CHAPTER 26

Positioning for Cranial Surgery

R. Webster Crowley ■ Aaron S. Dumont ■ M. Sean McKisic ■ John A. Jane Sr

Although it is not always adequately emphasized, positioning of the patient for intracranial procedures remains a critical step in a successful surgery. Optimal positioning allows the surgical team to complete their objective in the most effective fashion in many ways; for example, ideal positioning may reduce or eliminate the need for brain retraction, help provide a clear and bloodless field, reduce intracranial pressure and avoid venous obstruction, present the anatomy and pathology in the ideal perspective for the surgeon, and minimize the chance of avoidable complications such as brachial plexus stretch injuries and pressure neuropathies. This chapter reviews fundamental principles of positioning for the most common approaches to cranial disease.

PTERIONAL (FRONTOTEMPORAL) CRANIOTOMY

The pterional craniotomy, otherwise known as the frontotemporal craniotomy, is considered to be the craniotomy most commonly performed by the neurosurgeon. Its versatility has made it a fundamental component of the neurosurgeon's repertoire, and it (or its derivatives, such as the cranio-orbito-zygomatic approach) has become the craniotomy of choice for a large number of procedures. These procedures include but are not limited to the vast majority of supratentorial intracerebral aneurysms and pathologic processes of the anterior and middle cranial fossae, the central skull base, and in select instances, the posterior cranial fossa.

Positioning for the pterional craniotomy begins with placement of the patient supine on the operative table. The patient is then placed in the Mayfield-Kees head fixation or similar cranial immobilization apparatus. When possible, we prefer to position the pins such that the single pin is placed in the frontal bone contralateral to the operative target, approximately 2 to 3 cm above the brow. The dual pins are then placed in the occipital bone on the ipsilateral side. It is usually preferable to place the pins along the axial plane; however, depending on the extent of the planned skin flap, it may be necessary to orient the pins along the sagittal plane. Others, however, advocate placing the single pin posteriorly, a decision that typically comes down to the surgeon's preference.[1] Regardless of this decision, careful attention should be paid to avoid the frontal sinus anteriorly and the mastoid air cells posteriorly. Once the patient is in pins, a shoulder roll is placed under the ipsilateral shoulder along the long axis of the patient. This allows adequate rotation without compromising venous return by obstructing the jugular veins in the neck. We also generally place the patient in some reverse Trendelenburg to promote brain relaxation and to allow the head to be fixed higher than the level of the heart.

Once the patient's body has been positioned correctly, the head can be adjusted. Appropriate positioning of the head requires a combination of head flexion, rotation, and neck extension that is designed to provide the ideal surgical trajectory while minimizing brain retraction. The head is first rotated toward the contralateral shoulder. The degree of rotation can vary greatly and is largely dependent on the desired surgical target. For example, internal carotid artery disease is often approached from 5 to 20 degrees of contralateral rotation; anterior communicating artery aneurysms may require up to 60 degrees of rotation to allow optimal visualization of the anterior communicating artery complex. In general, for approaches requiring wide opening of the sylvian fissure, avoidance of excessive rotation is preferred because the greater the contralateral rotation, the more the temporal lobe and its operculum obstruct the trajectory into the sylvian fissure. Once the desired degree of rotation is obtained, the head is laterally flexed slightly, followed by an extension of the neck. This last maneuver should present the malar eminence as the highest point on the patient and aids in retraction by allowing gravity to pull the frontal lobe from the skull base. Once it is in position, the head fixation device is secured to the table (Fig. 26-1). The patient's arm that is adjacent to the scrub nurse or technician is padded and tucked close to the body; the other arm is supported on an arm board to provide unfettered access for the anesthesiologists. Pillows and padding are placed under the patient's knees and feet, and the patient is secured to the table with a padded safety belt or padding and tape. In cases in which significant bed rotation is anticipated during the surgery, additional tape or belts are applied to secure the patient to the table.

TEMPORAL AND SUBTEMPORAL APPROACH

The temporal or subtemporal craniotomy (or derivatives such as a middle fossa, extended middle fossa approach) may be performed alone (such as for petrous apex disease, other disease of the middle fossa, or basilar apex aneurysms). It may also be performed in conjunction with another approach, such as the pterional or lateral suboccipital craniotomy.[2]

In preparation for the subtemporal craniotomy, the pins are placed for a lateral park bench position. This is accomplished by placing the single pin of the Mayfield-Kees head clamp into the frontal bone 2 to 3 cm above the ipsilateral brow and the dual pins in the occipital bone along the axial plane at midline and contralateral to the surgical site. Once in pins, the patient is placed on the side opposite the operative site on top of a vacuum-ready beanbag, with the inferior arm extended perpendicular to the patient's body on an arm board. In this position, it is critical to place a small axillary roll under the inferior axilla to avoid compression or other injury to the axillary artery or brachial plexus. Once the dependent arm is properly positioned and the beanbag is hardened, padding is placed between the superior arm and the patient's body. The arm is then placed in neutral position along the long axis of the torso, with slight flexion at the elbow before it is secured. For the subtemporal approach or middle fossa approach, correct head positioning is critical. The patient is placed in reverse Trendelenburg position to place the head above the level of the heart. In addition, the neck is laterally flexed, with the dependent ear being brought toward the ipsilateral shoulder. This also uses gravity to facilitate gentle retraction

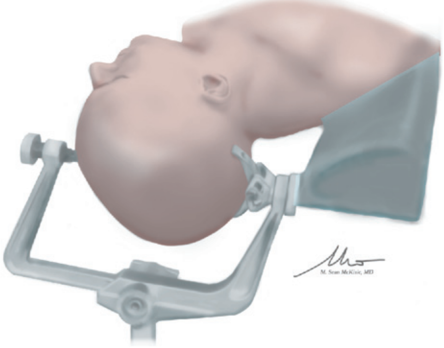

FIGURE 26-1 Positioning for pterional craniotomy. The ipsilateral shoulder is elevated with a shoulder roll, and the head is flexed slightly and rotated approximately 45 degrees toward the contralateral shoulder. The degree of rotation is adjusted on the basis of the surgical target. Ideal positioning should place the malar eminence at the highest point of the surgical field.

of the temporal lobe. The head fixation apparatus is then secured to the table, and the patient's body is supported with safety belts and tape (Fig. 26-2).

Alternatively, the temporal or subtemporal approach can be accomplished with the patient in the supine position as long as the patient's neck is supple and 90 degrees of rotation can be accomplished easily. A large roll under the ipsilateral shoulder can facilitate head rotation, and the other principles of positioning outlined for the pterional approach can then be applied.

ANTERIOR PARASAGITTAL AND SUBFRONTAL APPROACHES

The positioning is similar for the anterior parasagittal and subfrontal approaches, with only slight variations on the flexion angle of the head. The anterior parasagittal approach is typically used for interhemispheric approaches, such as for lesions of the anterior interhemispheric fissure, for distal anterior cerebral artery aneurysms, or for access to the third or lateral ventricles for colloid cysts or other intraventricular disease. The subfrontal approach is used for lesions of the anterior cranial fossa, such as meningiomas from the olfactory groove to the tuberculum sellae.

Perhaps more than for any other cranial procedure, the positioning for these approaches must take into account both the planned craniotomy site and the planned surgical incision. For the subfrontal craniotomy specifically, the bicoronal incision is typically several centimeters from the posterior edge of the craniotomy, and therefore it is important to position the patient so that both the incision and the craniotomy site are comfortably within the neurosurgeon's operative reach.

