



Neurovascular Injury in Hip Arthroplasty

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Neurological and vascular complications following hip arthroplasty are uncommon, and their impact ranges from transient and trivial to permanent and devastating. The proximity of neural and vascular structures makes any operation on the hip potentially hazardous. Direct or indirect injuries of these structures may occur during operative exposure and subsequent procedures. Thus, complete awareness of the anatomy of the pelvis and proximal femur is required. Peripheral nerve injuries can involve either distant sites or nerves in the immediate vicinity of the hip joint. Sciatic nerve injury is the most common nerve injury following total hip arthroplasty. Femoral nerve injury is much less common and is associated with an anterior approach. Its diagnosis is often delayed, but the prognosis is generally better than with sciatic nerve injury. The superior gluteal nerve is at risk during the direct lateral approach. Obturator nerve injury is the least common type of injury and has the least functional consequences. Vascular injuries are less common but more immediately life threatening. The mechanisms of vascular injury include occlusion associated with preexisting peripheral vascular disease and vascular injury during removal of cement during screw fixation of acetabular components, cages, or structural grafts. It is critical to avoid the anterior quadrants for acetabular screw fixation. All acetabular and femoral defects should be bone-grafted to avoid inadvertent cement migration. Following these guidelines, surgeons should be able to offer the most appropriate treatment and counseling to the patients.

Key Words: Hip, Neurovascular injury, Hip arthroplasty

NEUROVASCULAR INJURY IN HIP ARTHROPLASTY

Although neurovascular injury is not a very common complication, once it occurs it can have serious

consequences for both patients and doctors. To prevent neurovascular injury, it is important to have accurate knowledge of the anatomical structures and to recognize anatomical variations that may be encountered in primary operations and re-operations.

NEUROLOGIC INJURY

In general, the prevalence rate of neurologic injury after primary hip arthroplasty is estimated as 0.7-3.5%⁸⁻¹¹, whereas it may increase up to 7.6% after revisional hip arthroplasty^{8,9,12,13}. The most common sites of injury are the sciatic nerves and the peroneal portion; the tibial portion is an additional possible site. Femoral nerve injuries are reported at a rate of 0.1-0.2%, and obturator nerve damage is reported very rarely.

The major etiological causes of neurologic injury are stretching, compression, contusion, laceration, thermal

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injury from bone cement, and vascular compromise during operations. Of these causes, stretching is the most common one and is due to either traction or excessive extension of the pelvic limb. Other risk factors are acetabular hip dysplasia, female gender with below-average height and muscle mass, posttraumatic arthritis, anatomical variations of the nerves, minimally invasive surgical procedures, and revisional hip arthroplasty; however, neurologic injury can occur in the absence of these risk factors. Therefore, it is critical to perform traction operations with caution or to protect the sciatic nerves of high-risk patients in advance via desquamation to prevent nerve injury. Furthermore, if needed, it is also recommended to prevent bone cement leakage and excessive lengthening of the pelvic limbs, and to understand the variability of anatomical structures at every operation. Lastly, it is also necessary to maintain an optimal level of anticoagulant agents to avoid pressure damage due to hematomas.

1. Sciatic Nerve Injury

The sciatic nerves are most susceptible to injury due to the low mobility of the fibular head of the knee joint and the point projected via the sciatic notch from the pelvis. Damage of the fibular parts is more common than that of the tibial parts; in particular, the outer part of the fibular area is known to be damaged more often. Sciatic nerve injury is the most common peripheral nerve damage following hip arthroplasty (79% of all cases of neurologic damage caused by this surgical procedure)^{8-10,14}. The risk factors for this type of injury are as follows: a revisional hip arthroplasty, congenital hip dislocation, antecedent pelvis and acetabular fractures, and excessive extension of the pelvic limbs^{8-10,14}. In particular, extension of the pelvic limbs of more than 2.7 cm damages the tibial part, whereas extension of more than 4.4 cm is a risk factor for sciatic nerve injuries in both fibular and tibial areas.

Direct causes of sciatic nerve injury following hip arthroplasty include direct external injury, lengthening of the pelvic limbs, thermal injury from bone cement, pressure damage due to a hematoma, and traction damage due to dislocation of the femoral region, but in approximately 40% of the cases the cause of injury remains unknown^{15,16}. Of all cases with known causes, lengthening of the pelvic limbs was responsible for 50%, whereas 22% of the cases were related to direct

external injury, and approximately 20% were associated with complications due to bleeding^{15,16}. Because of the prevalence of fibular area damage, it is helpful to double-check if there is inability or impaired ability to raise the great toe or raise the foot from the ankle (dorsiflexion) following surgery; in addition, if patients present edema and tension on the wound along with pain in the pelvic limbs and the hips, it is strongly recommended to check for a hematoma¹⁵.

Prognoses of sciatic nerve injury upon hip arthroplasty vary, and 70-80% recovery (at least to some extent) has been reported, unless patients' pelvic limbs are significantly damaged or amputated.

