Successful coil embolization of a ruptured pseudoaneurysm of the superior gluteal artery after a percutaneous awake robot-assisted sacroiliac joint fusion: illustrative case

Samah Morsi, MD, MSc,1 Alyssa M. Bartlett, MPH,1 Andrew A. Hardigan, MD, PhD,1 Mounica Paturu, MD,1 Shawn W. Adams, MD,1 Malcolm R. DeBaun, MD,2 Waleska Pabon-Ramos, MD, MPH,3 and Muhammad M. Abd-El-Barr, MD, PhD1

Departments of 1Neurosurgery, 2Orthopedic Surgery, and 3Radiology, Duke University Hospital, Durham, North Carolina

BACKGROUND Robot-assisted sacroiliac joint (SIJ) fusion has gained popularity, but it carries the risk of complications such as injury to the superior gluteal artery (SGA). The authors present the case of an awake percutaneous robot-assisted SIJ fusion leading to an SGA pseudoaneurysm.

OBSERVATIONS An 80-year-old male, who had undergone an awake percutaneous robot-assisted SIJ fusion, experienced postoperative left hip pain and bruising. Subsequent arteriography demonstrated an SGA branch pseudoaneurysm requiring coil embolization.

LESSONS An SGA injury, although uncommon (1.2% incidence), can arise from percutaneous screw placement, aberrant anatomy, or hardware contact. Thorough preoperative imaging, precise robot-assisted screw insertion, and soft tissue protection are crucial to mitigate risks. Immediate angiography aids in prompt diagnosis and effective intervention. Comprehensive knowledge of anatomical variants is essential for managing complications and optimizing preventative measures in robot-assisted SIJ fusion.

https://thejns.org/doi/abs/10.3171/CASE2413

KEYWORDS superior gluteal artery; pseudoaneurysm; sacroiliac joint fusion; robot-assisted; percutaneous fixation; arterial embolization

The sacroiliac joint (SIJ) is a complicated joint with many associated ligamentous and neurovascular structures and serves as the critical connection between the spine and pelvis, therefore transmitting axial loads from the lumbar spine to the lower extremities. SIJ dysfunction and degeneration is an increasingly recognized cause of low-back and radicular pain. In addition to degenerative changes, the SIJ can be damaged through trauma or oncolytic processes, all of which can necessitate surgical stabilization. Traditionally, fixation for trauma uses a lateral-to-medial trajectory (i.e., iliosacral screws), whereas oncological or degenerative conditions typically use a medial-to-lateral trajectory (i.e., sacroiliac screws), as these pathologies often require spinopelvic fixation. Recently, there has been interest in more minimally invasive lateral-to-medial techniques for degenerative conditions as well.1

Although minimally invasive techniques are associated with decreased complications such as a reduced risk of revision surgery, less infection, fewer instrumentation complications, and decreased postoperative opioid use, there are important iatrogenic complications that can occur. In SIJ fixation, injuries of the deep superior and superficial branches of the superior gluteal artery (SGA) during the placement of sacroiliac screws have been reported.2–4 In this paper, we report the case of an SGA pseudoaneurysm during percutaneous awake robot-assisted SIJ fusion for the treatment of SIJ dysfunction-related pain. This complication was managed with endovascular arterial embolization. Here, we discuss the cause, prevention, treatment, and future recommendations to avoid SGA injury, along with a review of the literature.

Illustrative Case
An 80-year-old male with a past medical history significant for paroxysmal atrial fibrillation for which he was taking apixaban, anemia, and facet arthritis of the lumbar region presented to our
institution with 10 years of chronic low-back pain rated as an 8 of 10. Although he had moderate improvement in pain after transforaminal lumbar epidural steroid injections (ESIs) at L3–4, L4–5, and the left SIJ, the pain still had a significant impact on his activities of daily living. On physical examination, the patient presented with tenderness to palpation of the left SIJ and positive Faber and Gaenslen tests with no neurological deficits. Diagnostic imaging showed multilevel degenerative changes in the lumbar spine with moderate spinal canal stenosis at L3–4 and moderate to severe bilateral neuroforaminal stenosis at L4–5. Computed tomography (CT) spectroscopy (Fig. 1) revealed increased radiotracer uptake at L5–S1 as well as the left SIJ. Given the increased tracer uptake in the left SIJ and his previous symptomatic improvement after left SIJ ESI, the patient was considered an appropriate candidate for awake robot-assisted SIJ fusion. Of note, the patient ceased taking apixaban 5 days before surgery.

