16 Special Considerations for Pediatric Positioning for Neurosurgical Procedures

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Abbreviations

CSF Cerebrospinal fluid
VP Ventriculoperitoneal

Introduction

The proper positioning of infants and children undergoing neurosurgical procedures presents special challenges to the neurosurgeon, anesthesiologist, and operating room care team. This is a direct result of age-related differences in surgical lesions, as well as anatomical and physiological differences in children. With this being said, there are many similarities in regard to general positioning guidelines of adult patients undergoing neurosurgery. This chapter will focus only on special considerations when positioning pediatric patients for the most commonly encountered procedures.

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Age Terminology

Children undergo a wide range of neurosurgical procedures, from elective to emergent and life saving. When considering optimal positioning, the care team should always take into account the patient's chronological age and developmental level. While most procedures are performed within dedicated pediatric medical centers, a significant number are found in adult centers, underscoring the importance of recognition of the special needs of each pediatric age group. The most commonly used terms for discussing pediatric age groups are:

- Premature newborn—born prior to 37 weeks gestation
- Newborn—less than 72 h of age
- Neonate—first 28 days of life
- Infant—neonate to 12 months of age
- Toddler—13 to 24 months
- Childhood—2 years to 11 years of age
- Adolescence—12 to 18 years of age (some sources 21 years of age [1])

The special needs of each age group will be mentioned as necessary in the following sections. If no age group is specifically mentioned, it can be assumed that the particular principle will apply to all age groups.

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General Principles of Pediatric Positioning

As is the case with adults, careful preoperative planning is essential to allow adequate access to the patient for both the surgeon and anesthesiologist. During pediatric procedures, a small neonate or infant may quite literally disappear under the surgical drapes. Therefore, the anesthesiologist must ensure an unobstructed view of the child during surgery. This includes access to the airway and all lines (arterial lines, intravenous lines, urinary catheter, and ventriculostomy/lumbar drain tubing).

The endotracheal tube should be secured carefully and intuitively based on the procedure. The patient's airway should always be accessible during the procedure. When drapes are applied to the face area, care should be taken to avoid attaching them to or around the endotracheal tube. This is especially important when using sterile adhesive drapes commonly found in pediatric medical centers.

All pressure points should be padded and peripheral pulses checked or prevent compression or injury. Bed sheets or disposable bed linen is commonly used for tucking and securing upper extremities to the bed. If bed rotation is anticipated, padded straps are secured across the patient and bed maneuver testing is carefully performed prior to sterile drape application. It is imperative to prevent skin and soft tissue injury due to improper contact with objects such as instrument stands (if utilized) and grounding wires.

Several physiologic effects of body and head position should be considered during preoperative planning and utilized as needed. In most cases, the body habitus of children is much more amenable to changes of positioning given there smaller size. However, some older adolescents may approach or even surpass adults in weight and height. Head elevation (in either supine or prone position) will offer enhanced cerebral venous drainage and decreased overall cerebral blood flow. This position may also cause increased venous pooling in the lower extremities and postural hypotension in children, however. Conversely, the head down position will increase cerebral venous and intracranial pressure. This position may be beneficial during venous sinus injury, but will also result in decreased functional residual capacity and lung compliance. The prone position, one of the most common utilized in pediatric neurosurgery, often results in venous congestion of the face and neck, as well as venocaval compression. Head flexion should also be mentioned here, as this position is sought in many prone procedures.

Extreme flexion, however, should be avoided as this may lead to brainstem compression in those patients with certain mass lesions of the lower posterior fossa. This may also cause endotracheal obstruction from kinking or displacement to the carina or main stem bronchus. Likewise, extreme head rotation may impede venous return via the jugular veins and lead to increased intracranial pressure, impaired cerebral perfusion and venous bleeding.

Thermal Homeostasis

Maintenance of normothermia, with avoidance of both hypothermia and hyperthermia, is the goal of intraoperative thermoregulation. Neonates and infants are especially susceptible to hypothermia during surgical procedures due to their large surface area-to-weight ratio. Large head size relative to body size, thin skin, lack of subcutaneous fat, and limited compensatory mechanisms puts these patients at risk for rapid heat loss [2].

