicated extensive interstitial edema in all compartments without collection, hematoma, or hemorrhage. The patient was treated with dexamethasone and Lasix for four days. Rehabilitation activities included exercises to improve range of motion (ROM), strength exercises, and a home workout routine. Two weeks after discharge, the swelling decreased by about 80%.
Conclusion: We believe that using a tourniquet during the reconstruction surgery may be responsible for the extensive edema in the limb. However, despite several diagnostic methods, we could not explain the reason for the edema in the limb following surgery.

Keywords: Anterior Cruciate Ligament; Case Report; Anterior Cruciate Ligament Reconstruction; Edema

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Background

The tourniquet is commonly used in knee arthroscopy surgery to prevent hemorrhage and improve observation during the surgery. This tool consists of a round pneumatic cuff into which air enters at high pressure under the control of an adjustable air pump (1). It creates temporary ischemia in the limb and results in a clear observation without bleeding. Utilizing this tool will help the anatomic structures be differentiated at a high resolution (2). Nerves and skeletal-muscular tissues are more susceptible to tourniquet-induced injuries. Although muscles are more prone to ischemic injuries, nerve injuries, including ischemic neuropathy and compressive neuropathy, are more common in clinical evaluation (3). Tourniquet-induced paralysis has a high correlation with compressive neuropathy (4). In this paper, we report a 32-year-old man who developed extensive edema in the thigh following anterior cruciate ligament (ACL) reconstruction surgery using a tourniquet.

Case Report

The patient was a 32-year-old man suffering from trauma in the right knee following a motorcycle accident that occurred a year ago. He reported knee pain, giving away, and locking. Physical examination revealed positive Lachman, drawer, and pivot tests in favor of ACL tearing. Magnetic resonance imaging (MRI) confirmed a rupture in the ACL and posterior horn of the medial meniscus. The patient was hospitalized in Akhtar Hospital, Tehran, Iran, on January 1, 2022, for ACL reconstruction surgery along with repair of the medial meniscus tear. He had a history of controlled psoriasis, alcohol and opioid consumption, and smoking.

He underwent ACL reconstruction surgery on January 2, 2022. Spinal anesthesia was carried out on the bed. Tourniquet was fastened on the proximal femur in the supine position. The right limb was suspended from the bed edge, while the left limb was in the lithotomy position. After being prepped and draped and 1 gram intravenous (IV) cefazolin was injected, the tourniquet was turned on and inflated to a pressure of 350 mmHg. Normal saline (1 L) was used as an irrigation liquid without pumping, just by placing the serum container 3 feet above the patient's knees to use gravity as the driver of the irrigation liquid. Anteromedial and anterolateral portals were made, and initial arthroscopy was carried out.

After proving the ACL rupture, an arthroscope was removed from the knee, and an incision was made in the anteromedial proximal leg to remove hamstring tendons; gracilis and semitendinosus tendons were harvested. The arthroscopic device was re-entered into the knee through the anteromedial portal and guided to the posterolateral from the notch space. Then, using an angiocatheter and under direct observation, the portal and posterolateral paths were identified. The portal was made by blade No. 11. In the next step, the trocar was entered by a new sheet from the posterolateral portal and carried to the medial direction from the posterior cruciate ligament (PCL) in a transseptal form. Then, the arthroscopic device was

removed from the anteromedial portal and placed in the posterolateral portal; hence, the posteromedial corner was under direct observation. The posteromedial portal was made by using an angiocatheter and blade No. 11. The rupture site of the posterior medial meniscus horn was debrided by a shaver, and two sutures were applied in the rupture site using a 90-degree lasso, which was fastened by an all-inside method.

In the next step, two sutures were made in an inside-out fashion at the tearing site of the meniscus body using the cannula-specific zone. After completing the meniscus repair process, the tibial and femoral tunnels were made at the anatomical footprint of the ACL, and a tendon graft was passed. The proximal part of the graft was fixed with an endo-button, and its distal part was fixed with an interference screw. At this point, a 5-cm incision was made in the posteromedial of the knee, and after ensuring that the saphenous nerve was not damaged, the threads related to meniscus repair were tied to the capsule.

Finally, the tourniquet was taken off after two hours, and the portals, along with anteromedial and posteromedial incisions, were sutured. About 3 liters of serum were used for irrigation during the surgical procedure. At the end of the surgery, the distal pulse was controlled, which was normal. No active hemorrhage was observed from incisions or portals. Mild fluid extravasation was seen around the posteromedial and posterolateral portals. We applied dressing and fastened the knee immobilizer. The patient was then transferred to the recovery and subsequently to the ward at noon (12:00).