The patient was brought to the operating room, and spinal anesthesia was induced with 0.5% bupivacaine. He was then positioned prone with his arms less than 90° flexion at the shoulders. Needle electrodes were placed in the bilateral lower-extremity musculature for intraoperative neurophysiological monitoring of electromyography. Reference array was placed on the contralateral posterior superior iliac spine. Intraoperative radiographs were obtained and merged with preoperative CT images for instrument navigation. This merged image was then used to plan screws across the SIJ (Fig. 2). A local anesthetic was administered along the planned incision marked out, and a small incision was made. The incision was deepened to the fascia using cautery. Three procedure-specific screws were placed across the SIJ using the robotic navigation system ExcelsiusGPS (Globus Medical), as described in our previous paper. Of note, during placement of the screws, technical issues did not allow us to dock directly on the iliac bone and there was some tissue between the robotic end effector and the iliac bone.

Postplacement fluoroscopy and intraoperative CT (AIRO, Brainlab) confirmed appropriate placement of the instrumentation. The surgical site was irrigated with bacitracin, and closure was completed in a standard multilayered fashion. Intraoperative CT scan without contrast showed streak artifact adjacent to the distal screw but no blood products or intramuscular hematoma within the left gluteal muscles. The patient was discharged home on postoperative day (POD) 1.

On POD 4, the patient presented to the emergency department (ED) with worsening left hip pain and left anterior thigh pain. He did not endorse bowel or bladder dysfunction, numbness, or weakness. A CT scan without contrast showed an intramuscular hematoma in the left gluteal muscles, along with blood products near the distal screw (Fig. 3).

His laboratory results showed low hemoglobin at 10.1 g/dL and hematocrit at 0.297 L/L, indicating anemia. His condition improved with pain medication (acetaminophen 375 mg, hydrocodone-acetaminophen 5–325 mg, as needed) and muscle relaxant (methocarbamol 750 mg). The patient was able to ambulate with a walker and was considered stable for discharge on POD 5. Of note, he was instructed to restart his home Eliquis after POD 7.

On POD 11, the patient again presented to the ED with severe, acute-onset left leg pain and significant bruising from the left hip to the left ankle after feeling a “pop” near his left hip. The patient reported that he had been trying to roll over in bed when the pain...
began. His left leg was cooler to touch compared to the right. During this evaluation, the pain in the left lower extremity caused significant impairment, preventing the patient from standing or ambulating with his walker. Since his most recent presentation, he denied any falls or new focal weakness, numbness, and bowel or bladder dysfunction. Laboratory tests showed significantly reduced hemoglobin at 6.3 g/dL and hematocrit at 0.188 L/L. CT focusing on the lumbar spine without contrast revealed an increased size of the intramuscular hematoma in the left gluteus medius muscle, along with blood products adjacent to the distal screw.

After receiving two units of blood, abdominal CT angiography was performed with and without contrast. It revealed a recurrence of the hematoma and a pseudoaneurysm slightly below the distal screw (Fig. 4A). The iliopelvic vasculature had no evidence of dissection or stenosis bilaterally. The preembolization arteriogram showed a pseudoaneurysm originating from an upper branch of the left SGA and nearby extravasation near the distal screw (Fig. 4A).

Vascular interventional radiology was consulted, and the patient underwent endovascular coil embolization of the left SGA pseudoaneurysm without complication on POD 11. The postembolization arteriogram on the same day revealed successful coil embolization of the pseudoaneurysm and contrast stagnation in the upper gluteal branch, preventing further contrast flow into the pseudoaneurysm (Fig. 4B).

After embolization, the patient’s pain was managed with a self-controlled analgesia pump for 1 day before transitioning to oral pain medication. After consultation with cardiology, apixaban was discontinued in favor of aspirin (81 mg daily), which was restarted on postembolization day 3. The remainder of his hospital course was uneventful. He was evaluated by physical and occupational therapy with a recommendation for eventual discharge to a skilled nursing facility on POD 15 (postembolization day 3). At 1 month post–SIJ fusion, the patient’s pain had improved and was managed by aspirin, although there was persistent bruising from the left hip to the left ankle postembolization.