Hypothermia can be prevented warming the room to at least 23 °C (73.4 °F), ensuring the patient's temperature is at least 36 °C (96.8 °F) at surgical start and using warmed intravenous fluids. Patient insulation, forced-air warming devices, and circulating water mattresses are additional methods of preventing surgical hypothermia. It is vital to remember the importance of normothermia for adequate emergence from anesthesia, and the time required for rewarming even a mildly hypothermic child, especially a neonate or infant.

Head Immobilization Devices and Pediatric Patients

Head immobilization devices, such as the Mayfield skull clamp (Integra LifeSciences, Plainsboro, New Jersey), serve to immobilize the head during surgery and support pressure from surgical manipulation. While widely utilized in adult neurosurgery, immobilization device use in pediatrics is lower and remains a function of surgeon preference. Despite common availability, there are few reports of complications in the literature and virtually no guidelines for their safe usage in children. This has led to wide operational variability amongst surgeons, even within the same institution. Most commonly, infants under the age of 1 are not immobilized with a pinning device and pediatric size pins are utilized in patients under the age of 10. However, there is wide variability of practice in the pediatric neurosurgical community regarding the size of pins and torque screw reading (lbs) applied [3]. At our institution, for instance, immobilization devices are not utilized in patients less than 1 year of age and adult pins are used in all children who are placed in immobilization devices. The typical torque screw reading is variable, but we start at 10 lbs per year of age up to 50 lbs.

Due to weaker (thinner) bones of the skull, children are felt to be more susceptible to complications associated with head immobilization devices than adults [4]. Some complications of immobilization devices in children have been reported in the literature and include depressed skull fractures, epidural hematomas, pneumocephalus, and venous air embolism [5, 6]. It appears, however, that the overall rate of complications associated head immobilization device use is low. A recent, large retrospective study of MRI-compatible head immobilization device use in children revealed a complication rate of 0.7%, while conventional head immobilization device use yielded a 0.2% complication rate [7].

The presence of prolonged increased intracranial pressure tends to predispose children to complications while placing a head immobilization device. Prolonged increased intracranial pressure, typically chronic and on the order of months, can lead to decreased thickness of the cranial vault and thus higher incidence of pin-plunging with application, event at low torque screw pressures [8–10]. As a general guide, caution should always be observed while applying a head immobilization device in pediatric patients. Whenever possible, one should avoid using pin-type immobilization devices, if possible, and opt for a padded horseshoe-shaped headrest instead. While applying a device, certain warning signs should prompt one to stop and re-assess the safety of the patient (including neuroimaging). These include pins going too deep within the scalp/skull (pin plunge), cracking sounds, or a torque screw not reading properly or losing pressure.

Prone Positioning in Children

The prone position is frequently utilized in pediatric neurosurgery, most commonly for posterior fossa and spinal surgery. A spectrum of stretch injuries and compression issues can be associated with this position, in addition to the above-mentioned physiologic sequelae. Optimal prone position of a toddler is depicted in Fig. 16.1. This section will examine this position in detail.

Anesthesia is induced and all vascular access is obtained while the patient is in the supine position. A urinary catheter is placed if the procedure is expected to last longer than 2 h or if urinary output measurement is needed. It requires a careful and combined effort to flip the patient into the prone position, paying special attention to keep all lines and tubes intact. Typically, this maneuver is led by the anesthesiologist, with all members of the operating room team assisting. It should be noted that small body size does not always make for easier supine-to-prone transition, especially in neonates.

As mentioned above, the choice of head immobilization device is made on a case-by-case basis and a padded “U” shaped or horseshoe head holder should be utilized whenever possible. When using this immobilization device, care should be taken to avoid unnecessary compression

Fig. 16.1 Infant positioned prone on the horseshoe headrest. Note the supplementary padding added to the face area

of the eyes bilaterally. This is achieved by adjusting the width of the device and padding the face with additional foam as needed. With proper utilization, the horseshoe head holder can easily maintain a flexed head position without causing any untoward compression of the eyes or face. As mentioned above, care should be taken to avoid over-flexion of the head during prone positioning, which can lead to endotracheal tube issues and compression of the chin on the chest. Typically, at least one finger's breadth of clearance is needed between the chin and chest area. Over-flexion for extended periods can also lead to tongue edema due to blockage of venous or lymphatic drainage, which may cause post-extubation airway obstruction.

