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CASE REPORT

Unilateral Absence of the Psoas Major and Iliacus Muscles and Downstream Effects of Surgical Intervention in a 96 year-old Female Donor

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Abstract

Learning anatomy through donor dissection allows students the unique opportunity to explore variations in anatomical structures which may include or indicate pathological anomalies. Findings could reveal insights into the life of the donor, along with the downstream effects of clinical intervention. This case study discusses the findings of a group of first-year medical students during a full body dissection of a 96-year-old female. Among other anomalies, evidence of drastic surgical intervention, extreme scoliosis, and muscle atrophy were noted. Findings suggest that the donor's right psoas major and iliacus muscles were removed, likely as part of a surgical resection of a retroperitoneal tumor. Distal to the resected muscles, notable muscle atrophy with fat infiltration in the anterior right thigh muscles suggests muscle wasting, which could be secondary to the removal of these muscles. In addition, extreme scoliosis was discovered, likely attributed to the imbalance in hip flexor muscles following surgical removal of the iliopsoas muscle. The theorized surgical removal of iliopsoas muscles along with the downstream effects of muscle atrophy and severe scoliosis depict the impact surgical intervention can have on a patient's quality of life. Anatomical findings of the donor discovered during dissection and theorized surgical interventions based upon gross findings are discussed in detail within this case.

Key Words: *Donor dissection; Surgical intervention; Quality of life; Muscle atrophy, Scoliosis; Retroperitoneal tumor; Absent iliacus muscle; Absent psoas muscle; Absent iliopsoas muscle*

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Introduction

As technology advances, methods of studying human anatomy evolve. Although new methods such as virtual reality, videos, and imaging such as MRI and CT are constantly improving, dissection remains the cornerstone for the identification and discovery of anatomical differences and variations [1].

The iliacus, psoas major, rectus femoris, sartorius, and pectineus muscles allow for hip flexion, which is vital for ambulation [2]. The primary hip flexor is the iliopsoas muscle (a combination of the iliacus and psoas major muscles).

The iliacus muscle is a fan-shaped muscle that originates from the superior two-thirds of the iliac fossa, the ventral lip of the crest of the ilium, and the sacral ala. The psoas major muscle is a long spindle-shaped muscle that originates from the T5 to L5 transverse processes, vertebral bodies, and intervertebral disks. The distal iliacus and psoas major muscles combine at L5 to S2 to form the iliopsoas tendon which is encased by the dense iliac fascia and inserts on the lesser trochanter of the femur as the iliopsoas tendon [2-3].

Functionally, in addition to hip flexion, the iliacus and psoas major muscles create external rotation and abduction of the femur. Vertebral attachments of these muscles allow them to function as core muscles - supporting lumbar lordosis and an anterior tilt of the pelvis [2]. The combined functions of the iliacus and psoas major muscles are crucial in completing routine aspects of daily living, such as sitting, sustaining an erect spinal posture, and initiating the swing phase of the gait cycle.

The embryologic development of the iliacus and psoas major muscles are not well understood. However, it has been determined that the muscles develop from the paraxial mesoderm and are generally present by the 8th week of gestation. The muscles may arise from the myotomes of somites that are a result of paraxial mesoderm division [4].

Currently, as far as we know, there is one report in the literature of unilateral agenesis of the iliopsoas muscle, and no reports of bilateral agenesis [5]. There are rare reports of congenital unilateral absence of muscles including the trapezius, sternocleidomastoid, and pectoralis muscles. Proposed causes mostly center around possible injury during early embryogenesis, with one instance of a genetic cause [6].

This case report describes a unique finding in an elderly female donor: unilateral absence of the iliacus and psoas major muscles. To the best of our knowledge, this is only the second report of this anatomical variation, in either the congenital or surgical contexts.