Once the patient is ready for positioning, he or she is placed supine on the operative table before being pinned. As the incision is typically a bicoronal one, the patient must be placed in the head fixation apparatus such that sufficient room is given for the incision while not placing tension on the skin that could complicate the closure. The dual pins are placed behind the ear in the coronal plane; the single pin is placed at approximately the same point on the contralateral side. It is absolutely imperative to have confidence that the pins are securely fastened, something that may take up to 80 pounds of pressure with the Mayfield head holder tensioner.

Once in pins, the patient is strapped in with a waist belt, and the head of the bed is raised until the vertex of the patient's head is within the focal length of the neurosurgeon. The bed may be flexed slightly with concomitant lowering of the legs so that the thighs are elevated while the knees are flexed. Once the bed is in an appropriate position, the head is adjusted to the desired point. For the anterior parasagittal craniotomy, the head is flexed until the point of the planned craniotomy and the planned target are along a comfortable trajectory for the neurosurgeon. For the subfrontal approach, it is often necessary to actually extend the head slightly until the brow is the most superior point on the operative field. This will allow the frontal lobe to fall away from the anterior cranial fossa, minimizing retraction. During this extension, it is important to be mindful of the planned incision so as not to position it out of comfortable range of the surgeon. Despite the degree of flexion or extension, the head is kept in a neutral midline position along the long axis of the patient. Once it is in the desired position, the head is secured. The patient is then secured to the table with pressure points padded as outlined before (Fig. 26-3).

An alternative positioning strategy for the anterior parasagittal approach is to have the patient in a lateral position, with the side down depending on the pathologic process and the angle of attack. The head is then tilted upward until the surgical target is in the appropriate location, placing the pathologic process in the horizontal plane. This can be used, for example, with parasagittal meningiomas, whereby the ipsilateral frontal lobe may be placed dependent, facilitating brain retraction with the assistance of gravity. This position may also be used for approaches to the contralateral hemisphere through a transcallosal approach.[3]

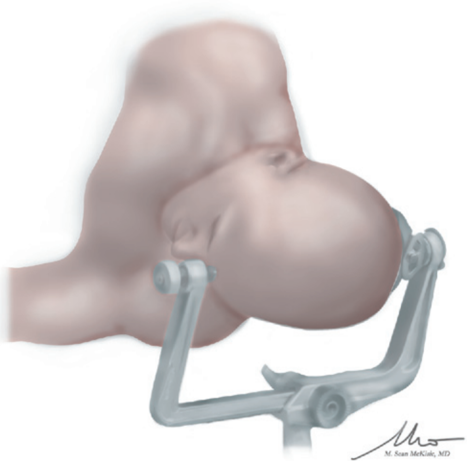

FIGURE 26-2 Lateral decubitus positioning for subtemporal or temporal approach. Once the head is positioned so that the sagittal plane is parallel to the ground, the head is tilted slightly toward the floor, a maneuver that allows the temporal lobe to fall away from the middle cranial fossa. This position can also be used for the lateral suboccipital craniotomy by rotating the face toward the floor, again allowing the operative site to be the highest point on the surgical field.

POSTERIOR PARASAGITTAL CRANIOTOMY

Despite its many similarities to both the anterior parasagittal and midline suboccipital craniotomies, the posterior parasagittal craniotomy does present several specific considerations. There are two distinct possibilities in positioning for a posterior parasagittal craniotomy, a decision that often depends on the posterior extent of the desired craniotomy. For cases in which the planned craniotomy is within several centimeters posterior to the cranial vertex, or if an awake craniotomy is desired, it is preferable to position the patient supine on the operative table. If it is farther posterior, the preferred position is often prone.

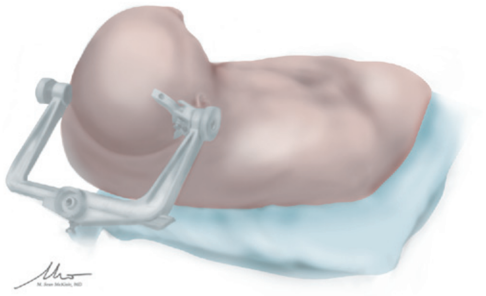

FIGURE 26-3 Positioning for anterior parasagittal or subfrontal approach. This is achieved through a standard supine position. The degree of flexion or extension of the head depends on the surgical target. For the subfrontal approach, the neck is extended past a perpendicular plane with the floor, allowing the frontal lobe to fall away from the anterior cranial fossa. For the anterior parasagittal approach, the head is flexed until the desired surgical site is comfortably within the surgeon's operative field. This positioning may occasionally be modified to accommodate a posterior parasagittal approach. This entails shifting the pins in front of the external auditory meatus. This also requires a higher degree of flexion than in the anterior parasagittal approach. If too much flexion is needed, it may be necessary to perform the procedure from a prone position.

If the decision is made to approach the patient from the supine position, he or she is placed in the Mayfield-Kees head clamp with the pins oriented in the axial plane, with the posterior of the dual pins approximately 2 to 3 cm above the external auditory meatus and the single pin slightly anterior to this point on the opposite side. However, unlike the prone position, the clamp is placed underneath the patient's neck when the pins are applied. Once the patient is in pins, the bed is flexed slightly until the site of the craniotomy is in the desired position. The neck can be flexed to augment this, a maneuver that may aid in decreasing complications such as air emboli that are associated with elevation of the back of the bed being too high. If an awake craniotomy is planned, the neck should remain in neutral position, with the thighs typically elevated to increase the patient's comfort. Once in position, the headrest is locked into place. This can also be accomplished in a seated position, the details of which are outlined in "Midline Suboccipital Craniotomy."

When the posterior parasagittal craniotomy is approached from the prone position, the pins are placed before the patient is flipped. These are placed as described earlier for the supine positioning. Once in pins, the patient is placed prone on the operative table; the arms are placed in the neutral position and are padded and tucked to the patient's side. The patient's chest lies on soft gel rolls placed parallel to the long axis of the body. It is important to avoid leaving electrocardiogram leads or wires on or across the anterior chest wall because this can produce pressure sores or abrasions. As is the case with all positions, the waist strap is placed before adjustments are made to the bed. Once the patient is strapped in, the bed is flexed into the Concorde position, with care taken to adjust the head positioning to avoid neck strain during flexion of the table. This is accomplished by flexing the legs and raising the head of the bed slightly. After an appropriate bed position has been achieved, the final manipulation entails extension or flexion of the neck. The degree of flexion depends on the exact location of the planned craniotomy, and this maneuver should be performed with the goal of placing the craniotomy site at the highest point of the operative field.

MIDLINE SUBOCCIPITAL CRANIOTOMY

The suboccipital craniotomy is the preferred approach for the majority of fourth ventricular lesions, and it can provide access to midline cerebellar lesions and pineal lesions. For this approach, the patient is placed in the Mayfield-Kees head fixation apparatus with the pins just below the superior temporal line on both sides. The dual pin side is typically placed so that the posterior pin is 2 to 3 cm above the external auditory meatus; the single pin is placed slightly anterior at the same level on the contralateral side. The patient is placed prone on the operative table onto two large chest rolls, and the arms are tucked into neutral position along the length of the patient. The patient is strapped to the bed with a waist belt and is then moved into the Concorde position, with flexion of the legs and extension of the back (elevation of the head). The patient can be placed in additional reverse Trendelenburg to ensure that the head is above the level of the heart, with an accompanying decrease in venous congestion.

