Intraoperative Patient Positioning and Neurological Injuries

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Key Points

- Thoracic cases usually involve repositioning the patient after induction of anesthesia. Vigilance is required to avoid major displacement of airway devices, lines, and monitors during and after position changes.
- Obtaining central venous access after changing to the lateral position is extremely difficult. If a central line may be needed, it should be placed at induction.
- Prevention of peripheral nerve injuries in the lateral position requires a survey of the patient from the head and sides of the operating table prior to draping.
- A large portion of the ipsilateral shoulder pain following thoracic surgery may be due to intraoperative positioning.
- Several centers now advocate minimally invasive esophagectomy surgery in the prone position to improve surgical access.
- Post-thoracotomy paraplegia is primarily a surgical complication.

The majority of thoracic procedures are performed in the lateral position, but depending on the surgical technique, a flexed-lateral (nephrectomy), supine, semi-supine, semi-prone lateral, or prone position may be used. These positions have specific implications for the anesthesiologist.

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Position Change It is awkward to induce anesthesia in the lateral position. Thus, monitors will be placed, and anesthesia will usually be induced in the supine position, and the anesthetized patient will then be repositioned for surgery. Sometimes multiple repositionings are required during a single case. It is possible to induce anesthesia in the lateral position, and this may rarely be indicated with unilateral lung diseases such as bronchiectasis or hemoptysis until lung isolation can be achieved. However, even these patients will then have to be repositioned after induction and the diseased lung turned to the non-dependent position. The operating room team, led by the anesthesiologist, needs to follow a standardized protocol to avoid injury to the patient and displacement of lines, tubes, and monitors during each position change.

Due to the loss of venous vascular tone in the anesthetized patient, it is not uncommon to see hypotension when turning the patient to or from the lateral position. All lines and monitors will have to be secured during position change and their function reassessed after repositioning. The anesthesiologist should take personal responsibility for the head, neck, and airway during position change and must be in charge of the operating team to direct repositioning. It is useful to make an initial "head-to-toe" survey of the patient after induction and intubation checking oxygenation, ventilation, hemodynamics, lines, monitors, and potential nerve injuries. This survey then must be repeated and documented after repositioning (see Table 19.1). It is nearly impossible to avoid some movement of a double-lumen tube or bronchial blocker during repositioning [1]. The patient's head, neck, and endobronchial tube should be turned "en bloc" with the patient's thoracolumbar spine. However, the margin of error in positioning endobronchial tubes or blockers is often so narrow that even very small movements can have significant clinical implications [2]. The carina and mediastinum may shift independently with repositioning, and this can lead to proximal misplacement of a previously well-positioned tube.

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Table 19.1 Neurovascular injuries specific to the lateral position routine "Head-to-Toe" survey

1) Dependent eye
2) Dependent ear pinna
3) Cervical spine in-line with thoracic spine
4) Dependent arm: (i) brachial plexus, (ii) circulation
5) Non-dependent arm[a]: (i) brachial plexus, (ii) circulation
6) Dependent and non-dependent suprascapular nerves
7) Non-dependent leg sciatic nerve
8) Dependent leg: (i) peroneal nerve, (ii) circulation

[a]Neurovascular injuries of the non-dependent arm are more likely to occur if the arm is suspended or held in an independently positioned armrest.

Fig. 19.1 Patient in the lateral position on a vacuum mat. Note both arms are supported on armrests which are fixed to the operating table. This position of the arms allows good access to the head for monitoring and airway management after surgical draping. The dependent leg is straight and the non-dependent leg flexed. (From Ref. [18])

Endobronchial tube/blocker position and the adequacy of ventilation must be rechecked by auscultation and fiber-optic bronchoscopy after patient repositioning.

