Magnetic Resonance Imaging of Compartment Syndrome: report of three cases

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ABSTRACT

Acute compartment syndrome in an extremity is a limb-threatening surgical emergency. However, magnetic resonance imaging (MRI) has rarely been performed to establish the diagnosis of this condition.

We report 3 cases of compartment syndrome of the lower extremities, one in the acute stage and two in chronic stages. All three patients were involved traffic accidents with unilateral lower limb fractures. No significant past medical history or other causes of myopathy was present in any of the three cases.

The patient with an acute compartment syndrome was diagnosed with the condition based on clinical information. MRI performed one-month following fasciotomy for suspected myonecrosis revealed muscular swelling, edema, interstitial hemorrhage, and myonecrosis. Muscular necrosis was confirmed by subsequent surgical debridement.

The other two subjects with chronic conditions had histories of lower limb fractures. One suffered from ankle deformity and the other, erythematous painful swelling in the leg. MRI demonstrated localized fibrosis and muscular atrophy in both cases as well as superimposed cellulitis in the second case. The myopathies in both cases were confined in the leg corresponding to previous fracture. The myopathies are contributed to neglected compartment syndrome without prompt fasciotomy 2 and 20 years ago, respectively.

Acute compartment syndrome is a limb-threatening surgical emergency, and urgent fasciotomy is usually required [1]. The cause of compartment syndrome is due to increased pressure in a limited myofascial space, leading to compromised microcirculation of nerves and muscular tissues with irreversible ischemic damage.

The diagnosis of compartment syndrome is basically clinical and might sometimes be difficult to establish. Intra-compartmental pressure (ICP) measurement can be helpful in reaching a clinical diagnosis of compartment syndrome, but ICP measurement is multifocal, painful, invasive, usually unavailable [2], and complicated with potential risks of infection or bleeding [3]. Furthermore, the nature, extent and severity of soft-tissue and other coexisting injuries cannot be determined by pressure measurement alone. Thus, there have been efforts to investigate the potential contributory role of imaging [4]. MRI can be helpful in the diagnosis as well as aid in determining the extent of compartment syndrome for selective fasciotomy [2].

We report 3 cases of compartment syndrome in the lower extremities: one in the acute stage and two in chronic stages. All three patients were victims of traffic accidents and unilateral lower limb fractures. There was neither past history of underlying rhabdomyolysis nor uncontrolled diabetes mellitus in any of the three patients.

Case 1
A 30-year-old male was transferred to our emergency
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department after a motor vehicle accident. Initial plain radiographs revealed supracondylar fracture of the right femur. Diagnosis of acute compartment syndrome of the right lower extremity was established based on clinical exhibition of swelling, pallor, diminished pulse, paresthesia and paralysis. Emergent fasciotomy of right leg then was performed.

MRI study was performed one month after fasciotomy for possible muscular necrosis. The patient was experiencing poor recovery of motor functions, and laboratory data revealed progressive elevation of muscular enzymes. MRI before and after intravenous administration of Gadolinium(Gd) contrast medium show pancompartmental muscular swelling (loss of muscular septations on the T1-weighted image, Fig. 1a), muscular edema (high-intensity signals on the T2-weighted image, transparent arrow in Fig. 1b), interstitial hemorrhage (increased signal intensity on T1-weighted image, solid arrow in Fig. 1a, 1c), areas of myonecrosis (non-enhancing muscular tissue with surrounding rim enhancement on post-contrast T1-weighted image with fat-suppression, arrowheads in Fig. 1d, 1e).

The findings on the MRI study were concluded as compartment syndrome with pancompartmental muscular necrosis. Subsequent wound debridement confirmed

Figure 1

Figure 1. MRI of the right leg, case 1, was performed after fasciotomy and showed pancompartmental muscular swelling (1a: muscular swelling with obliteration of intermuscular fat planes on the T1-weighted image), interstitial hemorrhage (thin black arrow in 1c: high-signal regions on T1-weighted images with fat-suppression), and edema (open arrow in 1b: high-signal regions on T2-weighted images). Post Gd-enhanced images show localized patchy enhancement and focal myonecrosis (arrowheads in 1d: non-enhancing muscles surrounded by rim enhancement concluded as myonecrosis). Note that the lesions are confined in the right lower leg with pancompartmental and continuous involvement without skip lesions.

a. T1-weighted image, TR (repetition time)/TE (echo time): 506/7
b. T2-weighted image, TR/TE: 4540/85
c. T1-weighted image with fat-suppression, TR/TE: 623/7
d. Post Gd-contrast T1-weighted image with fat-suppression, TR/TE: 623/7
e. Post Gd-contrast T1-weighted image with fat-suppression, TR/TE: 629/7
massive muscular necrosis based on the surgeon’s observation and opinion. Postoperative hyperbaric oxygen therapy and programs of rehabilitation were initiated, and the patient experienced progressive clinical improvement.

