The development of a postoperative neuropathy is a rare complication that can be devastating to the patient. In a study of 1210 patients who underwent major pelvic surgery, the rate of postoperative neuropathy was found to be 1.9%. Most cases of postoperative neuropathy are caused by improper patient positioning and the incorrect placement of surgical retractors. To fully understand the pathophysiology of postoperative neuropathy, the nerves that are at greatest risk of injury during gynecologic surgery will be presented through a series of vignettes. Suggestions for protection of each nerve will be provided.

Before embarking on a discussion of postoperative neuropathy, it is important to review a practical working classification of nerve injuries. In Seddon's classification system, there are three types of injury: neurapraxia, axonotmesis, and neurotmesis. Knowing the classification system can aid in counseling patients regarding their prognosis and treatment options.

A mild injury to a nerve may cause a conduction block across a small portion of the affected nerve. This type of injury is called neurapraxia and is caused by external compression to the nerve. This creates a disruption of the blood supply, which damages the nerve. This type of injury affects motor fibers more than sensory fibers. Recovery can take weeks or months and depends on how quickly the nerve fibers can remyelinate the segment that has been damaged.

A more severe injury to the nerve results in damage to the axon of the nerve, while maintaining preservation of the supporting Schwann cells. This type of injury is called axonotmesis and is caused by profound compression or traction on the nerve. Both motor and sensory fibers can be affected as well as autonomic function. Even though the axon of the nerve is disrupted, regeneration is usually complete, because the supporting Schwann cells remain intact. The recovery time for axonotmesis is much longer than neurapraxia.
The most severe injury is a complete interruption of the nerve and supporting structures. This nerve injury is called neurotmesis and is caused by transection or ligation of the nerve. Because both the nerve and supporting structures have been affected, neurotmesis has a poor prognosis for complete recovery. The necessary treatment is usually surgery to reconnect the two nerve ends.2

CASE 1

A 45-year-old Gravida (G) 5 Para (P) 5 (G5P5) presented with stage 3 pelvic organ prolapse. She was scheduled for a robot-assisted laparoscopic sacrocolpopexy. She was placed in dorsal lithotomy position, and shoulder braces were used to keep her from sliding on the table during steep Trendelenburg. As soon as the patient recovered from anesthesia, she complained of right hand numbness. On postoperative day number 1, a wrist drop was noted.

CASE 2

A 24-year-old G1 presented to the emergency room with abdominal pain and was found to be in hypovolemic shock. It was determined that the patient had a ruptured ectopic pregnancy, and she was taken immediately to the operating room. She underwent a laparotomy and left salpingectomy. During surgery, she was in supine position with her arms placed on arm boards. After 5 U of blood, she was stable and taken to the floor for recovery. On postoperative day number 1, she complained of pain and numbness to her left hand. On examination, there was significant weakness to the left lower arm and hand.

BRACHIAL PLEXUS INJURY

Case 1 and 2 represent two different mechanisms for developing a brachial plexus injury. The brachial plexus is made up of nerves from C5 to T1. These nerves course beneath the clavicle after branching out from the spinal cord. They then enter the arm medial to the humeral head. Usually the nerve plexus is protected by these bones. However, the structural relationship between the two can make the nerves more susceptible to stretch or compression injuries against the hard surface of the bone.

In the operating room, brachial plexus injuries can occur from several etiologies. The first is from the use of shoulder braces as seen in case 1. Often shoulder braces are used during laparoscopic surgery to prevent the patient from sliding on the operating room table (Fig. 1). This is a common issue when the patient is placed in steep Trendelenburg position. When shoulder braces are used, correct placement is important to prevent injury. If the shoulder brace is placed too lateral while the patient is in Trendelenburg position, a stretch injury can occur. Upward force on the shoulder by the brace is opposed by a downward gravitational force on the patient. These two opposing forces cause the brachial plexus to be stretched. General anesthesia tends to enhance this injury by creating increased joint mobility, especially when muscle relaxants are used. The shoulder brace also can cause an injury when placed too proximal to the neck. This causes a compression injury, because the brace presses the brachial plexus against the first rib.4

Correct placement of shoulder braces can help decrease the risk of a postoperative brachial plexus injury. The brace should be placed over the acromioclavicular joint, thereby avoiding a location that is too medial or lateral on the shoulder. Even with perfect positioning, however, a nerve injury can still occur. Finding an alternative to using the shoulder brace is a better option in reducing the risk of brachial plexus injury.
Some physicians use bean bags or gel pads. Another alternative is using an egg crate foam mattress pad on top of the operating room draw sheets (Fig. 2). When placed against the patient’s bare back, the drag coefficient, created by the weight of the patient and the pad, prevents the patient from slipping on the table during steep Trendelenburg.