At 17:00, the patient developed thigh swelling. Examination of the entire thigh indicated swelling in all three compartments (Figure 1). The right thigh circumference was 97 cm in the area with maximum swelling, while the same area on the left thigh had a circumference of 56 cm. The vital signs were stable without hemorrhage from the surgical wound. The swelling was mainly on the tourniquet site, i.e., proximal thigh, and its intensity was decreasing toward the knee. We did not observe swelling distal of the knee. The distal pulse of the limb was normal. Neurovascular examination of the legs and fingers was normal. The swelling of the thigh compartment was not tense. The patient was placed on nil per os (NPO) status due to the possibility of compartment syndrome and the need for a fasciotomy. The immobilizer and all dressings were removed, and an ice pack and elevation were applied.

Figure 1. The right thigh swelling

At 20:00, right thigh ultrasound was performed, which indicated extensive interstitial edema in all thigh compartments. Collection, hematoma, hemorrhage, and deep vein thrombosis (DVT) were not seen. At 22:00, an MRI of the right thigh showed extensive interstitial edema, preferably in the proximal region, i.e., the muscle bulk site in all three compartments, including the post, anterior, and medial compartments. No collection, hematoma, and hemorrhage were observed (Figure 2). The patient was transferred to the intensive care unit (ICU), and the following orders were followed: ice bag, elevation, cefazolin [1 g, three times a day (TDS)], holding enoxaparin, pantoprazole (40 ml daily), Apotel [1 g, when required (PRN)], normal saline serum (1 L, stat), then Dextrose (3.33%) NaCl (0.3%) serum [1 L, twice a day (BID)], gabapentin (300 ml daily), and dexamethasone (8 ml, IV, TDS).

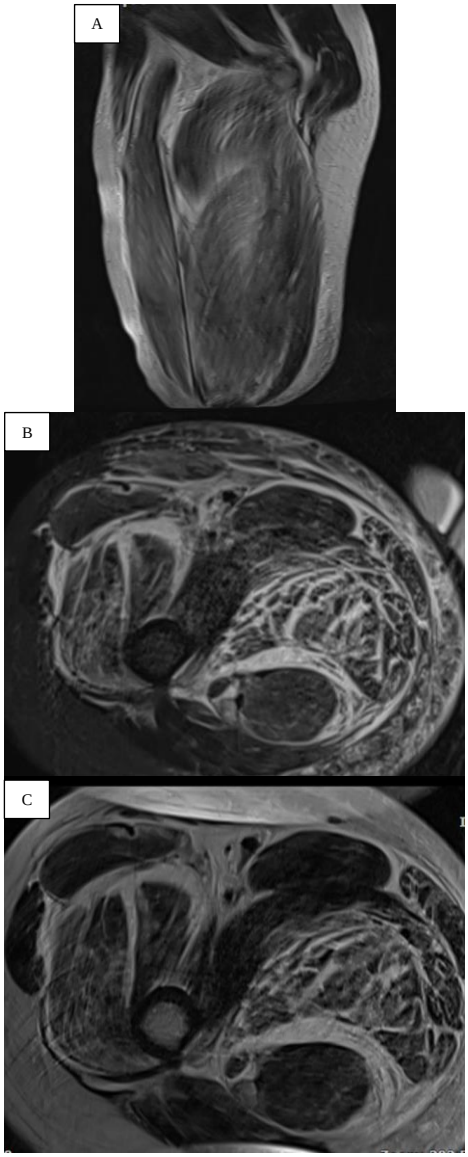

Figure 2. Magnetic resonance imaging (MRI) of the right thigh A: coronal cut MRI, B: proximal femoral shaft axial cut MRI, C: middle femoral shaft axial cut MRI

On the first day post-operation, the swelling slightly decreased. Examination of the knee, leg, ankle, and fingers was still normal. The sensation and movement of the

fingers were normal. Ketorolac and morphine injections were started as analgesics. Enoxaparin was restarted. Lasix injection (20 mg BID) was administered. On the second day post-surgery, the swelling decreased by about 30%. The thigh circumference was 85 cm. The patient became per os (PO), and the serum was held Dextrose (3.33%) NaCl (0.3%) serum and normal saline serum (1 L) was started after 24 hours. Vital signs were stable, and a distal leg examination revealed no abnormalities. On the third day post-surgery, the swelling decreased by about 50%, and the thigh circumference was 77 cm. The results of the rest of the examinations were the same as the previous day. The laboratory test results were as follows: creatinine (Cr) = 1 mg/dl, sodium (Na) = 134 mmol/l, potassium (K) = 5 mmol/l, blood sugar = 177 mg/dl.