The Lateral Position (also referred to as the lateral decubitus position) This is the commonest position for thoracic surgical procedures. The patient may be positioned on a vacuum mat (see Fig. 19.1) or on cushions (see Fig. 19.2). The operating table headrest and pillows must be adjusted so that the cervical spine remains in-line with the thoracic spine. It is very easy after repositioning the patient in the lateral position to cause excessive lateral flexion of the cervical spine because of improper positioning of the patient's head. This malpositioning, which exacerbates brachial plexus traction, can cause a "whiplash" syndrome and is difficult to appreciate from the head of the operating table, particularly after the surgical drapes have been placed. It is useful for the anesthesiologist to survey the patient from the side of the table immediately after turning to ensure that the entire vertebral column is aligned properly. Both eyes should be visible to the anesthesiologist throughout the procedure to avoid compression on the globes by pillows or lines. The dependent ear pinna may be positioned in the center of a gel ring.

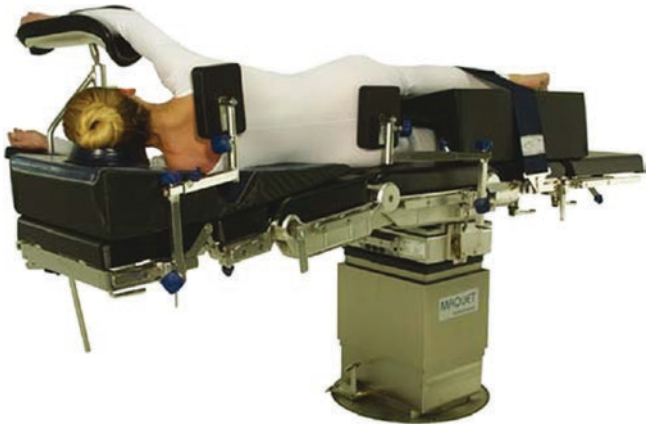

Fig. 19.2 Posterior view of a patient in the lateral view with a vacuum mat. It is very important to survey the patient from this perspective to ascertain that the cervicothoracic spine is in alignment prior to draping. After turning from the supine position, it is very easy to accidentally reposition the patient with a degree of lateral cervical flexion that is difficult to appreciate from the head of the table. Note the extra padding under the upper thorax below the axilla. Also note the gel ring preventing compression of the dependent ear pinna and the cushioning between the legs. (From Ref. [18])

The dependent arm is positioned on an armrest at 90° to the table, and the non-dependent arm is positioned on an armrest or pillows. The brachial plexus is the site of the majority of intraoperative nerve injuries related to the lateral position [3]. These are basically of two varieties: the majority are compression injuries of the brachial plexus of the dependent arm, but there is also significant risk of stretch injuries to the brachial plexus of the non-dependent arm. The brachial plexus is fixed at two points: proximally by the transverse processes of the cervical vertebrae and distally by the axillary fascia. This two-point fixation plus the extreme mobility of neighboring skeletal and muscular structures makes the brachial plexus extremely liable to injury (see Table 19.2). The patient should be positioned with padding under the dependent thorax (see Fig. 19.2) to keep the weight of the upper body off the dependent arm brachial plexus. Unfortunately this pad is called an "axillary pad" or "axillary roll" in some institutions. However, this padding will exacerbate the pressure on the brachial plexus if it migrates superiorly into the axilla.

The brachial plexus of the non-dependent arm is most at risk if it is suspended from an independently fixed arm support or "ether screen" (see Fig. 19.3). Traction on the brachial plexus in these situations is particularly likely to occur if the patient's trunk accidentally slips toward a semi-prone or semi-supine position after fixation of the non-dependent arm. Vascular compression of the non-dependent arm in this situation is also possible, and it is useful to monitor pulse oximetry in the non-dependent hand to observe for this. The arm should not be abducted beyond 90° and should not be extended posteriorly beyond the neutral position nor flexed

Table 19.2 Factors contributing to brachial plexus injury in the lateral position

a) Dependent arm (compression injuries):
1) Arm directly under thorax
2) Pressure on clavicle into retro-clavicular space
3) Cervical rib
4) Caudal migration of thorax padding into the axilla[a]
b) Non-dependent arm (stretch injuries):
1) Lateral flexion of cervical spine
2) Excessive abduction of arm (>90%)
3) Semi-prone or semi-supine repositioning after arm fixed to a support

[a]Unfortunately this padding under the thorax is misnamed an "axillary roll" in some institutions. This padding absolutely should NOT be placed in the axilla.