Patient Informed Consent
The necessary patient informed consent was obtained in this study.

FIG. 4. A: Preembolization selective left superior gluteal arteriogram on POD 11 showing a pseudoaneurysm (white arrow) from a cephalad branch of the SGA and extravasation (black arrowhead) adjacent to the distal screw (not visible in the image). B: Postembolization selective left superior gluteal arteriogram on POD 11 showing coil embolization (black arrowhead) of the pseudoaneurysm and contrast stasis (white arrow) in the cephalad superior gluteal branch that led to the pseudoaneurysm with no progression of contrast into the pseudoaneurysm.
surgical management of SGA injuries, leading to successful outcomes in this case. In our case, the patient experienced an SGA pseudoaneurysm after awake robot-assisted sacroiliac screw insertion because of direct damage from the robotic screw driver during screw placement. This was believed to have occurred because of the lack of a protective sleeve for the screwdriver or because the robot effector was not docked directly on bone and hence the injury was likely attributable to soft tissue dissection or direct injury by the screws or taps. However, radiographically appropriate screw placement was confirmed, and the patient initially recovered well before his presentation requiring endovascular embolization for a ruptured SGA pseudoaneurysm, as described above.

Anatomical Understanding of the SGA and Variants

The SGA is a significant blood vessel that supplies the gluteal region of the body. It arises from the posterior division of the internal iliac artery and typically exits the pelvis through the greater sciatic foramen, superior to the piriformis muscle. Its main branches include the superficial branch, which supplies the gluteal muscles and overlying skin, and the deep branch, which provides blood to the deeper gluteal muscles. It can arise directly from the internal iliac artery or the internal pudendal artery.

Injury to the SGA can occur because of trauma, such as pelvic fractures, penetrating injuries, or surgical complications. The consequences of arterial injury can be severe, leading to significant bleeding and potential ischemia in the gluteal region. Prompt recognition and management of such injuries are essential to prevent complications.

SGA Injury With Trauma Screws: Lateral to Medial

During the insertion of iliosacral or SIJ fixation screws, there is a risk of damaging the SGA and its branches, particularly in the anterior region of the sacral alar area. This can adversely affect the gluteus medius and gluteus minimus muscles, which rely on SGA branches for blood supply. The risk of SGA injury is lower when using S1 intercristal line and S2 transsacral screws versus S1 transsacral screws.

SGA Injury With Degenerative Screws: Medial to Lateral

For degenerative conditions and trauma causing spinopelvic instability and requiring SIJ fixation, screw insertion is typically performed from medial to lateral. Relative to the lateral-to-medial technique, there is limited information available on SGA injuries specifically related to this screw placement technique. This is likely due to the location of the SGA superficial to the lateral aspect of the ilium. Violation of the greater sciatic foramen during sacroiliac screw placement in spinopelvic fixation risks injuring both the SGA and the inferior gluteal artery (Fig. 5). It is also important to consider the potential risks and variations in SGA anatomy. Abnormal anatomy or variations in the SGA can contribute to the risk of injury despite correct screw placement.

Uniqueness of SGA Injury in Degenerative Cases With Lateral-to-Medial Screw Placement

The discussion surrounding the occurrence of SGA injuries specifically in degenerative cases with lateral-to-medial screw placement is limited. With the increased popularity of stand-alone SIJ fusion, further research is needed to explore the prevalence and manifestations of SGA injuries in this scenario to better understand any potential risks and complications.

Prevention of SGA Injury

To minimize the risk of SGA injury, various protective measures have been suggested. In hindsight, immediate consideration of vascular imaging at the initial presentation to the ED on POD 4 may have facilitated early detection and management of the SGA injury associated with iliosacral screw placement. The use of soft tissue protection tools or sleeves during guide pin, drill, tap, and screw insertion has been suggested. Other strategies involve using smaller guide pins initially, locating the insertion site accurately, using slightly broader skin incisions, trocar-tipped drill sleeve systems, and gentle retraction of deep soft tissues. The posterior ilium between the sciatic notch and the iliac crest has been proposed as an ideal location for sacroiliac screw insertion considering the anatomical parameters of the superior gluteal nerve and artery. The use of shading scanners, fluoroscopy-based imaging, three-dimensional C-arm, preoperative CT-based planning, computer navigation, and robot-assisted techniques have also shown promising results in ensuring accurate and safe screw placement while minimizing the risk of SGA injury.

