Chapter 36: Anesthesia at Pediatric Offsite Locations

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INTRODUCTION

FOCUS POINTS

1. When providing anesthesia at offsite locations, one should ensure adequate staff trained to assist the anesthesia provider, and a means to request further assistance when needed.
2. During all anesthetics, the patient's oxygenation, ventilation, circulation, and temperature (when clinically significant changes are expected) shall be continuously monitored.
3. The anesthetic plan will vary depending upon patient characteristics, past medical history, and the type of procedure or imaging modality. Commonly used anesthetics in offsite locations with no scavenging system include propofol, dexmedetomidine, benzodiazepines, ketamine, and opioids.
4. The length of stay following a procedure will be based upon the surgical procedure and/or imaging exam, as well as patient and anesthetic variables.
5. Providing anesthesia in the magnetic resonance imaging (MRI) area has unique challenges, due to the high magnetic field. MRI-compatible equipment is required, and the anesthesiologist assumes greater physical distance from anesthetized patients.
6. The shorter nature of most computed tomography (CT) scans, some of which do not require intravenous access, allow for variable anesthetic techniques.
7. Children may require anesthesia for general fluoroscopy, nuclear medicine, radiation therapy, and MEG (magnetoencephalography) scans, despite the usually non-painful nature of these imaging modalities. A short-acting anesthetic such as propofol and dexmedetomidine can provide adequate conditions for successful images.
8. Procedures in the interventional radiology suite can be both simple and complex, and patients can have significant comorbidities. The anesthesia provider anesthetizing in this area should be flexible, communicate well, and expect the unexpected.

The topic of "Offsite Anesthesia" or "Non-Operating Room Anesthesia" (NORA) is becoming increasingly common in the pediatric anesthesiology world. With the rising number of imaging modalities and non-invasive procedures being performed outside of the traditional operating room, anesthesiologists will be increasingly asked to provide care to pediatric patients—often times, in unfamiliar locales. Providing safe care is of top priority, and requires an in-depth knowledge of the patient, procedure, and an understanding of the logistics and limitations of the location itself.

GENERAL CONSIDERATIONS

Children or infants may require procedures and imaging exams at sites outside of the usual operating room environment. Imaging exams on non-movable equipment (MRI and CT), rare disease processes that require specialized treatment (radiation therapy) or providers with subspecialty skills and procedures requiring specialized equipment (interventional radiology), will require a traveling anesthesia provider. A qualified provider who is *comfortable with being uncomfortable* is ideal, as problems not typically experienced in the familiar operating room setting are likely. This traveling provider must pay the utmost attention to details, preferably have a good rapport with team members, and be prepared for adverse events which will inevitably occur.

Preoperative Evaluation

The ability to provide safe anesthetic care to a child begins with a thorough preoperative evaluation and a clear understanding of the patient's disease. This includes, in particular, assessment of the patient's airway, respiratory, and cardiovascular systems. A note from the referring physician is helpful in ascertaining why the procedure or imaging exam is being performed. The patient's family should be contacted a day or two before the procedure by telephone, to review any changes in the medical history, discuss day-of-procedure medication administration, and ensure an understanding of non-profit organization (NPO) guidelines. For unfamiliar parents, a brief description of what to expect on the day of the procedure can be helpful in allaying any pressing concerns.

Patients scheduled for procedures and imaging exams as an outpatient may have recently seen their primary care physician, who may mark them "cleared for anesthesia." This "clearance" needs to be taken with caution, as it is ultimately at the discretion of the anesthesiologist whether or not the patient is truly ready on the day of the anesthetic. To avoid confusion and potential frustration by the patient, family, and ordering provider, it can be recommended that patients with a significant past medical history have an appointment in a pre-anesthesia clinic to compile any relevant history, results of tests, and labs, to perform a physical exam, and to assess their readiness for anesthesia. Patients with complex medical histories and/or preterm infants may also need arrangements for admission with observational status.