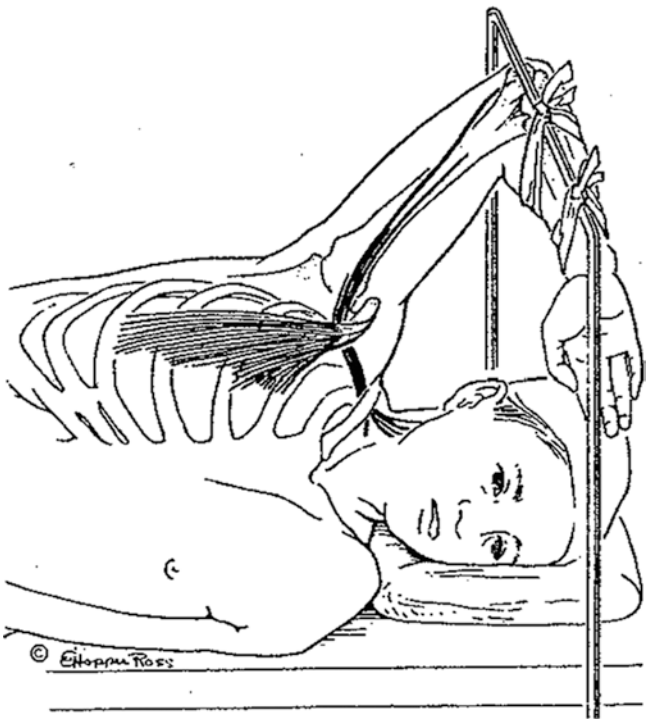

Fig. 19.3 Bilateral malpositioning of the arms in the lateral position. The non-dependent arm is hyperextended and fixed to the anesthetic screen. This causes traction of the brachial plexus as it passes under the clavicle and the tendon of the pectoralis minor muscle. This traction may increase if the patient's torso rotates during surgery, while the arm remains fixed. The dependent arm is directly under the thorax with the potential for vascular compression and/or injury to the brachial plexus. (From Ref. [3])

anteriorly greater than 90°. Fortunately, the majority of these nerve injuries resolve spontaneously over a period of months.

Anterior flexion of the non-dependent arm at the shoulder (circumduction) across the chest or lateral flexion of the neck toward the opposite side can cause a traction injury of the suprascapular nerve. Malpositioning can also cause a deep, musculoskeletal pain of the posterior and lateral

Fig. 19.4 Posterior view of the flexed-lateral position commonly used for thoracoscopic (VATS) surgery. The patient is on a vacuum mat, and a forced-air warmer has been applied to the lower body prior to draping. The flexed-lateral position is more likely to cause impairment of venous return and hypotension than the lateral position

aspects of the shoulder and is responsible for a large proportion of cases of postoperative ipsilateral shoulder pain [4]. The anesthesiologist should question the patient before surgery about any shoulder problems, and, if there is any history, the intraoperative position should be tested preinduction to find a comfortable position for the non-dependent arm.

The dependent leg should be slightly flexed with padding under the knee to protect the peroneal nerve lateral to the proximal head of the fibula. The non-dependent leg is placed in a neutral extended position and padding placed between it and the dependent leg. The dependent leg must be observed for vascular compression. Excessively tight strapping at the hip level can compress the sciatic nerve of the non-dependent leg.