Schmalzried et al.¹³ investigated patients with nerve injury symptoms after hip arthroplasty and found that most patients fully (or nearly) recovered if they exhibited such symptoms either during or right after the operation, although individuals with serious abnormalities had a very bad prognosis.

Edwards et al.⁸ found that patients with direct damage to nerves have better prognosis than patients with injuries due to extension of the pelvic limbs. Generally speaking, recovery from temporary traction injuries may take several days to weeks, but extreme axonal damage results in no or partial recovery after 1-2 years¹⁷.

2. Femoral Nerve Injury

Femoral nerves branch mostly from 2-4 lumbar nerves in the pelvis and pass through the iliopsoas and the femoral triangle. This is close to the front and inside of the hip, and femoral nerve injury in this area is most common. This area lacks elasticity, which makes femoral nerve more susceptible to extension, hematomas, and surgical procedures. Femoral nerve injury also often occurs during screw fixation in the inner acetabulum. As opposed to the sciatic nerves, excessive use of a retractor is considered as the most important factor responsible for femoral nerve injuries. Paralysis of the femoral nerves can also be caused by other factors such as leakage of bone cement or hip surgery for correction of flexion^{12,14}. In general, femoral nerves are more susceptible when a frontal or anterolateral approach is used for hip surgery.

According to Simmons et al.¹⁸, femoral nerve injury is the second most common injury (13%) and occurs mostly during operation due to the use of a retractor; anatomically, it has been well known that the ligament

of the iliopsoas muscles is not able to protect the pelvic limbs against compression and traction of nerves by a retractor. Furthermore, recovery prognosis of femoral neuropathy is closely related to the injury mechanisms. Femoral neuropathy related to traction by the retractor generally does not recover as fully as that due to compression caused by the retractor. In addition, the authors reported that all patients (n=10) fully recovered from the compression caused by the retractor. Expected symptoms include paresthesia in medial aspect of pelvic limbs and overall pain in the femoral area, and patients should suspect the femoral nerve injury if they experience difficulties in climbing stairs due to weak quadriceps, as well as reduced patellar tendon reflex.

3. Obturator Nerve Paralysis

Paralysis of the obturator nerves is often overlooked since it is difficult to diagnose and does not result in serious functional disorders. Fortunately, its prevalence rate is very low. Symptoms including groin pain, leakage of bone cement, and weakness of adductor muscles may be evidence for obturator nerve paralysis that warrants further thorough medical checkup¹⁹⁾.

4. Gluteal Nerve Paralysis

This mainly occurs if the gluteus medius is opened proximal more than 4 cm for the Hardinge approach; under certain circumstances, gluteal nerve paralysis may result in continuous claudication or dislocation due to weak abductor muscles following an operation²⁵⁾. In particular, the superior gluteal nerve may be damaged during extensive reconstruction of the acetabulum or hip arthroplasty in patients with dysplastic hips²⁶⁾.

5. Neurologic Injury Treatment

Understanding the causes is important when it comes to the treatment of postoperative sciatic and femoral nerve paralysis. If paralysis occurs right after the operation, sciatic and femoral nerve traction should be released immediately in a recovery room by knee flexion. After scrutinizing the appearance of the operation wound site, it is required to investigate whether there is pressure on the sciatic nerves due to a hematoma underneath the wound; it is further recommended to examine the extension of the limbs

using radiography after the operation. Fifty percent of causes of nerve paralysis following hip arthroplasty remains unknown, but it is often sufficient to observe symptoms after the operation if no specific causes are found such as a hematoma underneath the wound or limb extension. Lastly, regular electroneurography is also helpful to anticipate the degree of recovery after surgery.

For nerve paralysis caused by the extension of the pelvic limbs, immediate shortening of the limbs is required, which can be achieved by a substitution with shorter femoral components. If a hematoma underneath the wound is found, urgent decompression of the hematoma is needed. Fleming et al.¹⁵⁾ reported that 4 patients completely recovered only when immediate decompression was provided, although one patient did not recover.

Brown et al.²⁰⁾ addressed nerve paralysis that was due to local pressure, occurred in the middle of traction and was mostly temporary. Almost all such patients completely recovered unless the nerves were directly damaged by a sharp retractor. In addition, the authors reported that immediate decompression may result in a satisfactory prognosis when the pressure is caused by bone cement.

6. Somesthesia-evoked Potential

Peripheral nerve functions can be monitored during an operation via the somesthesia-evoked potential, which is a technique developed to observe nerve injuries in spine surgery. It is also useful for hip arthroplasty, as sciatic nerve paralysis often occurs. Weber et al.¹⁴⁾ performed a somesthesia-evoked potential test in 30 patients who underwent hip arthroplasty, and found that 21 patients showed nerve injury symptoms but only 2 patients eventually developed clinical symptoms. Stone et al.²¹⁾ observed that 12 patients out of 50 had temporary sciatic nerve paralysis, with 3 cases due to positioning a retractor in the acetabular area and 1 case caused by the use of an expanding reamer. Further, 6 patients experienced sciatic nerve paralysis when they underwent femoral overreaming procedures, while 2 other cases were caused by excessive extension of the limbs in the process of recovery. Black et al.²²⁾ stated that even though using the somesthesia-evoked potential is not a perfect option, it is efficient when it comes to price and may be very useful for performing an arthroplasty re-operation, which is accompanied by the risk of sciatic nerve paralysis, as well as in the cases where extension of the pelvic limbs of up to 2-3 cm is expected.