Once the bed is positioned correctly, the head is flexed until the chin is at least two fingerbreadths from the sternal notch. Although the patient's neck may permit further flexion, it is important to leave at least two fingerbreadths to prevent complications with the endotracheal tube. Once flexed, the head is lifted upward while maintaining the same degree of flexion, effectively distracting the neck while keeping the head in fixed position. This last maneuver ensures that the intended craniotomy site is the most superior point of the patient before final clamping into place. The patient is secured to the table and padded (Fig. 26-4A).

For the supracerebellar infratentorial position, the midline suboccipital approach is often best accomplished in the seated position. Although we think that this position can be awkward for the surgeon, it is perhaps ideally suited for this approach. The cerebellum falls away from the tentorium after arachnoidal adhesions are divided, and it provides a bloodless field. For the seated position, the patient is placed in pins with a configuration similar to that described earlier. Once in pins, the patient is strapped in with a waist belt, and the back is elevated until the patient is in the seated position. The bed is then flexed, with an elevation of the thighs and flexion of the knees until an adequate seated position is obtained. The head is then flexed slightly before the Mayfield-Kees head clamp is secured (Fig. 26-4B). This is done with a specific bed adapter that allows the Mayfield to be secured easily. The arms are then placed across the patient's abdomen and secured. The lower extremities are often wrapped in compression stockings or wrap to facilitate venous return. Appropriate anesthesia precautions against air embolism, such as a central line and precordial Doppler probe, are placed, but that discussion is beyond the scope of this chapter.

LATERAL SUBOCCIPITAL APPROACH

The lateral suboccipital craniotomy or craniectomy is the most frequently used approach for access to the cerebellopontine angle and lateral cerebellum. In addition to tumors of the cerebellopontine angle and lateral cerebellum, the lateral suboccipital approach can be used in the treatment of a variety of posterior circulation aneurysms, including aneurysms of the anterior inferior cerebellar artery, as well as in the microvascular decompression of the trigeminal nerve. Variations of the approach, such as the far lateral transcondylar approach, may be used to access lesions of the anterior foramen magnum and aneurysms of the posterior inferior cerebellar artery.

This approach can be performed from a number of positions, a decision that is similar to many of those made in neurosurgery in that it is a matter of the physician's preference. The lateral suboccipital approach can be done from a modified Concorde position, from a lateral park bench position, supine position, or even in the seated position, all of which have their advantages and disadvantages.

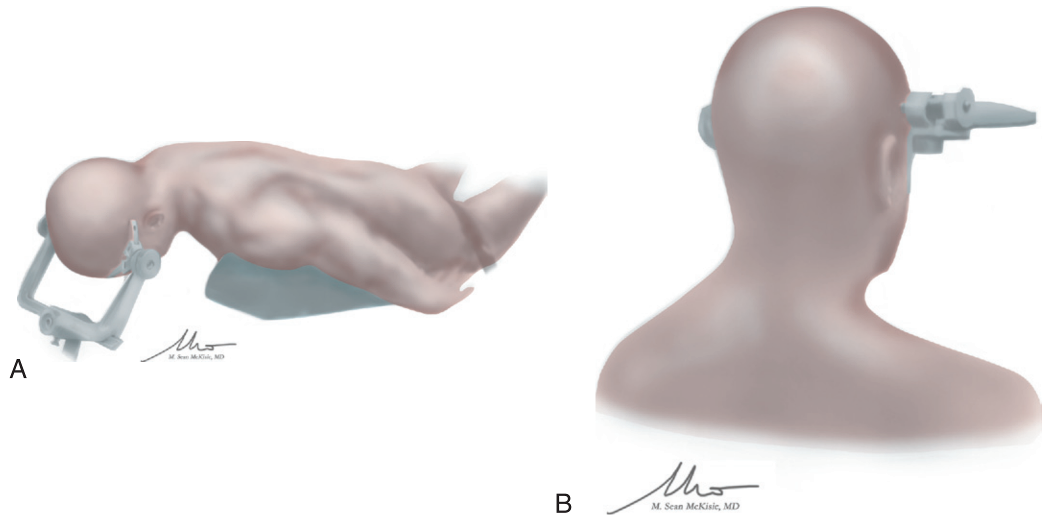

FIGURE 26-4 **A,** Prone positioning for midline suboccipital approach. This is typically performed from the Concorde position. The head is flexed and elevated, making sure to keep two fingerbreadths between the chin and the chest. **B,** Seated positioning for midline suboccipital approach.

Our preference for many lateral suboccipital procedures is the modified Concorde position. For this, the patient is positioned exactly as with the midline suboccipital approach, with a slight modification to bring the site of the craniotomy or craniectomy into a more prominent location. By rotation of the patient's head approximately 45 degrees to the shoulder ipsilateral to the lesion before the head is fixed in the Mayfield clamp, the planned surgical field is adequately exposed. The patient should be well secured to the table to facilitate additional bed rotation to achieve a far lateral trajectory (Fig. 26-5).

The park bench position is another potential option for the lateral suboccipital craniotomy and may be better, particularly for far lateral transcondylar approaches. The patient is positioned as described for the subtemporal craniotomy. After the body is in its final position, a small variation is performed by rotating the face slightly toward the floor. If the pins are placed properly, this slight rotation will align the Mayfield-Kees head clamp so that it is parallel to the floor and presents the craniotomy site as the most prominent part of the operative field. It is important to pad pressure points and to add an axillary roll as described for the temporal or subtemporal approach. An additional maneuver is to tape the ipsilateral shoulder inferiorly to provide more room for the surgeon to work. A supine position with a shoulder roll also may work for suitable patients.

For the sitting position, the patient is placed in pins with a configuration similar to that of the midline suboccipital position; the dual pins are placed 2 to 3 cm above the external auditory meatus on the side contralateral to the surgical site, and the single pin is placed 2 to 3 cm superior and anterior to the external auditory meatus. Once in pins, the patient is strapped in with a waist belt, and the back is elevated until the patient is in the seated position. The bed is then flexed, with an elevation of the thighs and flexion of the knees until an appropriate seated position is obtained. The head is then flexed slightly and rotated, depending on the pathologic process at hand, before the Mayfield-Kees head clamp is secured. The arms are then placed across the patient's abdomen and secured.

Each of these positions for the lateral suboccipital approach has advantages and disadvantages. The modified Concorde position may be more comfortable for the surgeon, and for cerebellopontine angle disease, it takes advantage of gravity to aid in retraction of the cerebellum. There is a risk of air embolus, although it is decreased compared with the seated position. It also carries the risk of pressure sores and blindness from elevated intraocular pressures that are not typically seen with the park bench or seated position; however, these risks can be minimized with proper padding of pressure points and by ensuring that the head is above the level of the heart. The park bench position is more likely to have brachial plexus injuries or other stretch injuries; however, it facilitates cerebellar retraction and is also considered a comfortable position for the operating surgeon as long as the ipsilateral shoulder does not encroach. It also provides a lateral perspective anterior to the brainstem for the far lateral approach. The sitting position aids in lowering intracranial pressure as well as venous congestion and gives the anesthesiologist superior access to the face. It also provides a clear, bloodless field. However, it carries a higher risk of venous air embolism, tension pneumocephalus, and subdural hematomas.[4] It is usually avoided in instances of patent foramen ovale (although not universally so),

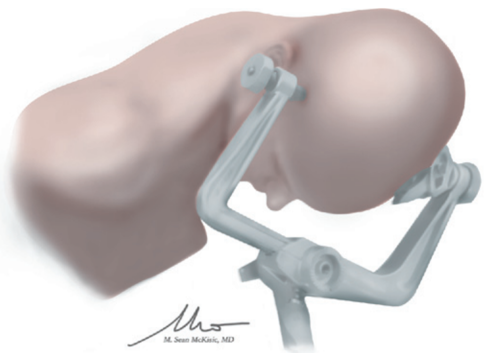

FIGURE 26-5 Positioning for lateral suboccipital approach. This position is similar to that for the midline suboccipital approach; however, the head is rotated so that the ipsilateral mastoid process is brought into the operative field. This head positioning may be achieved from the lateral position as well.