On the fourth day post-operation, the swelling was reduced by about 60%, and the thigh circumference was 72 cm. According to counseling with an internist, the insulin protocol was implemented to control hyperglycemia. Dexamethasone and Lasix were stopped. On the fifth day post-surgery, he was discharged from the ICU, and his blood sugar was controlled (blood sugar = 97). The pre-op hemoglobin of the patient was 14, while his hemoglobin on the fifth day after surgery was 13.2. On the sixth day after the surgery, he was discharged in good general condition and with stable vital signs, and the swelling of the thigh was about 40% of the swelling on the evening of the surgery day.

He returned to the clinic a week later, and the swelling was slowly subsiding, showing about a 70% reduction. Examination of the knee up to the distal was normal. He showed weakness in the contraction of the quadriceps muscle, for which he received isometric exercises. The electromyography (EMG) of the patient reported a slight decrease in nerve conduction velocity (NCV) in the femoral nerve pathway. Two weeks after discharge, at the next visit, the swelling had decreased by about 80%, and the thigh circumference was 64 cm. The quadriceps muscle strength was about 30% better than the previous week. Three weeks after discharge, the strength of the quadriceps muscle improved by about 10% compared to the previous week. The knee movements began in the form of active flexion and passive extension with the help of a physiotherapist. While the patient's knee movement was restricted due to thigh swelling and meniscus repair, he maintained a 15-degree flexion.

In the fourth week after discharge, his range of motion (ROM) was between 15° and 40° flexion; physiotherapy and isometric exercises continued. In the sixth week after discharge, he had a 5-degree extension deficit and flexed his knee at 45°, and the quadriceps force which was evaluated in physical examination was about 50% of the opposite side. Weight-bearing also started partially. In the eighth week post-discharge, he had full extension and 60° of flexion. The weight-bearing was gradually increased, and one walking cane was set aside. In the tenth week after discharge, he flexed his knee by 90° and started to walk with a cane as tolerated. The quadriceps force was about 60% of the opposite side. In the twelfth week after discharge, the second walking cane was set aside. Flexion was set at 105°. In the fourteenth week after discharge, the quadriceps force was 80% of the opposite side, and the flexion value reached 120°.

Discussion

This paper reported a 32-year-old man who developed abnormal thigh swelling following ACL reconstruction surgery. Several differential diagnoses can be introduced to explain the complications in this patient. The first one is a post-tourniquet syndrome. Tourniquet-induced ischemia causes tissue hypoxia and acidosis, followed by increased capillary permeability and alterations in blood coagulation status. Cell necrosis will occur if the ischemia is prolonged enough (5, 6). Muscles are more prone to ischemic damage than other tissues. Continuous ischemia for 2 hours or more during limb surgery leads to post-tourniquet syndrome, characterized by edema, stiffness, pallor, weakness without paralysis, and numbness in the limb (7). This syndrome seems to be the most common morbidity of tourniquet use, whose incidence has been underestimated. It usually resolves within a week. The symptoms of this syndrome start from the area below the tourniquet and extend to the distal end of the limb (8). In this patient, however, the distal knee area was completely normal, with no evidence of post-tourniquet syndrome. The high swelling of this patient's thigh was not consistent with this syndrome.

Extra-articular extravasation of irrigation fluid is relatively common during arthroscopy, which is always limited to the subcutaneous tissue around the portals (9). This fluid may sometimes leak into the thigh, popliteal cavity, or leg. When the lower limb is suspended during arthroscopy, the accumulation of extravasated fluid in the leg is more common due to gravity (10). Thigh extravasation is rare, as only 4 cases have been reported. During surgery, the extravasation is visible; it is quite obvious after the end of the surgery and the removal of the drape from the patient's limb (9, 10). Localization of this extravasation is not difficult and can be compared with the opposite limb. Cavaignac et al. reported a case of extravasation of the proximal thigh and scrotum after knee arthroscopy. Fluid infiltration from the bone's medullary canal following nail removal and using an arthroscopic pump have been proposed as involving factors (11). In this patient, slight extravasation was seen at the end of the surgery around the posteromedial and posterolateral portals. No extravasation was observed in the thigh, popliteal cavity, or leg.

Pedowitz et al. reported excessive tourniquet pressure due to an incorrect gauge setting as the cause of nerve and muscle damage (12). This injury tends to be more serious in the area below the tourniquet than distal due to a combination of ischemia and mechanical deformation in compressed tissues. EMG abnormalities are seen in 70% and 77% of lower and upper extremity cases experiencing tourniquet-assisted surgery, respectively (13). This abnormality sometimes remains in the EMG for up to 5 months and is associated with the post-surgery functional deficit, increasing clinical recovery time (12). A case of severe axonal femoral nerve neuropathy with EMG control was reported in patellar fracture surgery with a tourniquet (14). A pressure of 310 mmHg was used for 45 minutes. After the surgery, the knee lost its extension ability. Quadriceps atrophy emerged within three weeks. The injury was resolved after 18 months (6). In this patient, slight changes indicating femoral nerve damage were reported in the form of reduced NCV; no quadriceps paralysis occurred.