VASCULAR INJURY

The prevalence rate of vascular injury in hip arthroplasty is very low (0.1-0.2%), but such injury has catastrophic consequences, especially if a major blood vessel is damaged¹⁾. It may result in hemorrhage, obstruction and the formation of a false aneurysm. Major sites of vascular injury include the external iliac artery, common femoral artery, and medial and lateral femoral circumflex arteries.

The causes of vascular injury during surgical procedures are as follows: 1) bending back the blood vessels by putting a sharp-edged retractor, 2) direct damage caused by a sharp osteotome or a knife blade, 3) damage caused by an osteophyte during joint manipulation, 4) thermal damage, erosion, and obstruction of blood vessels due to direct contact when inserting bone cement, 5) overreaming of the acetabulum, 6) damage by inserts in the blood vessels, 7) injuries by drills and screws, and 8) damage inside blood vessels during surgical procedures of arthroplasty or pelvic limb manipulation in patients with advanced arteriosclerosis.

Thus, to prevent such injuries, 1) a retractor should be placed adjacent to the acetabular area, not inside the hip, 2) the use of retractors with long sharp-edged ends should be minimized, and 3) holes in the bottom of the acetabulum made during reaming procedures need to be repaired before inserting the acetabular cup. Furthermore, it is particularly important to pay extra attention when inserting screws into the acetabulum and using drills and pins as self-retaining retractors; lastly, it is also critical to prevent penetration of acetabulum inside the hip by placing screws in the hip bones. When using bone cement, thermal damage should be prevented, and leaked bone cement needs to be removed completely to avoid direct pressure. The temperature can be elevated up to 80° C during bone cement coagulation, and tissues in a direct contact with bone cement (<0.5 mm) can be necrotized. Other possible mechanisms of vascular injury include thrombosis of major blood vessels caused by heat and pressure of bone cement, false aneurysms, arteriovenous fistulas, and damage to collateral circulation from previous diseases and treatments.

Since blood vessels are fixed and/or adjacent to the vulnerable bones, and doctors deal directly with skeleton around the hip bones, detailed and accurate anatomical knowledge of the hip bones is essential. The most serious damage causing fatalities occurs mostly to

the iliac and femoral arteries; in such cases, immediate surgical measures should be taken to save patients.

When operating on the hip, in particular the acetabulum, Wasielewski et al.³⁾ suggested using quadrants formed by two lines, one connected to the center line of the acetabulum and the other one vertically separating it, to prevent vascular injuries inside the hip bones. Of these quadrants, the anterosuperior quadrant is the most dangerous. Any injury inside the acetabulum that is located in this quadrant may cause not only the obturator artery and vein, but also the external iliac artery and vein^{2,3)}. Furthermore, bones around this quadrant are thinner at the front than at the back side thus more critical. Therefore, screws in the acetabulum should be placed and fixed in the posterosuperior quadrant; it is possible to fix them in the posteroinferior quadrant but only when screws are shorter than 35 mm. However, it is important to note that the sciatic nerves and the superior gluteal vessel in the posterosuperior quadrant are also subject to injury by screws. In addition, femoral vessels passing through the femoral triangle can also be injured by a retractor.

When it comes to revisional hip arthroplasty, acetabular inserts can be trans-positioned into either the upper area of the hip or inside the hip, thereby placing vessels in more susceptible positions. Thus, surgeons should pay special attention when dealing with such circumstances. If needed, it is very informative to precede surgery with angiography to understand the positional associations between the hip bones, vessels, and inserts, especially when acetabular inserts are trans-positioned into the hip bones. When reaming the acetabulum, no perforation of the inside side of the inner walls should be made; if made, the perforation needs to be repaired prior to insertion of bone cement to avoid damage to the iliac vessels. In addition, it was reported that delayed damage to the iliac vessels was due to the movements of the acetabular inserts⁴⁻⁶⁾. Lastly, Stamatakis et al.⁷⁾ reported that surgical procedures resulted in obstruction of the femoral vein because of a twisted position of thigh in the dislocation.

CONCLUSION

To prevent (or minimize) neurovascular injuries, one of the complications of hip arthroplasty, it is essential to have accurate knowledge of the anatomical structures and to recognize anatomical variations. It is also

important to be cautious during the operation regarding excessive stretching, damage by the instruments, bone cement leakage, and hematoma formation. Furthermore, the fixation of acetabular screws should be performed in the posterosuperior area to minimize neurovascular injuries. Lastly, the possible movement of acetabular implants should also be carefully monitored.

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