The Flexed-Lateral Position To lower the non-dependent iliac crest so that it does not interfere with surgical access, most patients for VATS surgery are placed in a flexed-lateral position (see Fig. 19.4) similar to the nephrectomy position with lateral flexion of the lower thoracolumbar spine, while the upper thoracic and cervical spine is maintained in a horizontal plane. Some surgeons also use this position for thoracotomies to try and open the intercostal spaces. After repositioning and stabilization, the hemodynamics of the lateral position are not significantly different from the supine position. However, the flexed-lateral position impairs venous return and is associated with significant reductions in blood pressure and cardiac index (3.0 vs. 2.4 l/min/m^2 in one study [5]). This can particularly be a problem in the elderly, who are more liable to have clinically important falls in blood pressure with decreases in pre-load.

Positive pressure ventilation during anesthesia in the lateral position is associated with significant increases in mismatching of ventilation and perfusion. These changes are discussed in Chap. 5.

Supine Position The standard supine position with arms abducted is used for a variety of thoracic surgical procedures such as sternotomies for mediastinal tumors or bilateral wedge resections. The arms are positioned prone with careful attention to padding the ulnar nerves at the elbow to prevent pressure. The supine position with the arms abducted may be used for bilateral trans-sternal thoracotomies (the "clamshell" incision) for bilateral lung transplantation or large anterior mediastinal mass resections or for bilateral thoracoscopic procedures (see Fig. 19.5). The arms are positioned supine and not abducted more than 90°. The arms should be padded with the joints slightly flexed, so that the wrist is higher than the elbow and the elbow higher than the shoulder.

Prone Position Recently, the use of the prone position for the intrathoracic portion of minimally invasive esophagectomy procedures has been adopted in several centers because the surgical access is felt to be improved vs. the lateral position [6] (see Chap. 38). This has implications for airway management since it may be difficult to accommodate a double-lumen tube in a standard prone head rest. Some centers use a bronchial blocker for lung isolation in these cases. It has been reported that esophagectomy in the prone position can be performed with a single-lumen tube with surgical capnothorax and without one-lung ventilation [7].

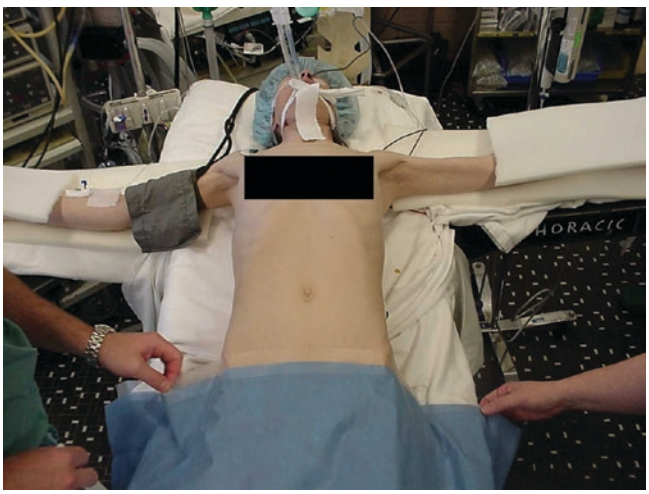

Fig. 19.5 The supine position with the arms abducted. This position is appropriate for bilateral thoracoscopic procedures or for bilateral lung transplantation

Central Neurological Injuries

Paraplegia With an estimated incidence of 0.08% [8], postthoracotomy paralysis (PTP) is a rare but devastating complication following thoracic surgery. PTP can occur as a result of spinal cord compression from an epidural hematoma or a foreign body or ligation of major arteries perfusing the vulnerable thoracic cord. Arterial embolus and perioperative hypotension have also been implicated.

Epidural hematoma (EH) is a rare but well-appreciated complication of neuraxial anesthesia. EH associated with epidural placement is estimated to occur with a frequency of 1:150000 [9]. Symptoms of EH vary but can include back pain, sensory and motor deficits, and incontinence. EH can present any time, including immediately postoperatively and after catheter removal. Prompt diagnosis, ideally with MRI scanning, can confirm the diagnosis. Immediate neurosurgical consultation should be obtained for decompression which has its best results within 12 h of onset of symptoms.