FIGURE 26-6 **A** and **B,** Positioning for endonasal transsphenoidal approach. The head is placed on the headrest and positioned so that the bridge of the nose is parallel to the ground. The foot of the bed is rotated away from the surgeon to ensure minimal obstruction. **C,** Positioning for sublabial transsphenoidal approach. The head is placed in pins and rotated so that the surgeon's trajectory is directed along a line from the base of the nose to the tragus.

and it can create fatigue for the surgeon operating for extended periods with outstretched arms. The decision to select one position over another depends largely on the surgeon's preference but also on the pathologic process at hand and the patient's morphologic features.

TRANSSPHENOIDAL APPROACH

As with the positioning for any cranial procedure, the positioning for transsphenoidal surgery is done to expose the intended target while maximizing the comfort of the surgeon. However, unlike in many other cranial procedures, incorrect positioning of patients for the transsphenoidal approach can make the surgery significantly more difficult or dangerous. With just a minimal alteration of the planned trajectory, a sellar approach can be missed altogether and result in the opening of the anterior cranial fossa. For this reason, it is imperative that the patient be positioned correctly, ensuring that the correct trajectory is taken.

At our institution, we use two different positions, depending on whether the patient is undergoing an endoscopic endonasal approach or the more traditional sublabial microscopic approach (Fig. 26-6). Ultimately, however, the position chosen and the approach taken come down to the physician's preference.

Positioning for the endoscopic endonasal approach begins with placement of the patient supine on the operative table. The head is placed on a horseshoe headrest, and the right arm is tucked with the hand positioned underneath the right thigh. The patient is then strapped in by a belt across the thighs. The bed is turned so that the feet are approximately 30 degrees to the patient's left in relation to the head. This allows the surgeon to stand as close to the head as possible without being obstructed by the body. Next, the bed is flexed into a beach chair position, and additional reverse Trendelenburg positioning is performed. This ensures that the head is sufficiently above the level of the heart, a maneuver that decreases venous congestion and subsequently decreases the bleeding encountered throughout the procedure. The bed is then tilted slightly to the right. Once the bed is in position, the head is turned to the patient's right with the bridge of the nose parallel to the floor. The head is rotated as much as the neck will comfortably allow until the nostrils and nasal cavities are easily accessible from the surgeon's standpoint.

The positioning for the sublabial microscopic approach must incorporate the microscope, and therefore proper positioning must take into account both the trajectory of the microscopic sight and the comfort of the operating physician while under the microscope. Similar to the previously described approach, the patient is placed supine on the operative table. The arms are tucked, and the patient is again belted in with a strap across the thighs. Unlike the positioning for the endoscopic approach, however, the patient is placed in the Mayfield-Kees pins. This will eventually allow the stabilization of the head in proper position and should allow the head to remain in this fixed position throughout the procedure. The pins are placed behind the ears to reduce potential obstruction of fluoroscopic images that are later obtained. Before the head is secured, the head of the bed is elevated slightly. The head is then flexed until the bridge of the nose is approximately 45 degrees from the horizontal axis. This degree of flexion is used to ensure that a line from the base of the nose to the tragus is along the same line as the surgeon's line of sight during the procedure. As is done with the endoscopic approach, the head is rotated to the patient's right until the patient is face-to-face with the surgeon before the Mayfield is finally locked in. This final position should allow the surgeon to comfortably operate under the microscope while giving sufficient room for the C-arm if needed.

CONCLUSION

An absolutely critical part of any neurosurgeon's practice is to become familiar with the various positions and their associated procedures and to be able to use them effectively. Knowing how to correctly position a patient is perhaps as critical as knowing which procedure one should perform, for even the most well thought out surgical plan can be undone by positioning the patient improperly. By obtaining a firm grasp on potential options, the operating neurosurgeon is able to choose the procedure that best suits each particular patient, rather than operating on a variety of intracranial pathologic processes through a limited number of approaches.

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Full references can be found on Expert Consult @ www.expertconsult.com

CHAPTER 27

Patient Positioning for Spinal Surgery

Peter D. Angevine ■ Paul R. Gigante ■ Paul C. McCormick

To obtain optimal outcomes from spinal surgery, any operation must be performed effectively and safely. Achieving the surgical objectives depends, in part, on the surgical field being positioned in a way that facilitates the procedure. The surgeon must select the appropriate surgical approach and then position the patient properly to ensure a safe surgical corridor. At the same time, the surgeon must ensure the patient's safety during the procedure. Particularly during long procedures and operations performed with the patient prone or lateral, morbidity may occur as a result of the patient's position. Appropriate positioning and attention to detail will minimize the probability of complications and facilitate the surgical procedure.

EQUIPMENT

Table

A basic electric operating table may be used for many spinal procedures (Fig. 27-1). Operations in the supine position, such as anterior cervical procedures and anterior lumbar fusions in the distal lumbar spine (L3-S1), are easily performed with such a table. Reversing the table may improve clearance under the table for the fluoroscopic unit. A lateral approach for thoracic, thoracolumbar, and lumbar procedures may also be performed on an electric table. For thoracoabdominal and retroperitoneal flank approaches, it is often helpful to place the level of pathology at the table break and flex the patient laterally.

A posterior approach for thoracic and lumbar procedures may also be performed on a standard operating table with either a Wilson frame or padded bolsters. If an instrumented lumbosacral arthrodesis is planned, however, care must be taken to ensure adequate lumbar lordosis. We generally do not use a Wilson frame for posterior thoracolumbar procedures that include instrumentation and fusion because of the possibility of inadvertently causing an iatrogenic flat-back deformity.

There are many advantages to modular spine-specific operating tables such as the Jackson Spinal table (Mizuho OSI, Union City, CA) (Fig. 27-2). The carbon fiber frame is radiolucent and low profile to allow 360-degree fluoroscopy and the use of intraoperative CT scanners such as the O-arm (Medtronic Navigation, Louisville, CO). Modular components allow customization for each procedure and for a wide range of patient phenotypes. The head may be secured in a foam headrest, in a rigid fixator, or with traction. The legs may be supported in a sling to allow lumbar flexion or on a rigid tabletop to enhance lordosis (Fig. 27-3). Finally, intraoperative repositioning for anterior-posterior or posterior-anterior surgery is facilitated with a rotational capability that obviates the need for moving the patient from one table to another.

Head Holders

The simplest method for supporting the head of a patient in the prone position is a purpose-made foam head holder. Cutouts for the eyes and endotracheal tube are the main safety features. An improvement over this system is the combination of a foam head holder and a rigid support. A mirrored base holds the support and allows the anesthesiologist to ensure that there is no pressure on the eyes.

