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CASE REPORT

Unilateral Variant Psoas Major with Split Femoral Nerve

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Introduction

The psoas major muscle includes slips of muscle that originate from the transverse processes of lumbar vertebrae 1-5 and intervertebral discs of T12-L4. These slips of muscle combine and join with the iliacus muscle to then course inferiorly and insert onto the lesser trochanter of the femur [1].The psoas muscle is considered one of the primary flexors of the hip joint and is innervated by the femoral nerve, which arises from ventral rami of lumbar spinal nerves 2-4. The femoral nerve then passes through the psoas major in an inferolateral direction until it emerges on the lateral border of the muscle and continues its course inferiorly to the anterior thigh [2]. These relationships can be seen in Figure 1.

Variations of the psoas major muscle have been previously described in the literature. Fabrizio et al showed a normal psoas major muscle with both lateral and medial variants originating from the L4 transverse vertebrae and pelvic surface of the sacrum, respectively. Both variants followed an inferolateral course and combined just anterior to the psoas major muscle before inserting onto the lesser trochanter [3]. The psoas quartus muscle is also described as lateral to the psoas major and originating from the transverse process of L3 and medial aspect of the quadratus lumborum muscle before descending to insert onto the lesser trochanter of the femur [4]. Psoas tertius is described as a slip of muscle originating from the inner half of the 12th rib and transverse processes of lumbar vertebrae 1-4 and attaching to the iliopsoas muscle [5]. Another study describes their findings of an accessory psoas major muscle originating on the left costal process of L3 and the intertransverse ligament between L3 and L4 [6]. Although rare, these variants have also been shown to split the femoral nerve. It has been proposed that this occurrence is associated with neuropathies. [5-9].

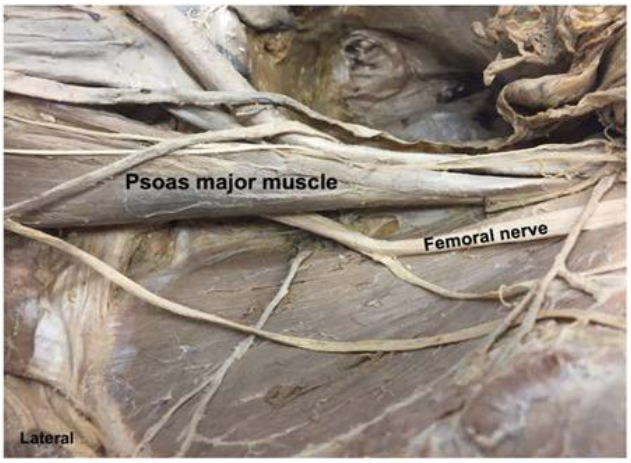

Figure 1: Typical anatomical relationship of the psoas major muscle and femoral nerve.

Case Presentation

Here we present a novel variant of the psoas major muscle. This case will add to the body of knowledge concerning variants of the psoas major muscle and help to understand its clinical importance. During a routine dissection of an embalmed 75-year-old female cadaver, a unilateral variant of the psoas major muscle was found on the left side (Figure 2). An additional 29 cadaveric specimens were examined (n=60)

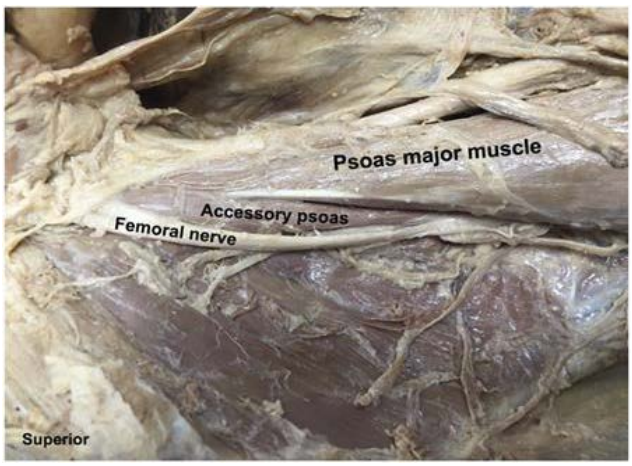

Figure 2: Accessory psoas emerging posterolateral to the psoas major. The femoral nerve emerges lateral to the psoas major and runs alongside the accessory psoas muscle

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Figure 3: Here the psoas major is shown to split the femoral nerve. Anterior and posterior fibers of the femoral nerve and its relationship to the accessory psoas muscle are marked. AF - anterior fibers; PF - posterior fibers

and no other psoas major variants were found. The variant in this case was observed as an accessory muscle to the psoas major. The accessory muscle lies posterior to, and runs parallel with, the normal psoas muscle fibers. It originates from the transverse process of the L4 vertebra and does not attach to the vertebral body. At the level of the L4 vertebra, the body of the accessory psoas muscle measured 3.5 cm in circumference. The psoas minor is not present in this specimen. An anomaly of the femoral nerve was also noted on the left side, seen in Figure 3. The femoral nerve arises from fibers that course both anterior and posterior to the variant muscle. There is a 5 cm split in the femoral nerve that begins 1.5 cm from the body of L4, where the muscle belly of the accessory psoas passes through. These nerve fibers recombine on the lateral border of the psoas major to form the femoral nerve. An additional peripheral neurovascular bundle to the accessory muscle was not observed during the course of dissection. No atrophy of the unilateral quadriceps muscles was observed.

