The Supine, Sitting, and Lithotomy Positions

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Introduction

Positioning is a critical component of the operation in any neurosurgical case. Inadequate positioning can impede access to the site of interest, limit the surgeons view, or injure the patient. On the other hand, appropriate positioning can facilitate the efficient completion of an operation, divert blood to optimize visualization, and protect the patient from injuries such as pressure ulcers or neuropathies. In this chapter, the authors discuss sitting, supine, and lithotomy positions. Indications for each position will be discussed, along with advantages and drawbacks of each position.

The Sitting Position

The sitting position for neurosurgical procedures was first described by De Martel in 1931 [1]. It has seen variable popularity over the intervening years, and controversy continues in the literature to this day. While it certainly has its advantages, it presents many challenges to the operative team and has the potential for significant complications for the patient. While commonly used for posterior fossa cranial surgery, it is also useful in certain spinal operations. On the whole, though, its use has been in decline [2].

Positioning the Patient

After induction of general anesthesia and placement of appropriate lines, monitors, and catheters, the patient is positioned in a Mayfield head holder. The AORN recommends use of a lateral transfer device and for multiple caregivers to work together to place the patient into position [3]. The table is then raised slowly to bring the patient into a sitting position. It is recommended to perform this change in position over several minutes to avoid major hemodynamic shifts, as patients have depressed cardiovascular reflexes under general anesthesia [4, 5]. The neck is then secured in a neutral and slightly flexed position [6]. The severe flexion needed for posterior fossa cranial surgery is not necessary in the case of sitting posterior cervical surgery. The Mayfield clamp is secured to a cross bar which is anchored to the operative table. Care is taken to ensure that the patient's hip and knees are not excessively flexed and that prominences are carefully padded. The arms are

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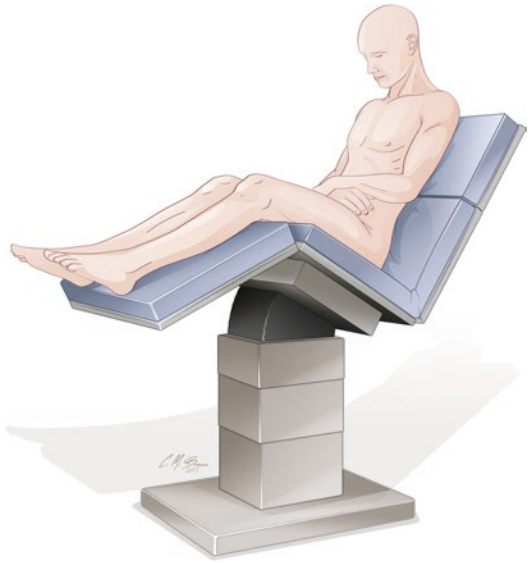

Fig. 11.1 The sitting position (illustration credit: Christopher Brown)

secured on arm boards and accessible to the anesthetist. The fluoroscope is then positioned with the base at the foot of the bed. Figure 11.1 illustrates the patient in the sitting position.

Procedures Performed

The most common spinal procedure performed in the sitting position is the cervical laminotomy or laminectomy, though some groups have reported performing thoracic laminectomies, as well [4–12]. Decompressive surgery for radiculopathy has been widely reported with a large number of patients [6, 11], and tumors can also be resected in the sitting position [13]. There is a single case report about a combined anterior and posterior reconstruction in the sitting position [5].

Anesthesia and Monitoring

Induction of anesthesia for surgery in the sitting position should follow the anesthesiologist's routine, with the same attention to neck positioning as other cervical operations. If intraoperative neuromonitoring is to be used, then total intravenous anesthesia will be necessary. Careful attention should be paid to hemodynamic status during positioning. Patients with poor autoregulation may be especially susceptible to drops in blood pressure during this phase [10]. Venous pooling in the lower extremities also limits venous return and may lower cardiac output [3, 10, 14].