Surgical bleeding at or near the costovertebral junction with posterolateral thoracotomy incisions can be difficult to manage. There are multiple case reports [10] of oxidized cellulose polymer (Surgicel) positioned and left at or near the angle of the vertebral body to control bleeding. The material has subsequently swelled and compressed the ipsilateral nerve root or even migrated into the spinal canal, causing permanent paralysis [11]. The product monograph specifically contraindicates the use of the polymer in this situation. Neurologic deficit in this scenario presents within hours of surgery. Diagnosis is confirmed with imaging and treatment is removal.

Paralysis due to spinal cord ischemia is a commonly appreciated complication of vascular surgery, where its postoperative incidence can reach upward to 20% [12]. Nonvascular thoracic surgery can also lead to spinal cord ischemia. Anatomical considerations related to this have been reviewed [13]. The thoracic spinal cord has a less luxurious blood supply than its cervical and lumbar counterparts. The cord is supplied by the solitary anterior spinal artery (ASA) which provides blood supply to the anterior 2/3 of the cord and the paired posterior spinal (PSA) arteries which supply the posterior 1/3. In the thoracic region, the ASA receives important contributions from a few variable radicular arteries which are branches of the posterior intercostal arteries. Ligation of small but integral intercostal arteries during thoracic surgery, leading to hypoperfusion and ischemia of the spinal cord, has been implicated in PTP, both in lung resection and esophagectomy. The classic presentation of spinal cord ischemia from ASA supply interruption in the thoracic region is bilateral motor, pain, and temperature loss with maintenance of proprioception, the so-called anterior cord syndrome. There may be associated autonomic dysfunction.

Treatment of ischemia due to inadvertent surgical interruption of spinal cord blood supply is guided by interventions driven at optimizing supply and demand to the cord. Commonly used strategies include maintaining a normal to supranormal blood pressure with vaso-inopressors, an adequate hemoglobin, and a steroid administration. It should be noted that none of these interventions have been rigorously proven to improve neurologic outcome and some, in particular steroid administration, are controversial. Spinal drains are commonly placed electively in thoracic aneurysm repair to optimize spinal cord perfusion, but this treatment has not been utilized in the PTP literature.

To conclude, post-thoracotomy neurologic deficit is usually assumed to be an anesthetic complication related to epidural placement. Although anesthesiologists must always be vigilant and act quickly in these cases to image the spinal cord to rule out a hematoma, we must also remember the differential includes surgically related causes.

Blindness Postoperative visual loss (POVL) has been infrequently reported following surgery in the lateral position. Similar to the POVL more often reported after surgery in the prone position, the risk factors include prolonged surgery, hypotension, massive transfusion, diabetes, and obesity [14]. The etiology in non-cardiac surgery has been primarily due to posterior ischemic optic neuropathy. The perfusion pressure in the posterior portion of the optic nerve is directly related to mean arterial pressure and inversely related to venous drainage pressure. In one case report following spine surgery in the lateral position via VATS and open thoracotomy, the visual loss was complete in the dependent eye and partial in the non-dependent eye suggesting the potential impact of venous drainage pressure [15]. Of note, this patient also had marked facial edema after the end of the case. Since there is no monitor available to assess the perfusion pressure in the optic nerve, prevention involves avoiding the treatable associated factors (hypotension and anemia), regular intraoperative observation of the face to assure that there is no direct pressure on the eyes and careful neutral positioning of the cervical spine to avoid any compromise of venous drainage.

Ischemic optic neuropathy has been well described following orthopedic surgical procedures in the prone position. If the patient can be placed with a slight extension of the cervical spine (10° above neutral) while prone, this will decrease the intraocular pressure [16]. This may improve optic nerve perfusion but has not yet been demonstrated to have a beneficial effect on outcome. To date, there do not seem to have been any published reports of blindness following prone esophageal surgery.