Discussion

According to prior research, there have been several cases of a bilateral accessory psoas major variant with only a few cases of a unilateral accessory psoas variant. Spratt et al found variant slips of iliacus or psoas major unilaterally in four of 68 cadavers, but the two examined specimens had different proximal attachments, such as one from the lateral aspect of iliolumbar ligament and another from ala of sacrum[9] While empirical data for accessory iliacus or psoas is scarce, a prominent study by Jelev et al described having only one case of an accessory iliopsoas encountered from 108 human cadavers over a period of 22 years [6]. The literature has described a psoas magnus, a psoas parvus, a psoas tertius, and a psoas quartus [10]. All of these have variable attachments at the lumbar vertebrae and the twelfth rib, with insertions into the quadratus lumborum, the iliacus, and the psoas muscles. The accessory psoas in this case has an attachment at the L4 vertebrae with an insertion into the psoas major muscle belly, which has not been previously described in the literature [10].

There have been notable occurrences of a split femoral nerve reported in the literature. One aspect found among some of the bilateral variants, and the variant in this cadaver, is the splitting of the femoral nerve. In this case, there is a 5 cm split in the femoral nerve where the accessory psoas muscle belly passes through. These anatomical variants are rare with some authors reporting as few as three occurrences in 136 lumbar plexuses [9]. Wong et al described a variant in which a slip of muscle, termed psoas quartus, split the femoral nerve [11]. Unlike our muscle, the psoas quartus originates from the quadratus lumborum. Jelev et al described another instance of the femoral nerve split by a slip of muscle from both the psoas major and iliacus [6]. Both of these cases, as well as the one presented here, illustrate the variety that can occur in these variations.

The splitting of the femoral nerve has been implicated as a possible cause of nerve entrapment syndrome [9]. Due to the rare nature of these variants, it is difficult to prove that femoral nerve entrapment occurs as a result of a split femoral nerve. Unat et al observed anatomic variations in the iliacus and psoas major that pierced the femoral nerve. It was postulated that tension on the femoral nerve can result in referred pain to the hip and knee joints and to L2-L4 dermatomes [12]. As a result, paresthesia in the medial thigh and weakness of the quadriceps could occur [7]. Another study performed by Vazquez et al looked at a variation found among 242 lumbar plexuses. They likewise speculated that the splitting of the femoral nerve by these variants could cause neuropathies based upon the same mechanism described above [8]. The splitting of the femoral nerve in the case presented here could conceivably cause nerve entrapment. However, neither Unat et al nor Vazquez et al were able to correlate their findings with comorbidities of the donor bodies. Likewise, we were unable to obtain such a record. Thus, it is difficult to conclude that a split femoral nerve is pathognomonic for femoral nerve entrapment.

The psoas major variant described has a number of clinically important features. An accessory psoas can result in issues with a lateral interbody fusion procedure. Its implication in femoral nerve injury is variable, and thus, spine or neurosurgeons must take particular caution when performing this procedure on patients with this variant [13].

Femoral nerve neuropathy can also be seen in hip operations, especially in abdominal hysterectomy. These surgeries include hip replacement, renal transplants, appendectomy, and aortic aneurysm repair. Hence, surgeons should pay extra attention to patients with this accessory psoas during the aforementioned operations to prevent additional deterioration of femoral nerve function [7]. African American men tend to have thicker psoas than average; therefore, extra precautions should be taken for those with this variation in terms of risk of femoral nerve compression [14].

In addition to femoral nerve entrapment, impingement of the psoas tendon is also a significant issue that can take place in

various operations. In rare cases, when impingement of the psoas tendon results in refractory labral pathology, a psoas tenotomy could be indicated. These rare situations include psoas snapping, psoas impingement, or uncontrollable psoas tendinitis. This poses a unique risk in our subject, as the psoas tendon is split by the femoral nerve. Thereby, additional precautions would have to be made when performing a tenotomy in the anterior hip region to prevent severing of the femoral nerve. An alternative approach could be to deepen the psoas tunnel in order to increase the range of motion of the psoas tendon, avoiding the femoral nerve altogether [12].

The muscles of the lower limb are important for maintaining posture when standing and walking. The psoas major and iliacus muscles come together to form the iliopsoas. When standing in neutral position, the iliopsoas works to provide support to the body by stretching tightly into the line of gravity that keeps the body upright. It contributes to keep the center of gravity of the body while standing and walking, helping maintain movement by using just a small amount of energy and producing movement that is smooth and sustained. The psoas is important in the swing phase of the gait cycle, which occurs after the toe off, where the toes leave the ground and before the heel strikes the ground again. The goal of this phase of the cycle is to accelerate the thigh forward and the psoas ultimately determines the stride length. For our anatomical variant, the accessory psoas has interesting implications in standing and walking. If the accessory psoas was providing extra power to the hip flexor this could have affected stride length and stability in gait, potentially leading to muscle pain or gait disabilities [15].

There may be a variety of mechanisms by which this anatomical variant occurred. At 4 weeks post-fertilization, limb buds appear and spinal nerves extend out and associate with myotomes. During myogenesis, pre-myoblasts express transcription factors PAX-3 and PAX-7. Mutations in these transcription factors may have contributed to the development of the accessory psoas muscle [16]. Cell signaling during development of the lumbar and thoracic myotomes may have contributed to developmental differences in the psoas muscle. During the process of elongation, muscles bring specific nerves from the trunk into the limb buds. Motor axons develop before sensory axons in the limb; thus, sensory axons may follow the path of the motor axons [17, 18]. It is possible that the psoas muscle may have slipped to grow over the motor axons, with sensory axons following the same path and growing around the muscle slips. Because of this, the femoral nerve may have split into different parts. It is also feasible that during the end of development, normal muscle apoptosis did not occur in the muscle slip [11].

Conclusion

Variations of the psoas major are uncommon. The psoas major presented here contributes to the current repository of anatomical variants of this muscle. Furthermore, this case showed a femoral nerve split by the psoas major. It is crucial to take into consideration these variants for clinical and surgical interventions in the lumbar and pelvic area.

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