Other head support options include a table-mounted three-pin skull clamp. This offers the greatest degree of control of the position of the head and cervical spine, but intraoperative repositioning is cumbersome. Craniocervical traction may also be used for spinal surgery in the prone position. Gardner-Wells tongs are the standard equipment for this; several weights totaling at least 15 lb should also be available.

Other Equipment

Although safe, effective patient positioning can be achieved without a large amount of specialized equipment, a few additional items are useful. A beanbag with a suction port effectively supports patients in a lateral position for a thoracotomy or retroperitoneal flank approach. Armrests for prone and supine cases should be available. A variety of foam pads such as doughnuts, kneepads, and arm supports are necessary. Disposable heating blankets such as those available for the Bair Hugger system (Arizant, Inc., Eden Prarie, MN) are used to prevent intraoperative hypothermia.

PRINCIPLES OF POSITIONING

Surgical Access

The primary goal of operative patient positioning is to allow the surgeon to achieve the surgical objectives. Selection of the surgical approach is based on the location and nature of the pathology and the specific planned procedure, and the patient's position is based on the chosen approach. Although a patient undergoing spinal surgery does not usually need to be positioned as exactingly as for intracranial procedures, surgical exposure is often facilitated by proper patient positioning. Operative considerations such as access for fluoroscopy or radiography and placement of table-mounted retractors should be anticipated by the surgeon and appropriate accommodations made.

In some circumstances, fluoroscopy or radiography is used before preparing and draping the patient, both to mark the incision and to confirm that surgical access is possible with the planned approach. For example, the trajectory for placing an odontoid screw is evaluated with the patient in the supine position to ensure that the patient's habitus and position will allow the proper angle for screw placement.

Patient Safety and Protection

Patient safety and avoidance of morbidity are important secondary considerations in operative positioning. Although the overall approach (posterior, anterior, lateral) is selected to allow

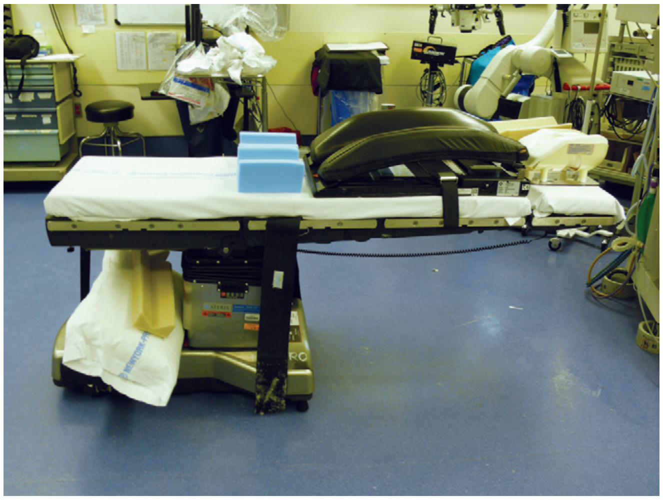

FIGURE 27-1 A standard electric operating room table may be used for many spinal operations. The bed is used in a reverse position to allow clearance underneath for the fluoroscopy unit. Either a Wilson frame (shown here) or padded bolsters may be used to support the patient.

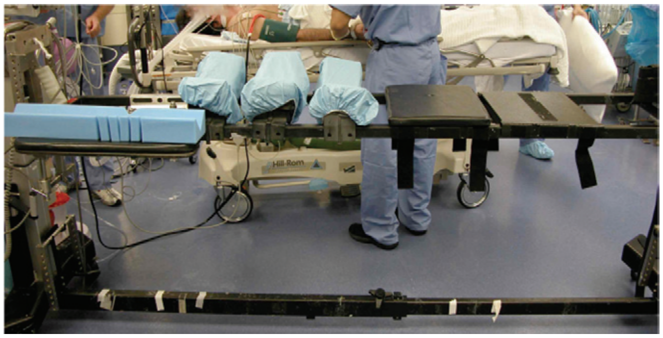

FIGURE 27-3 For lumbar and lumbosacral instrumented fusions, the spine table is set up with flat boards to support the legs. This maximizes hip extension and optimizes lumbar lordosis.

achievement of the surgical objective, it is meticulous attention to the specific details of positioning that ensures that patients do not suffer adverse sequelae from their position during the procedure. Properly padding all areas that may be exposed to pressure and placing extremity joints in relaxed, natural positions are basic preventive measures. Other important considerations may include head positioning and facial pressure and the relationship of the operative field to the level of the heart.

Neuropathies and Prevention

Ulnar neuropathy, one of the most common postoperative neuropathies, accounts for a third of all nerve injury claims in the American Society of Anesthesiologists Closed Claims Study database.[1] Although the etiology of postoperative peripheral nerve injury is not entirely known, it is thought to be related to intraneural capillary ischemia resulting from nerve overstretch or compression, perhaps exacerbated by prolonged intraoperative hypotension. The ulnar nerve appears to be more vulnerable to ischemia than the median and radial nerves, with a reported incidence of 0.04% after noncardiac surgery to 37% in one series of cardiac patients who underwent detailed postoperative sensory testing. The time of onset of ulnar nerve symptoms varies from immediately after surgery to 3 days postoperatively. The duration of symptoms tends to vary across reports, with some completely resolving spontaneously in days and others persisting for years after the initial insult.[2] Risk factors for postoperative ulnar neuropathy include diabetes, increased age, and male gender.[3]

Anatomically, the ulnar nerve appears to be particularly susceptible to direct compression as it courses through the superficial condylar groove at the elbow. Elbow flexion, especially to greater than 110 degrees, can tighten the cubital tunnel retinaculum and directly compress the nerve,[4] and external compression in the absence of flexion may compromise the nerve. With the patient in the supine position, direct pressure on the ulnar nerve at the elbow is significantly higher if both forearms are pronated than if they are in a neutral and supinated position (Fig. 27-4).[5]

Brachial plexus neuropathy may have findings similar to ulnar neuropathy but may additionally be characterized by symptoms such as shoulder pain, scapular winging, and shoulder weakness.

FIGURE 27-2 A dedicated spine table, here a Jackson Spinal Table, allows a greater range of height adjustment, full 360-degree clearance around the patient, and the use of multiple positioning pads and support devices. In addition, it is radiolucent.

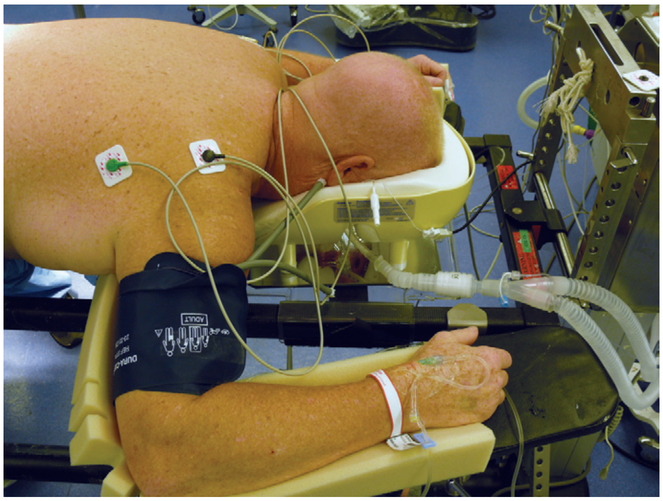

FIGURE 27-4 The arms are abducted to 90 degrees and the elbows flexed to 90 degrees or a bit less. The axillae and ulnar aspects of the arms are well padded. Note also the use of a helmet-type head holder with a reflective surface to ensure that no pressure is placed on the eyes. The neck is in relatively neutral alignment.