Standard hemodynamic monitoring, electrocardiogram, noninvasive and invasive blood pressure, capnography, and oximetry are employed in all cases. Monitoring for air embolus is mandatory during sitting position surgery, given the catastrophic nature of this complication [2, 7, 11, 14–16]. The ASA does not provide a specific guideline for what kind of monitoring to use, but the literature contains considerable information to help practitioners make this decision. The use of precordial Doppler was first described by Michenfelder et al. in 1972 [16]. This provides a characteristic auditory signal to the entry of air into the heart. Recent analyses have indicated this to be a highly sensitive way to detect air emboli—Standefer et al. indicate that it detected 91% of air emboli in their population [12], though others place the detection rate closer to 50% [4]. Even more sensitive than Doppler is intraoperative transesophageal echocardiography (TEE). This technique was first described by Cucchiara et al. in 1984, and they described the ability of TEE to detect as little as one air bubble in the cardiac chambers, and point out that TEE provides excellent spatial localization of the air, which Doppler is unable to provide [15]. Ganslandt et al. found that a much higher incidence of air embolism in a group monitored with TEE than they did with the Doppler [4]. Many groups also recommend preoperative evaluation for a patent foramen ovale to avoid paradoxical air emboli [8, 15, 17].

Advantages

The sitting position does create certain advantages for the surgeon—it places the head above the heart and can enhance venous drainage, leading to lower intracranial pressure, which is particularly important for posterior fossa tumor operations [7, 12]. This also decompresses the

epidural venous plexus, which may decrease epidural bleeding. For cervical spine surgery, allowing the shoulders to drop out of the way affords better visualization on fluoroscopy, and upright alignment is very evident [18]. It also allows drainage of blood and CSF out of the field by way of gravity, thus providing superior visualization of the operative field [7, 12, 18]. Furthermore, this position is much better tolerated by obese patients with regard to ventilation than is the prone position. The anesthesiologist also has easy access to both arms in case of problems with intravenous access or need for more lines.

Complications and Disadvantages

Air Embolism

Perhaps the most feared complication of sitting position surgery, air embolism carries with it the potential for catastrophic injury to the patient. Much has been written about this complication and how to manage it. There is variability in reporting, and the incidence may vary from as little as 1.6% to as high as 76% [4, 6, 12, 13, 15, 17, 19]. Part of the variability is due to differences in monitoring technique, but there is also variability in reporting. Some publications report all air emboli whereas others report only those that are "clinically significant"—the definition of which varies. The Tübingen group has published a grading scale in the hopes of standardizing the way that air emboli are reported and discussed in the literature with an emphasis on the patient's clinical status [7].

There does seem to be a difference between posterior fossa cranial operations and cervical spine operations with regard to the incidence of air embolism, with much less frequent air embolism in cervical operations—as low as 0.7% in the population of Himes et al. [8], 2.3% in the study by Zeidman and Ducker [11], and Standefer et al. found that there were a very small number of patients who had cervical laminectomies among their population of patients with significant embolic events [12]. Likely, this difference is accounted for by the fact that no large venous sinus is encountered in cervical surgery as opposed to posterior fossa operations. No group reported ischemic sequalae following air embolus detection intraoperatively, and it may be that small amounts of air pass frequently into the circulation but clinically have no effect [8].

Quadriplegia

Midcervical quadriplegia is an exceedingly rare but reported complication after sitting position surgery. It was first reported by Hitselberger and House in 1980 in the setting of acoustic neuroma surgery [14] but has since been reported again [20, 21]. The theorized mechanism is stretched on the cervical spinal cord when the neck is flexed may cause impaired autoregulation of spinal cord blood flow. Combined with the already reduced cardiac output in the setting of general anesthesia and the hemodynamics of the sitting position, the spinal cord may see significant ischemia, especially during prolonged surgery [22]. The spinal cord may elongate up to 2.8 cm from full extension to full flexion [21], and overlying cervical stenosis may contribute to constriction of the arteries.