Materials and Methods

A phenol-embalmed donor was dissected as part of a medical gross anatomy course. Informed consent had been obtained for the use of the body for anatomical education, training, and research under the Human Tissue Act 2004 [7]. The donor was a female, 96 years of age, whose cause of death was unspecified and listed as “natural causes”. Whole body dissection was performed by five first-year medical students (NO, SO, WN, KO, AN), following the outline of the Grant’s Dissector [3], and under the supervision and guidance of experienced anatomy faculty (DD, TH, EM). Dissection occurred four days a week over an 8-week period for an average of 2.5 hours each day. The regional order of dissection was as follows:

1. Back, Spinal Cord and Shoulder
2. Upper Limb

3. Thorax
4. Abdomen and Retroperitoneum
5. Pelvis and Perineum
6. Lower Limb
7. Head and Neck

Due to the abbreviated nature of the Human Structure course, the posterior forearm and intrinsic foot were not dissected. A full list of abnormal findings, by region, can be found in Table 1.

TABLE 1:
List of the dissection findings organized by body region.

Anatomical Regions	Findings Identified
Back, Spinal Cord, and Shoulder	Severe scoliosis
Upper Limb	No abnormal findings
Thorax	sliding esophageal hernia multiple lung infarctions
Abdomen and Retroperitoneum	Absence of right psoas major and iliacus Evidence of surgical intervention: midline abdominal scar and staples along the iliac fossa Atrophied right and left kidney
Pelvis and Perineum	Hernia mesh Centrally - located severely polycystic ovary
Lower Limb	Atrophy and fat infiltration of the right anterior thigh muscles
Head and Neck	Healing hemorrhage inside of the skull

The dissection of the posterior abdominal wall followed the outline provided by Grant's Dissector [3]. This included the opening of the abdominal wall and removal of the gastrointestinal tract, kidneys, and suprarenal glands. Following the removal of these structures, the psoas major muscle was to be identified by its proximal attachments on the lumbar vertebrae and distal attachment on the lesser trochanter. Students were also instructed to look for the presence of a psoas minor muscle at this time. Instructions to identify the iliacus muscle followed with the same identification technique of tracing the muscle from the proximal attachment on the iliac fossa to the distal attachment on the lesser trochanter. The following dissection instructions guided students through the unilateral removal of the psoas major muscle, in sections, to reveal the origin of the nerves of the lumbar plexus. It was at this point in dissection when authors realized the absence of the right psoas minor, psoas major, and iliacus muscles as indicated by the normal appearance of the same structures on the left side, the description in the dissection guide, and the bare appearance of all bony landmarks mentioned.

Results

During the dissection of the posterior abdominal wall, evidence of surgical removal of the right psoas major and iliacus muscles was found in the form of staples in and around the iliac fossa and the complete absence of the muscles (Figure 1). After a review of the literature and conversation with pathologists, the authors concluded that the most likely explanation for the removal of these muscles is an iliopsoas resection associated with surgical removal of a retroperitoneal sarcoma or ganglioneuroma [8].

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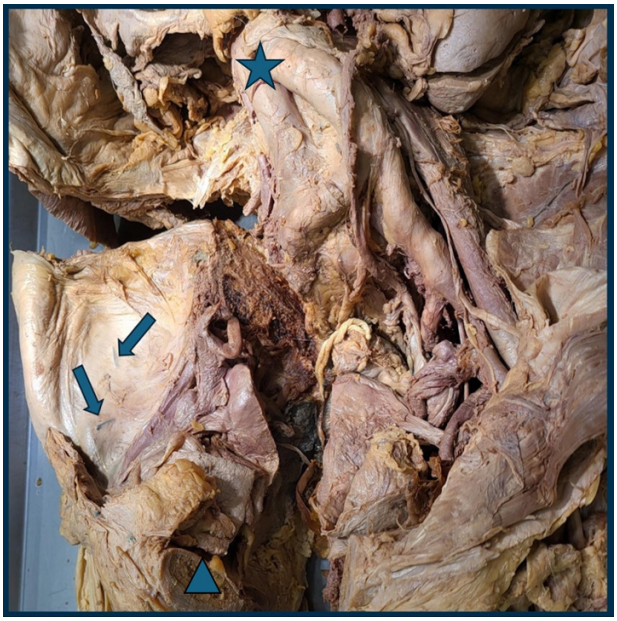

Figure 1) *Dissection of the right posterior abdominal wall shows evidence of surgical removal of the right psoas major and iliacus muscles. Arrows are pointing to staples in and around the iliac fossa. Star indicates bifurcation of the abdominal aorta. Triangle indicates pubic symphysis.*

Severe scoliosis was also observed during dissection of the abdomen (Figure 2). Considering the large role that the iliopsoas muscle plays in lumbar spine stabilization, this finding may be a result of the resection.