The incidence of brachial plexopathy during posterior spinal surgery has been estimated to be between 3.6% and 15%, as compared with 0.02% in a large study of 15,000 general surgical patients. Most patients achieve partial or full functional recovery, although some have persistent symptoms at late (1- to 3-year) follow-up.[6,7]

The majority of brachial plexus injuries are manifested as upper trunk injuries after surgery in the supine position and as lower trunk injuries after procedures in the prone position. The brachial plexus may be especially vulnerable to stretch in a prone-positioned patient with elbow flexion and shoulder abduction. Patients with congenital anomalies such as cervical ribs and shoulder contractures may have an increased susceptibility to stretch injury.

Some investigators have suggested intraoperative somatosensory evoked potential (SSEP) monitoring as a way to detect impending nerve injury. One retrospective study of 1000 spinal surgeries determined that the overall incidence of position-related upper extremity SSEP changes was 6.1%, with the lateral decubitus position (7.5%) and prone "superman" position (7.0%) having the highest incidence of position-related upper extremity SSEP changes. In this study, postoperative deficits did not develop in any patient who had positionally reversible SSEP changes.[8]

Lower extremity neuropathies have not been well studied in spinal surgery because they typically occur in patients undergoing surgery in the lithotomy position and after lower extremity orthopedic procedures. Injury to the common peroneal nerve has been reported more frequently than injury to any other lower extremity peripheral nerve, probably because of its vulnerable anatomic location. The common peroneal nerve is fixed in a superficial location as it traverses the head of the fibula, which leaves it susceptible to direct compression injury by devices that hold the legs in place. The legs should be padded and well protected at the level of the fibular head, particularly for procedures in the lateral decubitus position.[9]

In the event of a new postoperative neurological deficit, it is important to distinguish peroneal nerve injury from an acute L5 radiculopathy. A peroneal neuropathy is characterized by complete plegia of dorsiflexion and eversion without significant pain complaints, whereas an L5 radiculopathy usually results in dermatomal pain and sensory deficit accompanied by weakness of dorsiflexion, toe extension, and foot inversion.[10]

The lateral femoral cutaneous nerve (LFCN) originates from the L2-3 nerve roots and travels along the lateral border of the psoas major muscle and across the ilium toward the anterior superior iliac spine (ASIS). Because of its anatomic exit below the ASIS, compression neuropathy of the LFCN by posts or pads that support the pelvis may develop in patients who are placed in the prone position. In patients who sustain perioperative injury to the LFCN, hypoesthesia of the anterolateral aspect of the thigh usually develops, but some experience pain and dysesthesia as well. Few studies have been conducted to assess the incidence of positioning-related LFCN injury, although most estimates are around 20%. One study in particular estimated the incidence of LFCN injury to be 23.8% in patients who underwent prone spinal surgery with use of the Relton-Hall frame. All these patients experienced resolution of symptoms within 1 week to 2 months postoperatively.[11]

Soft Tissue Injuries

The patient's soft tissues must also be assiduously protected. Prolonged pressure leads to local ischemia and, in severe cases, tissue necrosis. The risk for injury may be minimized by, first, ensuring that sensitive structures do not bear significant pressure and, second, by distributing the pressure over a wide surface with careful padding. Materials that contact the skin should be permeable to prevent moisture buildup. Before placing the patient in the final position, an inspection should be performed to ensure that there are no electrocardiographic leads, intravenous line connectors, or other devices located in areas that will rest on the supporting pads.

With the patient in either the lateral or the prone position, the abdomen should be as free as possible. In the lateral position, the free abdomen will tend to fall anteriorly away from the spine, thereby facilitating a thoracoabdominal or retroperitoneal flank approach. With the patient positioned prone, having the abdomen free decreases intra-abdominal pressure. This both facilitates ventilation of the patient and decreases pressure in the valveless epidural venous plexus and thus reduces epidural bleeding.

Proper positioning of the breasts, particularly for relatively large women placed in the prone position, can be difficult. Adequate support of the upper thoracic region is necessary to achieve neutral cervical alignment and a stable operative platform. In general, the breasts are positioned so that they are medial and caudal to the supporting pads. Particular care is taken to ensure that direct pressure on the nipples is avoided, if possible.

Breast implants may pose a difficult positioning problem as well. The implants tend to be less compressible and less mobile than natural breast tissue, and it may be difficult to avoid direct pressure on the implants. It is important to discuss this potential problem with the patient beforehand and explain the risk for soft tissue injury from pressure and the rare possibility of implant rupture.

Head Positioning

Secure, neutral positioning of the cervical spine is a fundamental principle of patient positioning for all spinal operations, not just those directly involving the cervical region. Patients with degenerative disease in the thoracolumbar region frequently have concomitant cervical spondylosis and may therefore be at risk for postoperative cervical myeloradiculopathy if improperly positioned.

There are three main methods for providing head support and maintaining neutral cervical alignment. For lateral and supine cases, soft supports such as doughnut-shaped foam or gel pads or pillows may be used. Appropriately sized pads should be selected to avoid hyperextension, hyperflexion, or excessive lateral flexion. A specialized foam head holder with or without a custom rigid support may also be used to support the head for prone procedures. These are most appropriate for relatively short operations that do not involve the cervical or upper thoracic region.

Rigid head-holding devices may also be used. Three-point pin fixation devices with a table-mounted holder, such as the Mayfield system (Integra, Plainsboro, NJ), are familiar to most neurological surgeons, but perhaps less so to orthopedic surgeons. Proper positioning of the pins is necessary to prevent slippage of the head in the holder and to minimize the likelihood of perforating the skull. One benefit of rigid head fixation is that the occipitocervicothoracic region can be precisely aligned and the position maintained throughout the operation. A military prone position to reduce a malaligned dens fracture, for example, can be readily achieved, confirmed with fluoroscopy, and securely held during surgery. If a long instrumented fusion is planned, care must be taken during positioning to ensure proper alignment in all three planes and avoid creating an iatrogenic deformity.

Finally, traction systems can be used to secure the head. They allow some movement of the head and neck during surgery, which can have at least two benefits. First, by setting up dual vectors for traction, alignment of the spine can be altered during surgery by the surgeon while still scrubbed (Fig. 27-5). Second, the small amount of movement produced by the placement of upper thoracic pedicle screws might cause dislodgment of the head from a rigid fixator; a properly adjusted traction system

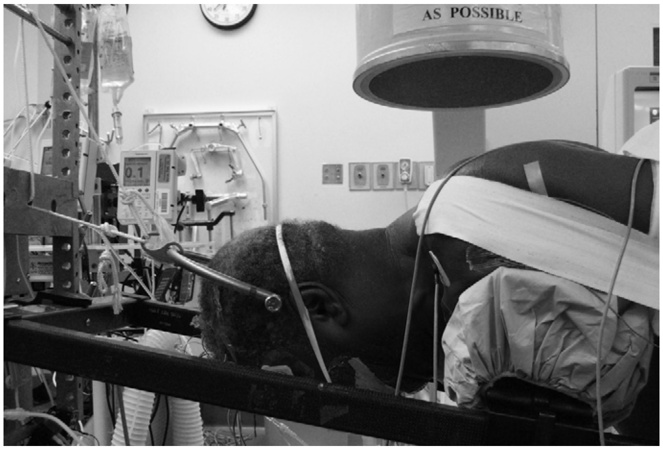

FIGURE 27-5 By using two ropes for the traction setup, one can change the alignment of the spine safely and effectively during surgery.

allows a safe amount of movement and eliminates this potential complication.