Peripheral Neuropathies

Sciatic and peroneal neuropathies have been reported after surgery in the sitting position. Bilateral sciatic neuropathy in a patient who underwent surgery in the sitting position was described by Wang et al. and is only the fourth reported case of sciatic neuropathy causing weakness of plantarflexion, all of which occurred after prolonger operations [23]. Peroneal neuropathy causing a foot drop is more common, though still occurs less than 1% of the time after sitting position surgery, and patients are able to recover function with time and therapy [10, 23, 24]. Patient factors that may increase the risk of peripheral nerve injury include a low BMI, old age, smoking, and pre-existing peripheral neuropathies [23]. Careful padding and patient selection can aid in minimizing this complication.

Face and Tongue Swelling

Tattersall reports a case of massive facial and tongue swelling that necessitated reintubation and a prolonged stay in the ICU, culminating in

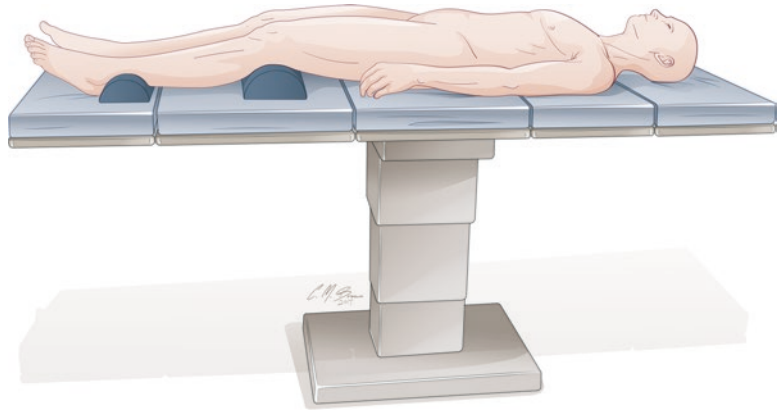

Fig. 11.2 The supine position (illustration credit: Christopher Brown)

patient death [25]. This was suspected to be due to excessive flexion of the neck which caused venous hypertension and ultimately thrombosis with no drainage of the head. Porter et al. recommend use of a small diameter echo probe and the avoidance of a rigid oral airway to minimize the risk of this complication [10].

Ergonomics and Learning Curve

The sitting position places a great deal of strain on the surgeon, who must keep his arms elevated for the duration of the surgery. This necessitates the surgeon to either work quickly or formulate a sterile solution upon which to rest his arms. Surgeon fatigue can lead to errors and potential complications. The learning curve for sitting position surgery can be significant for the operative team. Because this position is not commonly used, the first few cases will require extra time to get the patient safely into position. Repetition, however, will build competence and comfort for the team with the sitting position. Similarly, the anesthesiologist must be comfortable with the patient in this position and the accompanying changes as outlined above.

The Supine Position

The supine position is one of the most commonly used positions in neurosurgery and many other surgical subspecialties. Its ubiquity makes it straightforward for the operative team, but there are precautions that must be taken to prevent injury to the patient.

How to Position the Patient

The supine position is illustrated in Fig. 11.2. The patient may move onto the operating table under his or her own power if able, or he or she may be moved by the operative team. The AORN recommends the use of a lateral transfer device in the latter case, with at least four people (including the anesthesiologist) to assist with the transfer [3]. A pillow should be placed under the patient's knees to avoid any strain on the hamstrings and back muscles. The head should be on a headrest. The heels should be elevated or sufficiently padded with foam to avoid pressure ulcers. Some institutions may also pad the sacrum. A safety belt should be placed approximately two inches above the knees to protect the patient from falling off of the table [26]. If the arms are to be abducted on arm boards, care should be taken to avoid abducting the arms more than 90° to lower the risk of brachial plexus injury [3, 27]. If arms are to be tucked at the sides, the AORN recommends against "tucking" by wrapping the sheet around the patient's arm and securing it under the table, but rather supports "papoosing" the patient by wrapping the sheet around the patient to secure the arms [3]. If securing the patient's arms at the sides, care should be taken to pad all prominences at the elbow and wrist and pad the intravenous lines against the skin. The draw sheet should extend above the elbows [3, 26]. The IV lines should be carefully checked to ensure they are still running, as tubes can get kinked during arm positioning.