Figure 2) *Dissection of the abdomen reveals severe scoliosis. The dotted lines outline the trajectory of the spine.*

Similarly, dissection of the anterior thigh revealed possible implications of posterior abdominal wall findings, as there was significant atrophy in the right quadriceps femoris and sartorius muscles (Figure 3).

Figure 3) *Dissection of the right anterior femoral region reveals atrophy of the right quadriceps femoris and sartorius muscles. White asterisks (*) identify the sartorius muscle (right pictured in left image, left thigh pictured in right image).*

Complications in addition to musculoskeletal issues caused by severe scoliosis include breathing problems from lung compression against the rib cage, heart complications, and increased risk for esophageal hernias [9-10]. Consistent with these risks, a sliding esophageal hernia and histological findings of multiple lung infarctions were found in this donor (Figure 4).

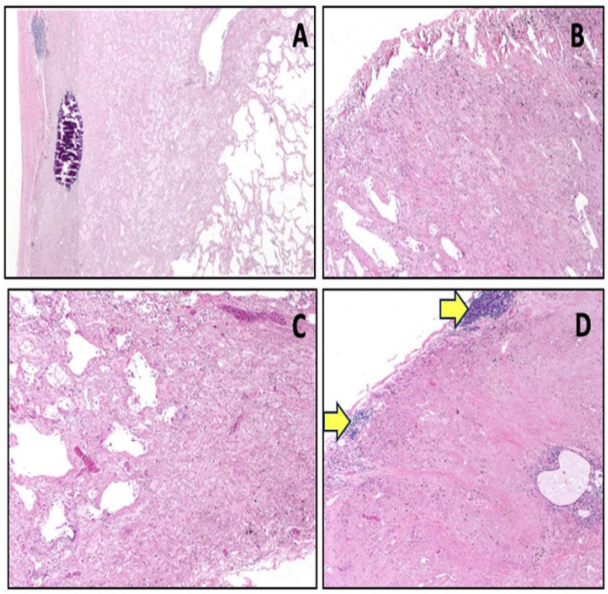

Figure 4) *Biopsies of the right lung were taken during dissection. Panels A-D depict sections of tissue in different areas of the lung stained with hematoxylin and eosin and at low magnification. (A) shows a full cross-section of a pulmonary infarct, (B) shows a second pulmonary infarct, (C) shows a third pulmonary infarct, (D) shows a pulmonary infarct along with areas of chronic inflammation.*

Discussion

As anatomical anomalies were observed, students were prompted to investigate the underlying causes and the impact on the quality of life of the donor. This investigation included literature searches as well as discussion and conversation with anatomists and practicing medical professionals.

Soft tissue sarcomas are rare as a group, and only a subset of those (15%) are found in the retroperitoneum [11]. As these tumors are typically very aggressive, resection is often the preferred treatment [11-13]. While some resection of muscle tissue is done in soft tissue sarcomas in the extremities, they are rarely, if ever, performed when the tumor occurs in the retroperitoneum [11-13]. Chiappa et al. (2018) [12] reviewed the surgical interventions of 83 patients with recurrent retroperitoneal sarcomas. These researchers found that, of the 53 patients (64%) who underwent removal of structures other than the primary tumor, none had any skeletal muscle tissue removed.

Consistent with the paucity of reported skeletal muscle resection due to retroperitoneal tumors, the literature does not reveal any reports of surgical removal of the psoas major and iliacus muscles. As further evidence against the removal of these muscles during resection, there are several downstream clinical implications to consider with this surgical intervention that were observed during this dissection. As the iliopsoas muscle is essential for maintaining posture, walking, running, and other everyday functions, the removal of this muscle group seemingly would have had an incredible impact on the donor's life. She would have likely suffered long-term weakness in the flexion of the thigh, which could be evident in some of the other findings in this dissection [2].