Visual Loss and Its Prevention

Postoperative visual loss (POVL) is an infrequently recognized but devastating complication of spinal surgery. Given that the estimated incidence of POVL has varied considerably across the surgical literature and was thought to be escalating in the mid-1990s, the American Society of Anesthesiologists created a POVL registry in 1999. Interim analyses of the POVL registry suggested a frequency of 0.0008% in noncardiac surgical patients undergoing procedures as disparate as hip arthroplasty, thoracotomy, and neck dissection. POVL in spinal surgery appears to be up to 100 times more frequent, with an incidence of roughly 0.08%.[12]

The most common cause of POVL in spinal surgery is ischemic optic neuropathy (ION) (89% of registry cases), which is more frequently unilateral than bilateral. POVL may also be attributed to central retinal artery occlusion (11% of registry cases). Although the precise etiology of ION in spinal surgery remains unclear, the leading hypothesis attributes ION to compromised blood flow in the optic nerve as a result of increased venous pressure and interstitial edema. Seventy-two percent of all ION cases were associated with prone spinal surgery; it occurred both in patients whose heads were maintained in facial supporters and in those for whom Mayfield pins alone were used for the entirety of the procedure. These data demonstrate that ION occurs independent of external pressure on the globe. Early data also suggested a relationship between POVL and prolonged anesthetic duration (94% of procedures had an anesthetic duration of 6 hours or longer), as well as between POVL and significant blood loss (82% of patients had estimated blood loss of 1 L or greater).[13]

Air Embolism

Air embolism is a concern that occurs almost exclusively when operating with a patient in the sitting position. This position is used by some surgeons for cervical foraminotomies and has been described for cervicothoracic osteotomies. With the operative field located significantly above the heart, air may be entrained into open, uncoagulated venous channels and result in air embolism. This may be more likely to occur with vascular channels in bone, which cannot collapse under atmospheric pressure. A precordial Doppler probe may help diagnose an air embolism early, and a long venous line with the tip in the right atrium may be used in an attempt to aspirate air. If air embolism is suspected during surgery, the field should be flooded with sterile irrigation fluid and the position changed to bring the head close to the level of the heart, if possible.

Spinal Alignment

As increasing numbers of instrumented fusions are performed, spinal surgeons are recognizing the relationship between achieving and maintaining proper spinal alignment and good clinical outcome. For procedures in which no arthrodesis is performed, such as lumbar microdiskectomy or cervical foraminotomy from a posterior approach, the patient's intraoperative position may be optimized to facilitate safe, thorough neural decompression. This usually involves a moderate amount of regional flexion. If the spine is instrumented as an adjunct to fusion, however, care should be taken to place the spine in anatomic alignment to avoid creating an iatrogenic deformity such as lumbar hypolordosis ("flat back"). There are important considerations specific to each spinal region that the surgeon should address when checking the patient's position before surgery.

Proper alignment of the occipitocervical region is essential for good patient outcomes after instrumentation and arthrodesis of the region from the occiput to C2. Improper positioning can lead to an overly extended position and an inability of patients to see their body. Excessive flexion or retraction can make swallowing difficult. Finally, coronal or axial (rotational) malalignment will require patients to compensate for head tilt or rotation to maintain level, forward gaze.

One option to ensure proper occipitocervical alignment is to place the patient in a halo and vest preoperatively. Adjustments can then be made to the patient's position before surgery. This strategy may be appropriate for patients who will require halo-vest immobilization postoperatively. It is less useful for procedures in which repositioning during the procedure is necessary or advantageous, such as combined transoral decompression and posterior occipitocervical fixation and arthrodesis. There can also be practical issues in accommodating the halo and vest on the operating table.

Estimating the chin-brow angle from fluoroscopy or radiographs can be difficult. We generally use a combination of low-magnification fluoroscopy, which maximizes the field of view and the ability to judge the relationship between the occipitocervical region and the subaxial cervical spine, and direct inspection of the relationship between the head and the torso. In some cases this does require the surgeon to scrub out of the sterile field to look under the surgical drapes.

When performing instrumentation and arthrodesis of the subaxial cervical spine, the surgeon must attend to the restoration or preservation of normal cervical lordosis. Patients who are fixed in a straight alignment are likely to complain about their head and neck position or pain, or both. To facilitate laminectomies, foraminotomies, and placement of lateral mass fixation, we prefer an intraoperative position of relative neck flexion. By using the dual-vector traction system described earlier, we can easily place the patient into cervical lordosis before rod placement and grafting. Although well-placed lateral mass screws can tolerate modest amounts of corrective force during rod placement, their relatively low pullout strength and the lack of a good salvage fixation option in the event of pullout has led us to try to achieve the final alignment through patient positioning and to use the fixation to maintain rather than achieve the final lordotic alignment (see Fig. 27-5).

Alignment of the cervicothoracic region deserves special mention. Without careful attention, it is easy to position the patient so that there is relative cervicothoracic kyphosis and a straight subaxial cervical spine. This is a particularly debilitating position in that the patient's head juts forward from the upper thoracic region and forward gaze is maintained only through

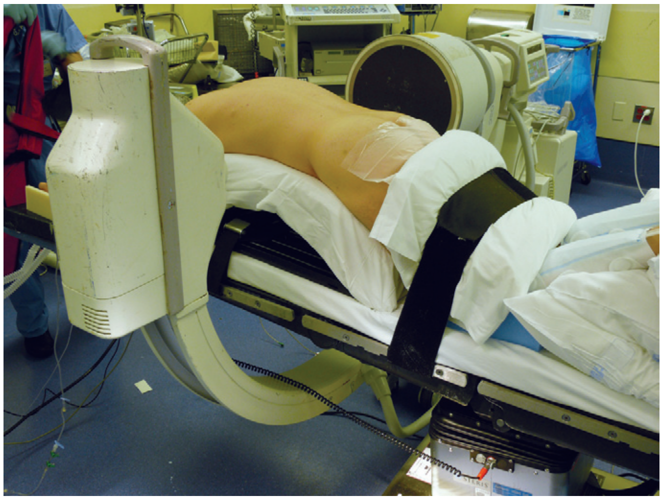

FIGURE 27-6 A patient positioned for lumbar decompressive surgery on a Wilson frame using the electric table. By raising the adjustable frame, lumbar flexion is created, which facilitates the decompression. This position would not be used if an arthrodesis were also to be performed.

hyperextension between the occiput and the upper cervical spine. Direct inspection is often the best method to detect whether this problem is in fact occurring intraoperatively. Again, we try to minimize the amount of force placed on implants and prefer to obtain optimal alignment through patient positioning.

Finally, the importance of restoring or maintaining adequate lumbar lordosis has received much attention—and rightly so. Lumbar flexion facilitates decompressive lumbar laminectomy and lumbar microdiskectomy but should be assiduously avoided if an arthrodesis is to be performed (Fig. 27-6). Adequate lumbar lordosis can most easily be achieved with maximal hip extension. Use of the Wilson frame and a leg sling should generally be avoided in procedures that involve lumbar arthrodesis. Instead, we use modular hip and thigh pads on a spine table and a flat leg rest padded with pillows (Fig. 27-7).