For patients with less complex past medical histories, and/or patients having simple imaging exams or procedures, the responsibility of the history and physical rests exclusively on the shoulders of the anesthesiologist. Performing a chart review of previous anesthetics is useful. In particular, it is important to look at prior intraoperative airway information, vital signs, drugs used, any pertinent intraoperative notes, as well as the immediate postoperative documentation in the Post-Anesthesia Care Unit. For returning patients, talking with them about prior anesthetics can help guide current anesthetic plans, basing technique upon past successes and failures.

Location Set-up Requirements

The American Society of Anesthesiologists (ASA) has published *Standards, Guidelines, and Practice Parameters*, which can be found on the ASA Web site.[1] Its "Statement on Non-operating Room Anesthetizing Locations" updated in October 2013, includes minimal guidelines for all anesthesia personnel providing care to patients outside of the operating room. These guidelines include the following:

- A reliable source of oxygen available for the entire procedure (centrally-piped oxygen source strongly encouraged), as well as a backup oxygen supply, which should include the equivalent of, at a minimum, a full E-cylinder.
- A reliable and adequate suction source (one that meets operating room standards is strongly encouraged), with appropriate suction tubing and apparatus
- A reliable and adequate scavenging waste system during the use of inhalational anesthetic gases
- A self-inflating hand resuscitator bag able to deliver at least 90% oxygen and positive-pressure ventilation
- Adequate anesthetic drugs, supplies, and equipment to care for the patient
- Adequate monitoring equipment to adhere to the ASA "Standards for Basic Anesthetic Monitoring" (Table 36-1)

Table 36-1

ASA Standard Basic Anesthetic Monitoring Guidelines

1. Qualified anesthesia personnel shall be present in the room throughout the conduct of all general anesthetics, regional anesthetics, and monitored anesthesia care.
2. During the conduct of all anesthetics, the patient's oxygenation [inspired gas (oxygen analyzer) and blood oxygenation (pulse oximeter and color)], ventilation (continuous observation, $ETCO_2$ analysis, circuit disconnect alarm), circulation (continuous ECG, BP, and HR measured at least every 5 minutes), and temperature (when clinically significant changes are expected) shall be continually evaluated.

Additionally, the guidelines include minimal requirements with respect to electrical outlets and the provision of emergency power supply; adequate illumination of the patient, machine, and equipment, as well as a back-up battery-powered source of illumination (other than a laryngoscope); sufficient space to accommodate the patient, equipment, and caregivers; and pediatric emergency equipment and drugs to provide cardiopulmonary resuscitation.

Personnel

As with caring for any patient, but particularly with offsite pediatric anesthesia, there should be adequate staff trained to assist the anesthesia provider, and a means to request further assistance. This includes trained personnel to assist transporting the patient from one location to another, and a continuation of appropriate basic anesthetic monitoring. It should be strongly recommended that personnel involved in caring for patients during an anesthetic (including transporting the patient during emergence) be Pediatric Advanced Life Support (PALS) certified.

Choice of Sedative Medications/Anesthetic Plan

The anesthetic plan will vary depending upon patient characteristics, past medical history, and the type of procedure or imaging modality. Patients may or may not require a peripheral intravenous line for the procedure and/or imaging exam, which may alter the anesthetic plan. This will also vary based upon the specific offsite location. For example, a volatile agent cannot be administered in a location with no available scavenging system. Common anesthetics and their reversal agent (when applicable) should be immediately available and easily administered.

As with any anesthetic, a back-up (and a secondary back-up) plan should be considered. While providing offsite anesthesia, preparation is crucial. An anesthesiologist may need to allow for significant additional time for the delivery of drugs, equipment, or even emergency help.