Depending on the patient's size and spinal levels of interest, there may be a need to push the

shoulders down with a brace or with tape to obtain better exposure of the lower cervical spine for fluoroscopy. In myelopathic patients, care should be taken with neck position and neck manipulation during anesthetic induction. The need for cervical traction is determined by the surgeon on a case-by-case basis. The neck should be placed in slight lordosis to maintain the anatomic alignment after fusion.

Procedures Performed in the Supine Position

The supine position is ideal for anterior cervical exposure for discectomy or corpectomy. The surgeon can access almost the entire cervical spine from the anterior exposure. Access to the C2-C3 level may be somewhat limited by the mandible. One group from Japan places the patient in extension and rightward rotation to move the mandible out of the way, but has found that this can affect the extent of decompression and place the vertebral artery at risk of injury [28]. Anterior odontoid screw fixation is also best accomplished in this position. The supine position also allows for anterior lumbar spine exposure. This often requires the spine surgeon to work with a general or vascular surgeon for access to the surgical site.

Anesthesia and Monitoring

Induction of anesthesia is relatively straightforward and can follow the attending anesthesiologist's routine. Total intravenous anesthesia is used if intraoperative neuromonitoring is to be utilized. Great care should be utilized in myelopathic patients or patients with unstable cervical spine injuries, in whom intubation should be carried out either while the patient is awake and/or with minimal neck manipulation. Light wand and GlideScope™ are optimal tools to use for intubation in the setting of myelopathy. Standard monitoring should include EKG, pulse oximetry, capnography, noninvasive blood pressure, and invasive blood pressure at the discretion of the anesthesiologist. Monitoring of motor and somatosensory evoked potentials and electromyography should be used at the discretion of the surgeon. For anterior lumbar operations, in which the iliac arteries and veins are retracted, use of lower extremity oximetry may be used at the discretion of the surgical team [29–31].

Advantages

The supine position is common and thus easy for the surgical team. This also allows for the patient to be positioned relatively quickly (in contrast to the sitting position, which can add considerable time to the positioning portion of a case). The anesthetic is also usually straightforward in the supine position though very obese patients or patients with significant pulmonary disease can have some difficulty with ventilation in this position [3]. The supine position is also ergonomically familiar and comfortable for the surgeon and surgical technician.

Disadvantages and Complications

Visualization

Adequate visualization can be difficult in the supine position, especially in large patients. The fluoroscopic image is significantly limited by the patient's shoulders in the lower cervical spine. This creates a hazard when localizing and requires the surgeon take extra steps to ensure that the correct level is exposed. Seeing into the operative field is also difficult in large patients, especially if the chest is prominent, creating limited working space between the chest and the chin. Limited light and a long reach for instruments can make the surgery both more technically challenging and raise the risk of complications for the patient.

Working angles can be a challenge for hardware placement at the extremes of the cervical spine. At C3-4 (and indeed at C2-3), the chin and mandible can create difficulty with appropriately angling fixation screws for the anterior plate. Similarly, at C7-T1, the manubrium can create difficulty with placing hardware. In a patient with a large chest, obtaining the correct angle for an odontoid screw can be particularly challenging.

Venous Congestion

Lying flat allows redistribution of venous blood to the head and neck and can engorge the epidural venous plexus. In contrast to the sitting position, where there may be little to no epidural bleeding, this can be much more significant in the supine position. Furthermore, if a chin strap is used for cervical traction, this can further worsen venous congestion by compressing the jugular vein. Congestion can be somewhat mitigated by placing the patient in a slight reverse Trendelenburg position.

Patient Anatomy

In the setting of a patient with a very steep sacral slope, it may be difficult or impossible to access the L5-S1 disc space to perform an anterior discectomy and fusion. In such cases, it may become necessary to use the lithotomy position (to retrovert the pelvis) or use an alternative procedure. Patients with previous shoulder operations or pre-existing shoulder conditions may suffer from worsened shoulder discomfort or stiffness after prolonged taping of the shoulders.