Another situation where a brachial plexus injury can occur is demonstrated in case 2. Improper positioning of the upper extremities on arm boards places the patient at increased risk for a brachial plexus injury during surgery. The brachial plexus is at risk for a stretch or compression injury, as it runs caudal to the humeral head. This can occur if for an extended period of time the arm is abducted greater than 90° from the body (Fig. 3). Inspecting the position of the arms on the arm boards before each surgery can reduce the risk of a brachial plexus injury. The arm boards may have been placed by the anesthesiologist or operating room staff and could be overlooked by a busy surgeon. An alternative to arm boards would be to tuck the arms at

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**Fig. 1.** Incorporation of shoulder braces during steep Trendelenburg. (Courtesy of Amber D. Bradshaw and Arnold P. Advincula; with permission.)

**Fig. 2.** Operating room set up with egg crate foam mattress padding on top of draw sheet. (Courtesy of Amber D. Bradshaw and Arnold P. Advincula; with permission.)
the patient’s side. Optimal positioning for tucking the arms will be addressed later. The symptoms of brachial plexus injury are variable. They range from slight numbness and tingling in the arm to the inability to move the arm. A characteristic wrist drop also may be observed.

CASE 3

A 46-year-old G1P1 presented with menorrhagia and a large fibroid uterus. She underwent a robot-assisted total laparoscopic hysterectomy and was placed in dorsal lithotomy position with her arms tucked at her sides. The surgery was prolonged due to the size and number of uterine fibroids. As the surgical drapes were removed, it was noted that the patient’s left arm had slipped out of the tucked position and was resting on the metal rail of the operating room table. As the anesthesia wore off, she complained of numbness and weakness of the fourth and fifth fingers of her right hand.

ULNAR NERVE INJURY

The patient in case 3 represents an ulnar nerve injury. The ulnar nerve is located in the olecranon groove as it crosses the elbow. This groove is located posteriorly between the medial condyle of the humerus and the olecranon process of the ulna. In the olecranon groove, the ulnar nerve can be susceptible to injury, as it is only covered by minimal soft tissue. Compression of the ulnar nerve can occur in the operating room from incorrect positioning when the arms are tucked at the patient’s side or when they are placed on arm boards. The risk of compression is related to how the lower arm is placed when in these positions. In particular, pronation or supination of the forearm is important depending on which position is used.

During laparoscopic surgery, a patient’s arms often are tucked at the sides. This allows the surgeon to stand further up the table. Incorrect positioning of the forearm, when the arms are tucked, can lead to a compression injury of the ulnar nerve. When the forearm is supinated, the olecranon process is located posteromedially. This supinated position places the ulnar nerve at the greatest risk of injury. If the drapesheet loosens and the arm migrates down against the edge of the operating room table, the ulnar nerve can be compressed. For this reason, it is important for the surgeon
to make sure that the forearm is in the pronated position before the arm is tucked at the patient’s side (Fig. 4). This position will rotate the olecranon groove both outward and lateral, protecting the ulnar nerve from compression against the operating room table. Foam padding also can be placed at the elbow before the arms are tucked to add extra protection to the ulnar nerve.

Another situation where the ulnar nerve is at risk is during laparotomy. For an abdominal procedure, the patient’s arms are usually placed on arm boards. Below the elbow, the ulnar nerve is unprotected and at risk for injury by incorrect positioning of the forearm on an arm board. If the forearm is pronated on the arm board, the ulnar nerve can be compressed between the arm board and the bony floor of the cubital tunnel. To decrease the risk of nerve injury, the surgeon should ensure the forearm is supinated before being placed on the arm board. Again, padding around the elbow can be used to protect the ulnar nerve from compression.

An ulnar nerve neuropathy presents with paresthesia of the fourth and fifth digit and the ulnar third of the hand. If the motor component of the nerve is affected, a claw hand may develop. This is caused by the fourth and fifth digits being hyperextended by the unopposed long extensors and the second and third digit being hyperflexed by the unopposed long flexors. Atrophy of the interosseous muscles also can occur.5

CASE 4

A 65-year-old G5P5 presented with stage 3 pelvic organ prolapse. She underwent a total vaginal hysterectomy, uterosacral ligament suspension, and anterior and posterior colporrhaphy. During the surgery, she was placed in the dorsal lithotomy position in candy cane stirrups. On postoperative day number 1, she complained of weakness in her lower extremities and had difficulty getting out of bed or climbing stairs.