Postoperative Care

Like the anesthetic plan, the exact location of the postoperative care of the patient will vary depending upon patient characteristics, past medical history, and type of procedure or imaging exam. Certain patients and procedures will necessitate the care and monitoring provided in an intensive care unit. Others may require the commonly used Phase 1 recovery in the Post-Anesthesia Care Unit. Still others may emerge quickly enough from their anesthetic that they may bypass Phase 1 and go directly to Phase 2 care.

Transportation of the patient after conclusion of the procedure can be risky, especially if the procedure and recovery area are separated by distance and include the use of elevators. The patient should have standard monitors in place, and the provider should bring a mask, anesthesia bag, and full E-cylinder oxygen tank. The provider should also consider bringing any emergency medications that may be necessary to administer during the transport.

The length of stay following a procedure will be based upon the surgical procedure and/or imaging exam, as well as patient and anesthetic variables. Overnight admission as an observational status for airway monitoring, cardiopulmonary monitoring, and pain control is reasonable. Another indication for overnight observation would be young gestational age, with infants ≤60 weeks post-conceptual age qualifying based upon their increased risk for apnea and bradycardia. This is particularly important in formerly premature infants, and especially in those receiving opioids. In the general anesthesia spinal (GAS) study, which compared infants aged 60 weeks or younger receiving either general anesthesia or spinal anesthesia for inguinal herniorrhaphy, the infants were monitored for apnea up to 12 hours postoperatively. The overall rate of apnea in this trial was 3%, with a greater risk of apnea (6%) in premature infants.[2] A conservative approach would be to monitor patients younger than 60 weeks post-conceptual age for at least 12 hours post-procedurally for apnea and bradycardia. This time period can be altered at the discretion of the supervising anesthesiologist, especially for extremely short anesthetics, or those in which opioids were not administered.

RADIOLOGY IMAGING LOCATIONS AND CONSIDERATIONS

Radiological imaging modalities are used for diagnostic and therapeutic purposes in children of all ages with widely varying systemic illnesses. An understanding of the physics of radiation and imaging modalities will better prepare the anesthesiologist to keep themselves, and their patient, safe. The anesthesia provider can learn basic fluoroscopy safety, by textbook or journal review, or by completion of a fluoroscopy safety course, available on the Internet.

MRI

Children that require MRI will often require anesthesia, due to the length and enclosing nature of the scanner. The high magnetic field present in the MRI environment poses challenges to the anesthesia provider, as completion of the scan requires normally functioning equipment that will not cause image-altering electrical interference.

MRI-compatible anesthesia machines, monitors, and infusion pumps are all available and will be required to safely administer anesthesia, as will equipment including laryngoscopes and their batteries, stethoscopes, and IV poles. MRI-compatible equipment can be safely used outside of the 50-gauss line, which is usually marked on the floor of most MRI rooms, but should be verified with the hospital's biomedical department.[3] ASA Standard Basic Anesthesia Monitoring guidelines should be followed, which will require magnet-safe pulse oximetry probes and cables, electrocardiogram leads, and temperature probes. Respiratory and end-tidal CO_2 monitoring can be accomplished by using a nasal cannula, and is extremely important in a patient that is distant from the anesthesia provider. Care providers are required to follow safety measures and remove all metal from themselves, including pagers, scissors, and even hair clips, as they can act as missiles as they are attracted into the magnet.

The length of the MRI will vary, with a usual range of 45 to 90 minutes. Several techniques can be used to provide safe and effective anesthetic care—all will ideally create an immobile, spontaneously breathing patient, who will have minimal postoperative nausea and vomiting, a rapid emergence, and be ready for a quick discharge. For young patients without a peripheral IV (PIV), the author either induces anesthesia with sevoflurane to allow placement of a PIV while the patient is unconscious, or uses a needle-free, subcutaneously injected buffered lidocaine system, the J-tip, to anesthetize the skin prior to PIV placement. For extremely anxious patients, oral midazolam, 0.3 to 0.5 mg/kg, can be given to allow a smoother induction. TIVA (total intravenous anesthetic) is then followed by one of two techniques. One effective technique is the use of a continuous propofol infusion. Most pediatric patients require an infusion rate of approximately 200 mcg/kg/min to assure immobility, assuming a non-instrumented airway.[3] Frankville and colleagues describe a similar technique, however, using a loading dose of 2 mg/kg of propofol, followed by a continuous infusion of 100 mcg/kg/min.[4] The author of this chapter uses a combination of the two techniques, giving a propofol bolus dose of 1 to 2 mg/kg, followed by an infusion of 100 to 200 mcg/kg/min, titrated to vital signs while maintaining an unobstructed, spontaneous airway.