Considering the rarity of these types of tumors and the unlikely resection of muscles in this area, the authors investigated alternative explanations for the observed changes. One possible alternative is that the muscles simply never completely formed due to a congenital abnormality, and the presence of staples is unrelated to the absence of the muscles. While there have been reports of congenital hypoplasia in this area, it typically only involves either the iliacus muscle or the psoas major muscle, and these reports only cite a partial hypoplasia of the muscles as well as hyperplasia of the contralateral muscles [14]. One report of complete unilateral agenesis of the psoas minor, psoas major, and iliacus muscles was discovered [5]. However, the individual in this report only had atrophy and fat infiltration in the ipsilateral paraspinal muscles, but no atrophy reported in the ipsilateral quadriceps muscles as in this donor. There were also no abnormalities with spinal alignment found in this report. Although we cannot rule out complete agenesis of these muscles in this donor, the lack of atrophy in the quadriceps muscles and spinal alignment issues make the cases significantly different. In addition, the agenesis hypothesis does not account for the presence and location of the surgical staples.

The age and presence of other anomalies in the donor lead one to consider extreme age-related atrophy as an alternative explanation for the absence of these muscles. However, literature suggests that atrophy in the group of muscles including the psoas muscles accounts for less than 50% of extreme muscle group atrophy amongst older (>80 yr) individuals. In addition, the literature does not reveal any psoas muscle atrophy that is greater than 37%, suggesting that, if atrophy were indeed the case in this donor, at least some of the muscle would be present and identifiable [15]. This atrophy hypothesis also

does not account for the presence and location of the surgical staples observed in this donor.

Although the rarity of soft tissue tumors and resection of posterior abdominal wall skeletal muscle provide reason to believe the observations in this case are not related to surgical removal, alternative explanations are seemingly more implausible. The presence and location of surgical staples, along with other unique anomalies observed in this donor support the hypothesis of surgical removal in this case.

The paralumbar region, where the psoas muscles are typically located, is the origin for many of the major nerves of the thigh. Specifically, neurons originating from the ventral rami of spinal nerves L2-L4 form both the femoral and obturator nerves, which are responsible for innervation of the anterior and medial muscles of the thigh respectively. For this reason, the removal of the right iliopsoas muscle and subsequent injury of the right lumbosacral plexus likely contributed to the atrophy and fat infiltration of the right anterior thigh muscles, which could have further hampered her mobility.

In addition, the finding of severe scoliosis with evidence of surgical interventions along the lumbar vertebrae could indicate an attempt to correct the scoliosis or be associated with the removal of the right iliopsoas muscle. While the prevalence of adult degenerative scoliosis increases with age due to the asymmetric degeneration of intervertebral discs [16], the removal of the right iliopsoas muscle is a probable explanation for the presence and potential worsening of the lumbar scoliosis observed during dissection given the muscles' role in stabilization of the lumbar spine. Previous studies have found that equal, bilateral contraction of the psoas major muscles maintains a proper, lumbar curve of the spine [17], while asymmetrical contraction and hypertrophy of a unilateral psoas major muscle is associated with idiopathic scoliosis [18]. As such, the removal of the right iliopsoas muscle could likely have caused or aggravated existing scoliosis.

The severe scoliosis in our donor is also a probable contributor to several other gross anatomical and histological findings present. Severe scoliosis can predispose individuals to pulmonary system problems as the lungs can be compressed against the rib cage, which can lead to reduced lung capacity, irreversible lung atrophy, and chronic respiratory failure [19]. In this dissection, multiple pulmonary infarctions were found bilaterally with signs of edema and calcification that may be attributed to a reduced lung capacity caused by severe scoliosis. Additionally, a sliding esophageal hernia was present. This may also be accredited to the severe scoliosis of our donor as adults with severe scoliosis in the lumbar region are more at risk for developing hiatal hernias [19].