Technetium-99 was used to identify the tourniquet-induced damaged areas, where the regions with higher absorption indicated greater damage (12). Technetium-controlled muscle damage was significantly greater in the compressed thigh muscles when the tourniquet was

applied at pressures higher than 200 for more than 2 hours than in the legs (15). A significant correlation occurred in the thigh area between the pressure cuff and the tourniquet time. In the leg area, this significant correlation was only with the tourniquet time. Biomechanical models of tourniquet compression show the highest shear stress at the edges of the tourniquet (16). In other words, the transition zone between compressed tissue and non-compressed tissue is linked to the edge effect, which increases damage at proximal margins and the distal area under compression (12). In our patient, the thigh area, especially the proximal part, had the most swelling. The severity of swelling decreased toward the knee. The combination of mechanical over-compression, possible failure of the tourniquet gauge, and ischemia can justify the symptoms of the thigh. However, we did not consider ischemia as the responsible factor since patient did not exhibit ischemia symptoms.

Ischemia reperfusion injury is a systemic immune response triggered by the release of pro-inflammatory mediators and reactive oxygen particles during the reperfusion of a tissue or organ that has experienced a period of ischemia (17). In a study by Cearra et al., 24 hours after the removal of the tourniquet, the thigh circumference increased by 13% due to reperfusion, implying a 30% rise in the cross-sectional area of the thigh. In this injury, the increase in creatine phosphokinase (CPK) and lactate dehydrogenase (LDH) occurs at the onset of reperfusion and reaches its maximum after 3 hours (18). In our patient, the levels of these markers were measured 5 and 7 hours post-surgery, which were normal. Normal distal leg muscles experiencing ischemia the same as the thigh area could not be justified by reperfusion injury. In a study by Lee et al., the patient developed red urine and uremia five days after ACL reconstruction. Evaluations showed myoglobinuria and increased creatine kinase (CK) and Cr, and the patient was treated with the diagnosis of rhabdomyolysis (19). The test results of this patient showed no signs of rhabdomyolysis.

Acute compartment syndrome occurs when the pressure inside a closed fascial space rises to the point where microcirculation is disrupted. A case of compartment syndrome in the leg after knee arthroscopy simultaneous with a high tibial osteotomy (HTO) was reported (20, 21). The rupture of the posterior capsule of the knee and the fluid extravasation were suggested as factors. In the surgical procedure, the tibial guide wire was repositioned several times, allowing fluid to leak from the osteotomy gap to the posterior leg compartments by creating multiple pathways. Severe swelling, tension, and pain are symptoms of this syndrome (21). This syndrome is less common in the thigh than in the leg and is mainly related to one or two thigh compartments (22). Our patient had no severe pain, and the swelling was similar in all three compartments, showing no tension. It was better to measure intracompartmental pressure, but the relevant device was unavailable.

Crush syndrome is a systemic manifestation of muscle cell damage emerging due to direct pressure or crash. Rhabdomyolysis and ischemia-reperfusion injury are the two main causes of this syndrome (23). After the release of reperfusion, myoglobin, urea, potassium, and phosphate from the damaged muscle cells into the circulation, a large volume of intravascular fluid leaks into the muscle tissue due to increased capillary permeability. Releasing toxins and hypovolemia lead to systemic effects of crush syndrome (24). The normality of these tests in the reported patient contradicts the incidence of this syndrome.

Tourniquet induces venous stasis and enhances platelet adhesion. It is effective in DVT if not using anticoagulants (1, 3, 25). In our patient, anticoagulants were prescribed after the surgery, while no evidence of DVT was seen in the Doppler ultrasound. Paradoxically, tourniquets can increase fibrinolysis and hemorrhage and increase postoperative hemarthrosis. An increased hemorrhage tendency after tourniquet release was reported previously (26). In our patient, there was no significant hemarthrosis. Ultrasound and MRI of the thigh showed no collection in the compartments in favor of hemorrhage.

Conclusion

The standard method to determine the proper tourniquet pressure is to use limb occlusion pressure (LOP), which is measured by Doppler. A 50 to 100 mmHg safety margin is also added to include the physiological changes during the surgery. The general recommendation involves continuous cuffing for 2-2.5 hours. It is important to know that there is no safe time for a tourniquet, and any duration can lead to limb injury (27). After various examinations on the cause of excessive thigh swelling along with normal leg and foot, we were unable to reach a definite conclusion in our patient because his symptoms coincided with none of the differential diagnoses. The hypothesis of tourniquet gauge failure was also rejected by controlling the applied device.

Conflict of Interest

The authors declare no conflict of interest in this study.

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