Padding is placed under the chest and pelvis to support the torso and minimize any increase in abdominal or thoracic pressure. This can be achieved in a variety of ways. In neonates and infants, two transverse-oriented padded rolls are fashioned from foam and sized appropriately to support the weight of the child. In children and adolescents, parallel-oriented chest rolls can be utilized as in adults. Ensuring free abdominal wall motion is imperative in either case, as increased abdominal pressure can lead to impaired ventilation, venocaval compression, and increased epidural bleeding.

Supplemental padding should be used liberally and placed under the elbows (prior to arm tucking, if necessary) and knees. It is important to remember thermoregulatory issues, and blankets and warmers can be added as necessary after padding is complete (Fig. 16.1).

Special Circumstances in Pediatrics

Neonatal Surgery

Most surgery on neonates is performed on an urgent basis and, as such, neonates tend to have higher perioperative morbidity than other pediatric age groups. Uncovering congenital anomalies, particularly of the heart and lungs, in the operating room may manifest as hypoxia and hemodynamic instability. This underscores the importance of easy access of the anesthesia team to the patient and should be planned for during positioning.

In particular, closure of a myelomeningocele presents unique problems for the operating room team. Tracheal intubation with the child in supine position may lead to rupture of membranes covering the exposed spinal cord (Fig. 16.2). However, supine intubation can be performed safely by supporting the child on "doughnut" or ring-shaped padding with the myelomeningocele in the center. Sometimes, for instance in the case of a large myelomeningocele, the lateral decubitus position can be utilized for intubation. Excision and repair of the myelomeningocele is performed in the prone position and can be

Fig. 16.2 Neonate positioned supine for myelomeningocele closure

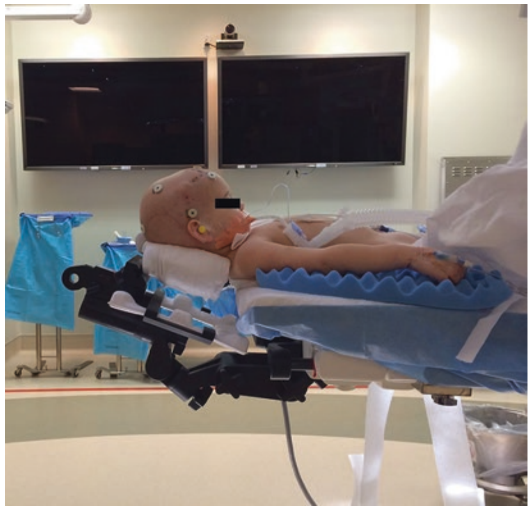

Fig. 16.3 A child positioned supine on the horseshoe headrest for an endoscopic procedure

combined with insertion of a ventriculoperitoneal shunt for hydrocephalus afterward in the supine position [11].

Hydrocephalus and Shunt Procedures

Hydrocephalus refers to an increased volume of CSF due to either over production or reduced uptake within the brain. The urgency of surgical intervention is related to several factors, most commonly raised intracranial pressure. The surgical management of hydrocephalus is CSF diversion from the ventricles to another body cavity, such as the peritoneum, pleural space, or right atrium. The placement of a VP shunt is the most commonly performed pediatric neurosurgical procedure. Alternatively, CSF diversion can be accomplished endoscopically, by performing a third ventriculostomy.

Preparation for VP shunt placement typically requires skin exposure from the head to the lower abdomen. As such, heat conservation strategies should be utilized, especially in premature newborns and neonates. The patient is positioned supine with the head turned to the opposite side of the proximal shunt. A padded roll is typically placed under the shoulders to elevate the torso for ease in tunneling the distal shunt tubing. The surgeon may need to manipulate the patient's head during the procedure (for instance, during ventricular cannulation) and the anesthesia team should be notified and prepared during this maneuver. The anesthesiologist may even want to manually hold the endotracheal tube in place under the surgical drapes. Intraoperative tunneling of the shunt tubing may be particularly stimulating, and the anesthesia team should be notified when this part of the procedure is happening to provide additional pain control.

Endoscopic third ventriculostomy surgery can be performed with the patient's head in a pin-type immobilization device or in a horseshoe headrest based on surgeon preference (Fig. 16.3). Frameless image navigation now makes rigid head fixation unnecessary.