The use of dexmedetomidine as a sole anesthetic agent for MRI has been employed and studied in the pediatric population. In 2005, Koroglu et al described the use of IV dexmedetomidine providing adequate sedation in children ages 1 to 7 years for MRI, without adverse hemodynamic or respiratory effects.[5] In 2006, they compared dexmedetomidine (1 mcg/kg initial dose, followed by 0.5 mcg/kg/min continuous infusion) versus propofol (3 mg/kg initial dose, followed by continuous infusion of 100 mcg/kg/min), finding dexmedetomidine to be a reliable sedative drug in certain patients.[6] Similarly, Mason et al described their high-dose technique of using a 10-minute IV bolus of 3-mcg dexmedetomidine followed by a continuous infusion of 2 mcg/kg/h, which allowed for adequate sedation without significant adverse sequelae.[7]

Another effective method commonly used at the author's institution involves a combination of dexmedetomidine and propofol. An IV bolus dose of 1 mcg/kg of dexmedetomidine over 10 minutes, combined with a single-bolus of 1 to 2 mg/kg of propofol, is used to induce anesthesia. Careful attention to the airway and vitals during this induction phase is important, as commonly described bradycardia may occur with administration of dexmedetomidine, particularly in children less than 12 months of age.[8] This regimen will occasionally require intermittent propofol bolus doses (0.5 to 1 mg/kg) for scans requiring table movement, patient repositioning, or when the radiology nurse manipulates the PIV for contrast injection, especially as the 45-minute mark approaches. While slightly more involved, this technique has the potential benefit of a wide-awake patient at the conclusion of the scan, who bypasses the extended recovery phase of anesthesia and is ready for a prompt discharge.

Patients may occasionally require placement of an oropharyngeal or nasopharyngeal airway to maintain an unobstructed airway. A supraglottic airway or endotracheal tube might also be placed for airway obstruction or airway protection. Both cardiac MRI and MRI angiography may require intermittent breath-holding during certain image sequences. This necessitates not only a secure airway, but commonly the administration of a muscle relaxant. It will also require the anesthesia provider to be physically in the scanning room during specific imaging sequences, to pause mechanical ventilation and/or administer medications (e.g. propofol) to temporarily induce apnea, while closely monitoring the patient.

CT

Children require computed tomography (CT) imaging for the evaluation of many disease processes. Children from the ages of a few months old through ages 3 or 4 will often require some type of anesthesia to allow scan completion. It is reasonable for skilled pediatric CT technicians and nurses to first attempt short scans without sedation (the practice at the author's institution). The importance of distraction techniques and a friendly disposition cannot be overemphasized at this point. A child-life specialist, or "professional distractor," can be extremely useful during this attempt.

If the child and/or parent is unwilling to attempt the scan without sedation, and/or fails the nonsedated attempt, an anesthesia provider may be necessary. A brief, but thorough history and physical should be performed, and the anesthetic plan discussed with the parent or guardian. In the case of scheduled scans, the anesthesia provider ideally has access to the proposed scans ahead of time, allowing for a complete review of the medical record.