Neck Positioning

In anterior cervical operations with significant stenosis, the patient may develop monitoring changes if the neck is extended to create lordosis. In such a case, the neck should be kept neutral or moved back into the last position with intact evoked potentials until the spinal cord is adequately decompressed, then lordosis can be created intraoperatively by removing bolsters under the head.

Peripheral Nerve Injuries

The brachial plexus is particularly vulnerable in any surgery where the arm may be abducted or the shoulder manipulated. This is because of its long course, relatively superficial position, and the fact that it is anchored at two fixed points—the spine and the axillary fascia as it passes into the arm [32]. The plexus also contacts the clavicle, first rib, and the head of the humerus along its course, all of which can cause stretch or compression on the plexus [32]. Uribe et al. describe brachial plexus injury after spine surgery in their population, with 44 of 514 patients suffering from brachial plexus injuries after being in the supine or lateral position. Fortunately, most patients recover completely and only a very small fraction have deficits persisting beyond 3 months [32]. Ben-David and Stahl similarly found in their population of patient with postoperative brachial plexus injuries that most patients recover full within 3 months and that a small proportion have a persistent deficit beyond that time period, but they noted that even patients with a persistent deficit tend to show continued functional improvement [33]. The mechanism of injury is likely prolonged stretch and/or compression along the course of the brachial plexus, especially in cases where the shoulders are taped down aggressively for visualization or if the arms are abducted beyond 90 degrees [3, 27]. Under general anesthesia, the normal defensive muscle reflexes and the ability to move the arm into a more comfortable position are absent, creating a situation in which nerve injuries are more likely [32].

The ulnar nerve, with its relatively superficial course, is also susceptible to injury due to malposition of the arm. The ASA recommends taking care to pad the elbow and keep the arm in a neutral position if tucked/wrapped or to keep the arm in a supinated or neutral position if placed on an arm board [27]. There is less concern regarding the radial and median nerves, as these are relatively protected by muscle along their respective courses, though the ASA does recommend taking care to avoid putting pressure on the spiral groove of the humerus [27].

The Lithotomy Position

Though the lithotomy position is uncommonly used in the neurosurgical world, it is useful to access the pelvis and perineal region and thus often used in urology, gynecology, and colon and rectal surgery. The lack of familiarity with this position can be a major challenge for operative teams, but it can be highly useful for select indications.

How to Position the Patient

The process of placing the patient in the lithotomy position begins with the patient supine on the operating table for induction. The legs are

then elevated, abducted, and placed in stirrups for support [34]. The patient is moved so that the buttocks are on the end of the table. The legs are elevated such that the pelvis can be retroverted. It is recommended to position the legs slowly and simultaneously, with support on both the foot and the lower leg [34]. The bottom section of the table should only be lowered after the legs are secured. Padding should be placed under the sacrum to prevent lumbosacral strain. Care should be taken to avoid excess pressure on the popliteal region and the heels should be padded to prevent pressure ulcers [3]. The arms are placed on arm boards and abducted less than 90 degrees. The patient should be secured to the table with a safety strap and/or tape. If any Trendelenburg posture is used, some authors recommend the use of a soft shoulder brace to prevent the patient from sliding cranially [35]. When taking the patient out of lithotomy position, the lower section of the table should be raised before the legs are removed from the stirrups, and they should be removed simultaneously and extended fully before lowering onto the table [34]. Figures 11.3 and 11.4 illustrate this position.