Surgeon Ergonomics

An important and often overlooked aspect of patient positioning is to optimize the working environment for the surgeon. Particularly for long or difficult procedures, surgeon comfort should be considered carefully, although it should never assume priority over patient safety. Working for a long period in an uncomfortable position or being unable to optimally visualize the surgical field may compromise the surgeon's ability to achieve the operative objectives. The operative field should be at a comfortable height for the surgeon. Tables designed for spine surgery are often adjustable through a greater vertical range than possible with standard electric operating room tables. This is advantageous in that it may obviate the need for the surgeons and assistants to use standing stools.

FIGURE 27-7 Hip extension enhances lumbar lordosis, thereby resulting in optimal spinal alignment for instrumented arthrodesis.

In general, we try to position the operative field in as close to a horizontal plane as possible. For lower cervical and cervicothoracic procedures, this often means that the patient must be placed in a considerable amount of reverse Trendelenburg positioning. In the thoracic and lumbar regions, the table is usually fairly level.

The operating microscope can also improve surgeon comfort, as well as provide excellent illumination and magnification. Particularly in the cervical region, its use can reduce surgeon discomfort during both anterior and posterior procedures. An additional benefit is that the assistant has an excellent view of the procedure and can assist, if necessary.

SPECIFIC PROCEDURES

Anterior Cervical

The two key aspects of proper patient positioning for anterior cervical surgery are maintaining the patient in gentle cervical extension (lordosis) and ensuring that the head and cervical spine are neutrally aligned in the axial plane. Inadequate cervical extension can make surgical access difficult and can result in a patient aligned in kyphosis postoperatively. Conversely, cervical hyperextension can exacerbate cervical spinal stenosis and place the patient at neurological risk intraoperatively.

The Caspar head holder provides a flexible, adjustable means of placing patients in optimal alignment. A firm rubber chin strap maintains neutral head alignment, and a small adjustable pad is used to fine-tune the cervical lordosis. It fits into the standard headpiece holder on electric operating tables. Another option is to use the flat tabletop on a modular spinal table (OSI). A small padded roll is placed underneath the patient and extended transversely to about the T2 level, and a foam doughnut is placed under the occiput. Paper tape extending from one side to the other and adherent to the forehead is adequate to maintain neutral alignment.

Posterior Occipitocervical, Cervical, Cervicothoracic

As mentioned earlier, careful patient positioning for posterior cervical procedures is essential, particularly if an instrumented arthrodesis is to be performed. A modular spinal table with movable pads is, in our experience, preferable to other options for several reasons. First, unobstructed anteroposterior and lateral radiographs or fluoroscopy can be obtained. Second, the tabletop can be set up in a moderate reverse Trendelenburg position without raising the head unit. This allows the ideal position of the patient to be achieved without raising the patient excessively high, thereby avoiding the need for the surgeon to stand on steps during the procedure. Third, the modular pads can accommodate a wide variety of body types. Finally, the dual-vector traction is easily set up and manipulated.

Posterior Thoracolumbar Arthrodesis

The specific patient positioning considerations depend on the patient's individual pathology and the planned procedure. For procedures that include an arthrodesis, instrumented or not, involving the lumbar spine, the patient should be positioned to maintain or enhance lumbar lordosis. Typically, we do this with a radiolucent spine table (OSI) and flat leg support (rather than the sling). All contact points, particularly the knees, are padded carefully. It is also important to flex the knees and to ensure that the feet are in a relaxed, neutral position and not in forced plantar flexion.

Positioning for procedures involving correction of complex coronal or sagittal deformities can be difficult. The most common situation is a patient with a significant thoracolumbar kyphosis or lumbar hypolordosis who is to undergo corrective osteotomies. For patients with fixed deformities, we position them in their natural (pathologic) alignment with a combination of built-up thoracolumbar supports and the leg sling. At the time of osteotomy closure and correction, the circulating nurse and an assistant will elevate the legs onto additional pillows, thereby increasing hip extension and helping to achieve correction.

Anterolateral, Retropleural Thoracic, Lateral Lumbar

Lateral positioning follows the same principles as for the more common anterior and posterior approaches. There is significant potential, however, for soft tissue or peripheral nerve injury secondary to focal pressure. Attention is therefore meticulously paid to these areas to ensure that adequate padding is used. The patient is placed on a beanbag covered by a sheet. A soft roll is placed under the dependent axilla to prevent excessive shoulder abduction and to distribute the pressure over a greater area. The dependent arm is externally rotated and the elbow is flexed to approximately 90 degrees. The upper part of the arm is also gently flexed. A folded pillow may be placed between the arms to keep them roughly parallel to the floor while allowing adequate access to the face. The dependent leg is flexed gently and the upper part of the leg is at most flexed slightly. Addition flexion may be helpful for lumbar flank approaches because it will tend to relax the iliopsoas and aid exposure. The common peroneal is susceptible to pressure injury as it crosses the proximal portion of the fibula just distal to the knee. This area must therefore be amply padded.

It is also helpful to have the patient in a true lateral position. The resultant orthogonal approach to the spine allows the surgeon to remain oriented to the location of the canal during decompression and placement of grafts and instrumentation. We also prefer to have the patient's back as close to the edge of the table as possible because we tend to operate mainly from that side, which reduces the effective depth of the wound.

Anterior Lumbar

Positioning for anterior lumbar procedures is fairly straightforward. The arms may be abducted to allow access for the anesthesiologists. The patient's heels and other pressure points are padded. A small folded sheet or pad may be placed underneath the lumbar spine to enhance the lumbar lordosis and to bring the ventral aspect of the spine closer to the surgeon. It is important, however, to make certain that anatomic alignment is preserved if an anterior arthrodesis is performed.

Intraoperative Repositioning

In some cases it is necessary or advantageous to perform "circumferential" surgery via different approaches on the same day. This requires intraoperative repositioning from a supine to a prone position or vice versa and may be accomplished with the use of two standard electric operating tables. We have found, however, that the patient must usually be moved to a stretcher before repositioning on the second table because the bulky table bases prevent them from being moved sufficiently close together to allow direct transfer of the patient from one table to the other.

It is more efficient to use a modular spine table that allows the placement of a second tabletop and rotating the patient on the table. Meticulous attention to detail is necessary to ensure safe repositioning. Adequate assistance must be available, but one individual should be in charge and delegate responsibility. We generally secure the head with Gardner-Wells tongs and 10 lb of in-line traction. For cervical procedures or if there is a concern about the cervical spine, we often also place a hard cervical collar on the patient.

Perhaps it seems obvious, but it is important to remember that what is on top of the patient before rotation will be underneath the patient afterward. The surgeon should therefore ensure that adequate smooth padding is in place and that the patient will not be lying on intravenous lines or other noncompressible objects. Before rotating the patient, a final check should be made that the tabletops are secure, that all lines are disconnected and secured, and that everyone understands the direction of the rotation. The ventilator is disconnected, the patient is rotated, the table is secured, the ventilator is reconnected, and the upper tabletop is removed.

CONCLUSION

Although seemingly mundane, proper patient positioning is a critical step. Failure to attend to the basic principles of positioning may compromise the surgeon's ability to achieve the surgical objective and may place the patient at risk for positioning-related complications.

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