Regardless of cause, the donor in this case had multiple anomalies that likely would have had an incredible impact on her quality of life. Previous studies examining long-term effects of scoliosis in women have shown significantly increased levels of psychologic and physical impairment when compared to the population norm [20]. For example, women with idiopathic scoliosis were reported to be unhappier with their lives and have lower self-esteem and higher depression scores than the population norm [21]. In addition, scoliosis has been associated with chronic pain, in which those with scoliosis report pain that is more persistent and progress over time than adults without scoliosis [22]. The mental impacts and chronic pain that can be associated with scoliosis could likely lead to social isolation and limitations to physical activity, affecting someone's quality of life.

Likewise, patients with pulmonary infarctions were found to have higher rates of hemoptysis, dyspnea, pleuritic chest pain, and right

ventricular dysfunction on electrocardiogram [23]. Additionally, esophageal hiatal hernias are strongly associated with refractory gastroesophageal reflux disease (GERD), Barrett's esophagus, and reflux esophagitis, which all can further aggravate dyspnea and chest pain [24]. Those with poor lung health are more likely to experience depression, anxiety, and post-traumatic stress disorder (PTSD) as they may find it more difficult to engage in activities they once enjoyed or be constantly worried about their need for medications and the possibility of their lung condition progressing further [25].

Similarly, the quality of the psoas muscle has been associated with the quality of life of a person. When performing a study in patients after total hip arthroplasty surgeries, Shinonaga et al. found that decreased psoas major muscle mass and quality prior to surgery was associated with decreased quality of life and increased pain [26]. The absence or decreased quality of these muscles can impede the performance of everyday tasks as the psoas major and iliacus muscles play critical roles in maintaining proper posture and mobility. The absence of the iliopsoas muscle could also lead to chronic lower back pain, which has been associated with higher rates of mood and anxiety disorders, kinesiophobia, and decreased physical ability [2,27,28].

As we found evidence that our donor had severe scoliosis, multiple pulmonary infarctions, a sliding hiatal hernia, and a missing right iliopsoas muscle, we can logically assume that her quality of life was significantly diminished considering the cumulative impact of these conditions.

In evaluating the rarity of skeletal muscle absence, authors found that muscles were typically absent due to a congenital abnormality, including syndromes and defects, or resection. One of the most commonly absent muscles is the palmaris longus muscle, which is found to be absent in 10.3% of cadaveric studies [29]. In regard to other muscles, a complete absence is rare. The most common defect is the absence of a pectoral muscle, which is only found in 1 out of every 11,000 nonsyndromic cases [30]. Following this, the next most common, as far as we can tell, is the congenital absence of the inferior rectus muscle, of which only eight cases have been reported [31]. Finally, as was mentioned earlier, there is one report of a complete unilateral agenesis of the iliopsoas muscle [5].

In a search of skeletal muscle resection, we found that the most commonly resected muscle is the medial rectus [32]. The rarity of the presence of a primary malignant soft tissue tumor in the area of iliopsoas muscle is highlighted throughout the literature on resections in this area [33,34], however there are some reported cases of iliopsoas muscle resections for gynecological malignancies [35] and for ossification in scoliosis [36]. Other muscles, such as the deltoid muscle, can also be resected for various reasons, however, the literature is consistent in the mention of how rarely resection of skeletal muscle takes place [37].

Conclusion

This case study highlights the intricate relationship between surgical interventions and anatomical variations and their potential complications and downstream effects. The notable absence of the right psoas major and iliacus muscles, likely resulting from surgical intervention, underscores the profound impact such anatomical adjustments and anomalies can have on a patient's quality of life. The resulting muscle atrophy, severe scoliosis, and associated pulmonary complications not only illustrate the physical consequences of surgical resection but also emphasize the importance of understanding

the interconnectedness of anatomical structures in clinical practice.

Our findings contribute to the existing body of literature by documenting a rare anatomical variation, possibly attributed to a previously unreported surgical resection, which offers insights into the cascading effects of surgical interventions on functional anatomy. As future medical professionals, it is crucial for students to appreciate these complexities, as they have direct implications for patient assessment and treatment planning. This case exemplifies the educational value of donor dissection in bridging theoretical knowledge with practical understanding, ultimately enhancing the foundation for compassionate and informed patient care.

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