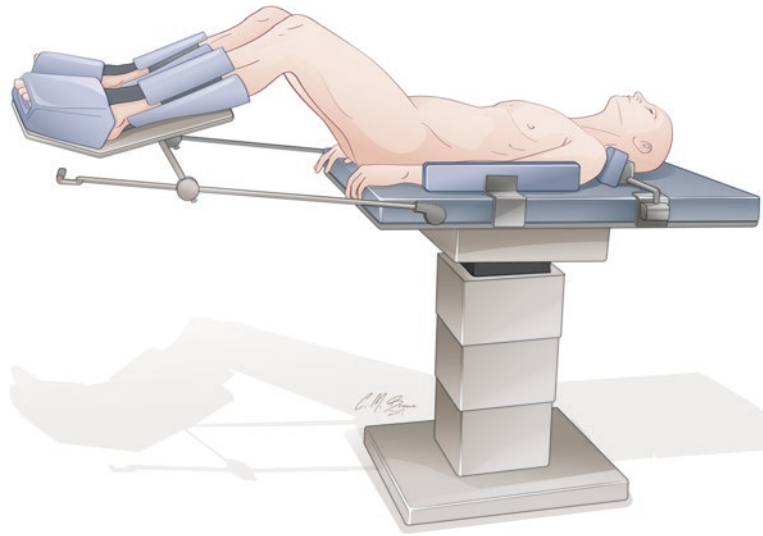

Fig. 11.3 The lithotomy position with Trendelenburg (illustration credit: Christopher Brown)

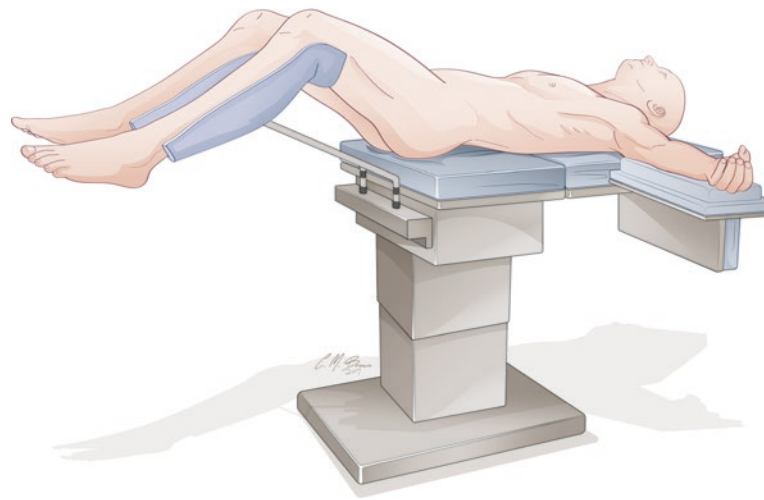

Fig. 11.4 The lithotomy position with less elevation of the legs (illustration credit: Christopher Brown)

Anesthesia and Monitoring

Anesthesia induction and maintenance should follow the anesthesiologist's routine for intra-abdominal surgery. It has been reported that physiological dead space is increased in lower abdominal surgery performed in the lithotomy and Trendelenburg position, and that respiratory compliance is decreased as a result of pressure on the lungs from the intra-abdominal contents [36]. The oxygen tension in the blood has been shown to be lower in patients in the lithotomy position after about 10 min, relative to the supine position [36]. This effect may be augmented in obese patients, requiring increased ventilator support while in this position. Monitoring should consist of standard intraoperative anesthetic monitors—EKG, noninvasive blood pressure, capnography, and oximetry. Invasive blood pressure monitoring can be performed at the discretion of the anesthesiologist.

Procedures Performed in the Lithotomy Position

As mentioned above, the lithotomy position is uncommonly used in neurosurgery. The primary indication for this position is for anterior lumbar interbody fusion involving the L5/S1 interspace in which there is a very steep sacral inclination which is difficult to access in the supine position. The lithotomy position allows for retroversion of the pelvis and brings the interspace more perpendicular to the floor and thus more accessible.

Advantages

By allowing the surgeon access to a steep L5/S1 disc or patients with a very high grade spondylolisthesis, the lithotomy position allows for solid interbody arthrodesis in group of patients with very challenging anatomy in whom traditional anterior and posterior interbody approaches are very difficult, if not impossible.

Disadvantages and Complications

Lack of Familiarity

The lack of experience among neurosurgical teams with this position is a major challenge and arises from the infrequency with which this position is used. As such, the risk of complications is higher if careful attention is not paid to each individual detail of positioning. Similarly, the surgeon's own comfort level with the lithotomy position and the anatomy when in this position may increase the risk of complications until sufficient experience is gained [37]. The perioperative team should consider utilizing the experience from other surgical departments for optimal patient safety.