CASE 5

A 45-year-old G2P2 presented with a history of stage 4 endometriosis and pelvic pain. She underwent a total abdominal hysterectomy, bilateral salpingo-oophorectomy, and lysis of adhesions through a Pfannenstiel skin incision. A self-retaining retractor was used for exposure. On postoperative day number 1, the patient complained of paresthesia over the medial aspect of the right thigh and knee. She also exhibited a weakness in her right leg.
FEMORAL NERVE INJURY

Case 4 and 5 represent two mechanisms for sustaining an injury to the femoral nerve. The largest branch of the lumbar plexus is the femoral nerve. It courses between the psoas and iliacus muscles in the abdomen. After coursing underneath the inguinal ligament, it then enters the thigh. This anatomy makes the femoral nerve susceptible to injury at several points along its course.

During a laparotomy, self-retaining retractors often are used for exposure. The incidence of femoral nerve injury with self-retaining retractors has been reported to be 7% to 12%.6 The femoral nerve is at risk for compression from the retractor blades in two ways. The first is from the retractor blades resting directly on the psoas muscle. This compresses the femoral nerve as it passes underneath the psoas. The risk of compression increases when excessively long retractor blades are used. Thin patients are at a greater risk because of a shorter distance between the anterior abdominal wall and the psoas muscle. A second way self-retaining retractor blades can cause compression of the femoral nerve is from directly retracting the psoas muscle laterally. If this occurs, the femoral nerve is compressed between the retractor blade and the boney pelvic sidewall. This type of injury is more likely with a large Pfannenstiel skin incision, because it allows more lateral placement of the retractor blades.6 It is important for the surgeon to carefully consider the retractor he or she uses during abdominal surgery. If a self-retaining retractor is used in a thin patient, the shortest blades that accommodate the patient’s anterior abdominal wall should be employed. Also, rolled laparotomy sponges should be placed between the retractor and the abdominal wall. This creates more space between the retractor blade and the psoas muscle. If the surgery becomes lengthy, releasing the retractors intermittently can reduce the risk of compression to the femoral nerve. An alternative to traditional self-retaining retractors are disposable self-retaining retractors. These retractors provide uniform exposure without the use of blades. Thus there is no risk of compression to the femoral nerve.7

The femoral nerve also can be injured during lithotomy position in candy cane stirrups as in case 4. This is caused by excessive hip flexion or extreme abduction and external rotation of the thigh (Fig. 5). These positions cause the femoral nerve to be angulated and compressed against the inguinal ligament. The longer the patient is in these extreme positions, the more likely an injury is to occur. Compression of the

Fig. 5. Hyperflexion of hips while in candy cane stirrups. (Courtesy of Amber D. Bradshaw and Arnold P. Advincula; with permission.)
femoral nerve also can be caused by surgical assistants leaning against the patient’s inner thigh during surgery. To reduce the risk of femoral neuropathy, it is important for the surgeon to check the patient’s lower extremity positioning when placing a patient in candy cane stirrups. The surgeon should make sure the thigh is not overly abducted or rotated and that the hip is not hyperflexed beyond 80° or 90°. It is also important to educate surgical assistants about the danger of leaning on the patient’s lower extremity during retraction.

A femoral neuropathy can cause paresthesias of the thigh and leg and an inability to flex at the hip or to extend at the knee. It also can cause a decreased or absent patellar reflex. Postoperative classic symptoms are falling when trying to get out of bed and the inability to climb stairs.

CASE 6

A 42-year-old G4P4 presented with menorrhagia refractory to medical management. She underwent a total vaginal hysterectomy and was placed in dorsal lithotomy position in candy cane stirrups. After the procedure, she was noted to have a foot drop and paresthesia of the lateral lower leg and dorsum of the foot.

COMMON PERONEAL NERVE INJURY

The patient in case 6 represents a common peroneal injury. The common peroneal nerve courses laterally across the knee joint before it wraps around the fibular head to enter the lower leg. With its close proximity to the bone and little superficial protection, the common peroneal nerve is vulnerable to injury. Compression of the common peroneal nerve can occur in the operating room from incorrect positioning when candy cane stirrups are used. If the patient’s knee and lower leg are allowed to press against the hard surface of the candy cane stirrups, the common peroneal nerve can be pressed against the fibular head. It is important to inspect the lower leg when the patient is placed in candy cane stirrups. The knee or lower leg should not be in contact with the stirrup. Padding of the knee also can be used for extra protection against injury.