Diagnosis and Treatment of Injuries

Accurate diagnosis is crucial in cases of SGA injury during sacroiliac screw fixation. CT imaging plays a significant role in identifying vascular structures and determining safe zones for screw insertion, thereby reducing the risk of neurovascular injuries. It is important to have a low threshold for performing arterial imaging, such as arteriography. Arterial coil embolization has been preferred for the treatment of SGA injuries, whereas a tamponade with gauze has been shown to be ineffective. Additionally, open exploration and removal of the hematoma have been performed successfully in cases in which significant symptoms, hematoma, and disrupted blood flow were
observed.4–6,9 Alternative treatments for a ruptured pseudoaneurysm of the SGA are illustrated in Supplementary Table 2.19,20

Risk of Robotic Surgery

Our case illustrates a critical incident involving a potential breach in protocol during robotic surgery; specifically, because of software errors, the robotic planning software initially hindered placement of the designated sacroiliac screws (SI-LOK, Globus Medical). Consequently, traditional screws were initially planned; however, during the actual procedure, SI-LOK screws were ultimately utilized. This deviation in screw selection resulted in the robot failing to dock directly on bone, posing a potential risk of vascular injury.

It is important to note that although robot-assisted surgery is generally safe, these risks highlight areas that require careful consideration and ongoing improvement in technology and surgical practices. The reported complication rate directly related to robotic malfunction is very low (approximately 0.1%–0.5%). Rates of permanent injury when robotic errors occur vary from 4.8% to 46.6%.21,22 The risk of robotic surgeries is outlined in Supplementary Table 3.

Lessons

In conclusion, careful surgical planning, accurate screw placement, and the use of protective sheaths are crucial to prevent SGA injury during surgery for degenerative disease of the SIJ. Prompt diagnosis, angiographic investigation, and arterial embolization are essential for effective management of SGA injuries. Surgeons should have a comprehensive understanding of the SGA anatomy and its variants and must be proactive in addressing complications to ensure patient safety during these procedures. Implementing these recommendations can optimize the prevention of SGA damage and ensure safe and effective outcomes for patients undergoing percutaneous sacroiliac screw fixation procedures.

References


Disclosures

Dr. DeBaun reported stock or stock options from Azra Care, NSite, and Resolute; research support from Next Science and DePuy, A Johnson & Johnson Company; consulting for Next Science, Resolute, Shukla, SI Bone, and Synthes; board or committee membership for the Orthopaedic Trauma Association; royalties from Resolute and Shukla; service as a paid presenter or speaker for SI Bone and Synthes; and publishing royalties and financial or material support from Wolters Kluwer Health/Lippincott Williams & Wilkins. Dr. Pabon-Ramos reported personal fees from NXT outside the submitted work. Dr. Abd-El-Barr reported consulting for Globus during the conduct of the study and for Brainlab, TrackX, and Elligue outside the submitted work.

Author Contributions

Conception and design: Abd-El-Barr, Morsi, DeBaun. Acquisition of data: Abd-El-Barr, Morsi, Bartlett, Adams, Pabon-Ramos. Analysis and interpretation of data: Abd-El-Barr, Morsi, Bartlett, Hardigan, Pabon-Ramos. Drafting the article: Morsi, Bartlett, Hardigan, Pabon-Ramos. Critically revising the article: Morsi, Bartlett, Hardigan, Pabon-Ramos. Approved the final version of the manuscript on behalf of all authors: Abd-El-Barr. Administrative/technical/material support: Abd-El-Barr, Morsi, Adams. Study supervision: Abd-El-Barr.
Supplemental Information
Online Only Content
Supplemental material is available with the online version of the article.

Correspondence
Muhammad M. Abd-El-Barr: Duke University Medical Center, Durham, NC. muhammad.abd.el.barr@duke.edu.