From the perspective of surgical education, the lithotomy position is somewhat suboptimal. Because the lithotomy position places the surgeon between the patient's legs, there is limited room for others to view the operative field. This creates difficulty for trainees and academic surgeons who wish to teach the procedure, whereas in prone and supine positions, the surgeon and assistant are able to stand across from each other.

Anesthetic Difficulties

As mentioned above, there are significant pulmonary changes while in the lithotomy position, especially if this is combined with Trendelenburg. The abdominal contents compress the diaphragm, raising pressure in the chest. In a high lithotomy position, especially in an obese patient, the thighs place pressure on the abdomen and further increase pressure on the lungs [36, 38, 39]. Fahy et al. mention that there is an expected reduction in PaO_2 and increase in $PaCO_2$, and while these shifts are not unacceptable in healthy patients, patients with pre-existing cardiopulmonary comorbidity may not tolerate them as well [38]. Ryniak et al. mention that lung elasticity and compliance increase when in the Trendelenburg position, and elasticity increase further with lithotomy positioning [39]. This knowledge necessitates careful monitoring of the respiratory status of patients while in the lithotomy position and implies that certain patients may be unable to tolerate being in this position.

Peripheral Neuropathies

Because of the unique positioning of the legs in lithotomy, multiple peripheral nerves are at risk for injury. The ASA recommends limiting hip flexion to 90 degrees, as this minimizes stretch on the sciatic nerve [27]. Gumus et al. found a postoperative neurapraxia in 12 of 1170 patients undergoing surgery in the lithotomy position. They, too, comment that excess hip flexion places the sciatic nerve under stretch which over time can result in injury. In their series, only two patients had a deficit persist beyond 1 month. They concluded that age over 70 and operative time longer than 3 h contributed to an increased risk of postop neurapraxia [37]. The ASA indicates that the femoral nerve may also be at risk with excessive abduction and external rotation of the hips [27]. Finally, both the ASA and the AORN recommend careful padding of the fibular head, as prolonged pressure on this region can lead to peroneal neuropathy and foot drop [3, 27].

Compartment Syndrome

This is a dreaded, though rare, complication of lithotomy positioning. Zappa et al. describe in their series of 473 patients undergoing gynecologic surgery in the lithotomy position, 8 patients developed compartment syndrome requiring fasciotomy [35]. Sajid et al. mention that the incidence of compartment syndrome requiring fasciotomy in colorectal patients is about 1/3500 [40]. The pathophysiology of compartment syndrome is prolonged ischemia followed by reperfusion and edema [35, 40–43]. It is suspected that raising the legs above heart level, combined with pressure on the leg musculature and vasculature while in stirrups, impedes blood flow to the calf musculature. The prolonged ischemia results in breakdown of the basement membranes around the blood vessels and leads to the leakage of fluid into the interstitial space, resulting in swelling of the muscle [41–43]. Consensus in the literature suggests that 3–4 h of operative time is the point at which the risk of compartment syndrome rises [40, 41]. Rapid diagnosis and treatment with fasciotomy is then necessary to prevent permanent neurologic damage or loss of limb [35, 40]. Recommended preventive measures include careful padding of the calf and heel, minimizing Trendelenburg positioning, and minimizing hypovolemia [40].

Realistically speaking, the lithotomy position is rarely used in spine surgery and is somewhat limited to centers where it is used in conjunction with vascular and general surgeons who are comfortable with set up and patient positioning. While it is not a necessary tool for the spine surgeon's armamentarium, it could be a useful adjunct from time to time, when a patient has a steep sacral inclination, and an anteriorly placed graft is required.

Conclusion

This chapter discussed the sitting, supine, and lithotomy positions in spine surgery. Methods of positioning were explained and nuances described. Advantages and disadvantages to each position were explored. Each position has specific indications. Surgeons must choose the position best suited for the individual operation and patient in order to optimize surgical access and minimize position-related injury.

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