**Case 2**

A 50-year-old male with diabetes under good control suffered from fractures of the left tibia and fibula in a traffic accident twenty years ago. No history of the diagnosis of compartment syndrome or fasciotomy was found in the patient's medical records. However, the patient was told that muscular necrosis had occurred during healing of the fractures. The patient was admitted to our infection ward under the impression of cellulitis. MRI performed for suspected osteomyelitis revealed old fractures of the tibial plateau and proximal fibula, subcutaneous soft tissue swelling (curved arrow in Fig. 2a-2c), focal calcification (black arrow in non-contrast computed tomography (CT),

![Figure 2](image-url)

**Figure 2.** A 50-year-old patient with well-controlled diabetes and history of tibial and fibular fractures 20 years ago. CT (figure 2a) and MRI (figure 2b-2e) of the left leg show pancompartmental muscular atrophy (straight white arrow), fibrosis with focal calcification (black arrow, low signal lesions on T1 and T2 weighted images). Circumferential subcutaneous soft tissue swelling (curved arrow) is consistent with clinical diagnosis of cellulitis.

a. CT without contrast enhancement  
b. T1-weighted image, TR/TE: 506/8  
c. T2-weighted image, TR/TE: 4300/102  
d. T1-weighted image with fat-suppression, TR/TE: 656/8  
e. T2-weighted image, TR/TE: 4532/86
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Fig. 2a) and pancompartmental muscular fibrosis manifesting as non-enhancing low-signal intensity lesions on T1 and T2 weighted images (white arrow in Fig. 2b-2e). The imaging study was concluded as an indication of cellulitis and chronic compartment syndrome with massive muscular fibrosis.

Case 3

A 28-year-old female suffered from left tibial fracture two years ago due to a traffic accident. During admission at another hospital, there was no record of either compartment syndrome or fasciotomy. Due to progressive ankle deformity, she visited our orthopedics out-patient

Figure 3

Figure 3. MRI of case 3 show hematoma (asterisk) with surrounding fibrosis or hemosiderin deposition (arrowhead) in the anterior and lateral compartments of the left leg (3a-3e) consistent with localized chronic compartment syndrome.

a. T1-weighted image, TR/TE: 467/9
b. T1-weighted image with fat-suppression, TR/TE: 723/8
c. Proton density-weighted image, TR/TE: 2160/30
d. Gd-enhanced, T1-weighted image with fat-suppression, TR/TE: 723/8
e. T2-weighted image, TR/TE: 3800/96
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Diabetic myopathy occurs primarily in patients with type I diabetes mellitus (DM) or poorly-controlled type II DM; it is usually accompanied by retinopathy, nephropathy and other vascular complications [6]. This type of myopathy usually begins with spontaneous, painful swelling of muscles, more commonly encountered in the thighs than in the lower legs, which may be bilateral with skip lesion.

Rhabdomyolysis is often preceded by a history of overexertion, drug use, carbon monoxide (CO) intoxication, seizure, etc [9]. This condition usually affects the muscles at the back and thighs and can be either unilateral or bilateral. Marked elevation of serum creatine kinase level is also characteristic but not pathognomonic. Rhabdomyolysis may also be complicated with compartment syndrome [8, 9], but we were unable to find published literature describing the MRI findings of patients with combined rhabdomyolysis.

All three patients had histories of unilateral fractures of the femur, tibia, or fibula without evidence of rhabdomyolysis. The second patient had diabetes that was well controlled without retinopathy or nephropathy, and muscular necrosis occurred after fractures that happened twenty years ago without known DM at the time, thus rendering the diagnosis of diabetic myopathy less likely.

MRI of all three patients showed continuous, non-skipping lesions of the lower extremities in which the fractures occurred, distributions based on compartmental involvement (Case 1, 2: pancompartment. Case 3: anterior and lateral compartments), and no clinical evidence of other potential causes of myopathy. The diagnoses of acute and chronic compartment syndrome are thus established.

Chronic exertional compartment syndrome is another form of chronic compartment syndrome, which is caused by increased intra-compartmental pressure and subsequent ischemic changes after exercise. Diagnosis can be confirmed with invasive pressure measurements or MRI before and after physical exercise [10].

CONCLUSION

Compartment syndrome manifests characteristic features on MRI studies, and the correlation between clinical information and imaging features facilitate in establishing the diagnosis. Neglected cases of acute compartment syndrome may result in severe complications including myonecrosis, fibrosis, atrophy, disability and deformity. MRI can be helpful for the early diagnosis of acute compartment syndrome in clinically equivocal cases.
REFERENCES