Other Position-Related Injuries The lateral position has been reported to be associated with a variety of pressure-related injuries to the legs. These include myonecrosis, sciatic nerve palsy, and compartment syndromes [17]. The majority of these reports involve orthopedic procedures of long duration (>5 h). Increased vigilance for potential position-related injuries is required in long procedures.

Clinical Case Discussion

A 60-year-old woman presents for a left thoracotomy for left lower lobectomy for lung cancer. Past medical history includes a remote myocardial infarction with a preoperative ejection fraction of 40%, controlled hypertension, and diet-controlled diabetes mellitus. Regular medications are taken the morning of the OR, including metoprolol and aspirin 81 mg. A flexible epidural catheter with inner stainless steel coil wire is placed at T6/7 for postoperative analgesia. After an epidural test dose of 3 ml lidocaine 2%, an infusion of bupivacaine 0.1% plus hydromorphone 15ug/ml is started at 5 cc/h. A central line is placed after induction. The operation is remarkable for intraoperative hypotension requiring dopamine and norepinephrine and brisk bleeding near the costovertebral junction. Immediately postoperatively, blood pressure is in the patient's normal range with no support, there is no motor deficit, and pain is well-controlled. Six hours postoperatively, a nurse from the ward calls to report that the patient is complaining of bilateral lower extremity motor weakness.

1. What is the differential diagnosis?

At this point, the differential is wide and includes a motor block secondary to epidural local anesthetic solution, an intrathecal catheter, compression of the nerve roots or spinal cord from an epidural hematoma or a foreign body, arterial embolus to a radicular artery, or a hypoperfusion state.

2. What should be done immediately?

Vital signs should be taken and documented, the epidural solution should be stopped, and the catheter should be aspirated. A focused chart review should be undertaken with special note taken of any recently administered anticoagulants. The surgeon should be called and be advised of the problem. A complete neurological examination should be performed.

3. What does the initial assessment reveal?

The patient is awake and alert. Her blood pressure is 89/65 with a normal heart rate and oxygen saturation. No blood or CSF is aspirated through the catheter. She is unable to move her legs. She has loss of sensation to pain

and temperature in both legs, but proprioception is intact. Thirty minutes after the epidural solution has been turned off, there is no change in her neurological status. The last documented INR is 1.29 5 h ago. The patient received subcutaneous heparin for DVT prophylaxis 1 h ago.

4. What should be done next? What bloodwork, imaging, and consults should be ordered?

Dopamine is started through the patient's central line to keep the blood pressure in her normal range (120/80) with continuous cardiac monitoring. "STAT" complete blood count and coagulation tests are drawn. There is hesitance to remove the epidural catheter in the context of a coagulation abnormality combined with recent heparin administration and aspirin. MRI is the preferred modality to diagnose an epidural hematoma. However, the in situ epidural catheter is not permitted in the scanner. After consultation with the radiologist, the epidural is left in place, and a CT is performed. The neurosurgeon and neurologist are called and made aware of the patient.

5. What is found on additional testing?

The CT shows no epidural hematoma or mass. The hemoglobin is 90 g/L. Platelets are normal. INR is 1.21. The patient is seen by the neurologist and given a provisional diagnosis of spinal cord ischemia causing an anterior cord syndrome.

6. What else can be done?

The patient is moved to a step-down unit with continuous monitoring. Neurologic vitals are done every 4 h. Dopamine is continued, and the patient is given 100 mg methylprednisolone IV q8h × 3 doses. Hemoglobin is maintained at 100 g/L. The epidural is removed 6 h after the last subcutaneous heparin dose. An MRI is then performed and is normal. Pain is controlled with hydromorphone intravenous PCA. Over the next 4 days, the patient gradually and completely recovers.

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