An injury to the common peroneal nerve can cause a paresthesia of the lateral lower leg and dorsum of the foot. If the motor fibers are affected, weakness of the ankle extensors and foot dorsiflexors can occur. This may cause a characteristic foot drop.

CASE 7

A 34-year-old G3P3 presented with dysmenorrhea and was found to have adenomyosis on magnetic resonance imaging (MRI). She underwent a total abdominal hysterectomy through a Pfannenstiel skin incision. At the time the fascia was closed, it was noted that the incision extended laterally beyond the rectus muscles. On postoperative day number 1, the patient noted a sharp pain at her incision that radiated to the pubic bone. She also noted a numbness of her mons pubis and labia majora.

ILIOHYPOGASTRIC AND ILIOINGUINAL NERVE INJURY

Case 7 illustrates an injury to nerves within the abdominal wall. The iliohypogastric and ilioinguinal nerves arise from T12-L1 and are at risk for injury during abdominal surgery. These nerves run laterally through the head of the psoas muscle and penetrate the transversus abdominis muscle before entering the anterior abdominal wall. These nerves are usually not injured during gynecologic surgery unless a Pfannenstiel skin incision is brought laterally beyond the edge of the rectus abdominis.
muscles. This wide incision puts the edge of the fascia in close proximity to these nerve branches. Damage to the nerve can occur from direct injury, incorporation during the fascial closure, or scar tissue formation after surgery. To decrease the risk of injury to the iliohypogastric and ilioinguinal nerves, the width of the Pfannenstiel incision should be kept within the rectus abdominis muscles. If the surgeon finds more exposure into the abdomen is needed, a Cherney or Maylard incision can be used. Performing these procedures laparoscopically also will decrease the risk of this nerve injury. During laparoscopic surgery, trocar sites are typically placed away from these nerve branches. Symptoms of an iliohypogastric or ilioinguinal nerve injury are a sharp pain and a burning sensation at the incision. There also can be a paresthesia over the mons pubis, labia, or inner thigh.

CASE 8

A 40-year-old woman presented with pelvic pain and a history of stage 4 endometriosis. She had failed multiple medical therapies and underwent an abdominal hysterectomy with resection of endometriosis, enterolysis, and ureterolysis. On postoperative day number 1, the patient complained of groin pain and numbness over her anterior thigh.

GENITOFEMORAL NERVE INJURY

The genitofemoral nerve arises from L1-2. It runs on top of the psoas muscle before splitting near the inguinal ligament. Because of the location of the genitofemoral nerve relative to the psoas muscle, it is also at risk for a compression injury during laparotomy. Compression of the genitofemoral nerve can occur when using self-retaining retractors. To reduce the risk of this nerve injury, the same precautions can be taken that were noted earlier when the femoral nerve was discussed. Another cause of injury to the genitofemoral nerve is inadvertent transection during a retroperitoneal dissection. A genitofemoral nerve injury can result in a paresthesia over the anterior thigh below the inguinal ligament. Groin pain also can occur.

CASE 9

Six years after a total vaginal hysterectomy, a 46-year-old G6P6 presented with symptomatic pelvic organ prolapse and stress urinary incontinence. She underwent a sacrospinous ligament suspension, anterior and posterior colporrhaphy, and transvaginal tape procedure. The patient was placed in dorsal lithotomy position in candy cane stirrups. After the procedure, she complained of paresthesias of the anterolateral thigh.

LATERAL FEMORAL CUTANEOUS NERVE INJURY

The lateral femoral cutaneous nerve arises from L2-4 and courses over the iliacus. It then runs underneath the inguinal ligament near the anterior superior iliac spine. This nerve can be injured in the operating room during lithotomy position. A compression injury can occur from excessive flexion of the hip. Checking the lower extremity position before surgery will help resolve any excessive flexion of the hip. An injury to the lateral femoral cutaneous nerve causes a sensory loss over the anterolateral thigh from the inguinal ligament to the knee.
SUMMARY

Postoperative neuropathies are rare but serious complications of surgery. Most nerve injuries occur from incorrect patient positioning or placement of self-retaining retractors used in the operating room. Understanding the anatomy of the nerves and how this neuroanatomical relationship can contribute to a compression or stretch injury is important to prevent this complication. Before each surgery, the surgeon should always check the position of every patient’s upper and lower extremities. It is also important for the surgeon to choose the right retractor for the patient’s anatomy. When these steps are followed, the risk of postoperative neuropathy will be decreased, and patient safety will be significantly improved.

REFERENCES