Sometimes children present with severe, chronic hydrocephalus, with gross enlargement of the head (macrocephaly). This will present challenges to positioning, but also with airway management. The head may be a large proportion of the patient's body weight and thus must be supported appropriately when moving the patient. Intubation may need to be performed in the lateral decubitus position to avoid unnatural craniocervical manipulation. Otherwise, standard positioning approaches are utilized with emphasis on robust padding for the head.

Pediatric Brain Tumors

Brain tumors are the most commonly encountered solid tumor of childhood, and the majority of these lesions occur in the posterior fossa. Surgery for these lesions, therefore, almost always requires the prone position. At our institution, we have virtually eliminated the use of the sitting position for posterior fossa surgery in children. Rotation and elevation of the operating room bed may be required during the procedure and thus rigid head immobilization in pins is frequently used. All possible bed positions should be carefully tested prior to starting surgery to ensure patient safety, especially when multiple corridors of surgical approach are anticipated (Fig. 16.4).

Fig. 16.4 A child positioned prone in a head immobilizer for brain tumor resection. Note the planned incision includes a midline posterior fossa approach in combination with a retrosigmoid approach. This approach is utilized for large ependymomas. This will require significant lateral operative bed mobility

Surgery for Craniofacial Abnormalities

Craniosynostosis is defined as the premature closure of one or more skull sutures and usually occurs in otherwise healthy children. The best results are obtained if surgical repair is performed early in life, usually before 12 months of age. Surgery for cranial remodeling is varied and involves the removal of the part(s) of the skull vault by a neurosurgeon, followed by refashioning by craniofacial plastic surgeons. Typically, the patient is positioned supine with some degree of head flexion. The use of a horseshoe head holder may be useful and the chin should be padded between contact areas with the chest. Ocular lubricant should be placed in the eyes and eyelids taped shut (if possible) as the upper face may fall into the surgical field during these procedures. It is important to inspect all tape or occlusive dressings of the face below the orbital rim to avoid excessive facial edema. These procedures are associated with a significant loss of blood volume and perioperative transfusion is invariable required. Thus, ready access to all vascular lines is paramount.

Epilepsy Surgery

The surgical treatment of medically intractable epilepsy is common in children and may range from focal cortical resection, corpus callosotomy, or hemispherectomy, to placement of a vagal nerve stimulator. These procedures are typically performed in the supine position (rarely prone), often utilizing the horseshoe headrest (Fig. 16.5). However, it should be noted that these procedures are usually performed with a neurologist in the operating room during electrocorticography and

Fig. 16.5 A child positioned supine with padded shoulder roll on horseshoe headrest for resection of an epileptic focus

thus open access to the surgical field by the epilepsy monitoring team is necessary. At our institution, these procedures are typically performed in larger operating rooms to accommodate the increase in personnel.

Trauma

A small child's head is often the point of impact in traumatic injuries and craniotomy for trauma is a common procedure in pediatric neurosurgery. These procedures are typically performed in the supine position, with a padded roll placed under the ipsilateral shoulder to aid in head rotation (achieving a semi-lateral position). The head can be placed on a ring-shaped pad on the operating bed or on the horseshoe headrest. Although cervical fractures are less common in children than in adults, cervical spine immobilization remains essential to avoid secondary injury by manipulation of the patient's neck during positioning or airway during intubation.

Spine Surgery

The most common indication for laminectomy in pediatric patients is spinal dysraphism, and many of these patients have undergone previous myelomeningocele closure followed by several other procedures. Thus, release of a tethered spinal cord will often require electromyographic monitoring (including the anal sphincter) during surgery. The prone position is utilized with appropriate pressure point protection. As a result of increased cervical spine mobility in children, the head may be turned to one side and placed on a ring-pad on the operative bed during the procedure. Urinary catheters are usually placed and continued postoperatively, as these patients typically require bed rest for at least 24 h after surgery. Electromyographic electrodes are placed after the patient is moved into the prone position. A clear surgical drape is often utilized for direct visualization of the lower extremities if nerve root stimulation will be performed during surgery. It is important to discontinue or antagonize muscle relaxants to allow for adequate monitoring.

Conclusion

The positioning of pediatric patients for neurosurgical procedures presents unique challenges to the neurosurgeon, anesthesiologist, and ancillary operating room team. While the prone position is commonly encountered in pediatric neurosurgery, it has several nuances that differ from positioning in adult patients. A thorough understanding of age-dependent variables (such as thermal regulation) and proper positioning practices is essential for minimizing perioperative morbidity.

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