Types of anesthetics may vary for these scans, depending upon the length of the scan, patient comorbidities, or need for IV access (for injection of iodinated contrast and angiogram imaging). The type of anesthetic commonly used at the author's institution for short CT scans is a mask induction with volatile agent. For brief scans without contrast injection, it may be possible to perform the scan quickly following completion of the induction phase. For longer scans, anesthetic maintenance can be achieved using volatile agent or TIVA. A continuous technique using the anesthesia mask and careful placement of a mask-strap keeps the anesthetic depth constant and simultaneously allows for monitoring of $ETCO_2$ in a spontaneously ventilating patient. Alternatively, once an adequate depth of general anesthesia is achieved following mask induction, volatile agent can be administered intermittently by mask, with use of a nasal cannula to monitor $ETCO_2$. This requires the anesthesia provider and CT technician to be in close communication with one another, as the timing of the scans could interfere with the need for patient intervention, for example, deepening the anesthetic or airway manipulation. Patient histories, physical characteristics and history of snoring or sleep apnea may influence the anesthetic plan, and placement of a supraglottic airway or endotracheal tube is sometimes necessary. Total IV anesthesia with propofol can also be used successfully, by either intermittent injection or continuous infusion, and is perfect for the short duration of most CT scans. In rare cases, the anesthesiologist may have to wear lead protection and remain present during the scan, usually for airway monitoring.

If a peripheral IV is required, as is in the case for injection of iodinated contrast and angiography, the IV anesthesia can be placed in the holding area, preferably using a local anesthetic vapo-coolant (freeze spray) or local anesthetic via jet-injector (J-tip lidocaine). Alternatively, it can be placed after inhalation induction by mask. It should be noted that while some patients may tolerate placement of the PIV, they may have a difficult time tolerating the physical injection of the intravenous contrast media. The feeling of IV contrast being injected by bolus has been described as a mild, warm flushing at the site of injection, which spreads over the body and may be particularly intense in the perineum. Patients may also experience nausea, headache, flushing, itching, and/or a metallic taste.[9]

Fluoroscopy

The anesthesia provider will occasionally be contacted to assist with imaging exams in the General Fluoroscopy Department. Commonly encountered exams in this area include barium enemas, as well as simple radiographs of extremities, the head and neck, and chest. Autistic patients with developmental delays or physically stronger patients (often adolescents or young adults) may require sedation for even the briefest of exams. Utilization of an oral anxiolytic, such as diazepam, prescribed by the patient's primary care physician, can be given to patients described as "difficult to get into the hospital without getting upset," and may be sufficient to allow exam completion. If insufficient, intramuscular injection with ketamine and/or midazolam, or inhalational volatile anesthetic technique can be employed. The latter technique will require a scavenging system for exhaled gases, and therefore may be less feasible. Additional assistants, care providers, or security personnel may be required with older (and heavier) patients who are combative.

Nuclear Medicine

Nuclear medicine technology is used for patient requiring diagnostic scans for various disease processes, including bone abnormalities (infection, tumor, or fracture), metastatic tumors (PET—positron emission tomography), urologic abnormalities (Lasix–Rena scan), gastrointestinal bleeding, brain, heart and lung function, and others. A peripheral IV is usually required for injection of a radioactive agent. After injection, a specified amount of time is required to pass until a body scan is performed. For most scans, there is zero stimulation during the scan itself, similar to other radiographic imaging. For all scans, it is a requirement that the patient is motionless, in part due to the very narrow scanner dimensions, but also because excessive movement may require the scan to be recompleted in its entirety. The scanner itself emits no radiation; therefore, the anesthesia provider may be present in the room during the entire scan.

Like other imaging procedures described in this chapter, the anesthetic technique will vary depending upon patient characteristics, and type and length of the scan. Most scans will be 45 minutes to an hour in length. Any provider skilled in peripheral IV placement can place the line. The child may be allowed to temporarily leave the Nuclear Medicine Department following injection of radioactive material if the scan requires a time delay, but adherence to strict NPO guidelines must be stressed, as well as ensuring the PIV is safely secured and will not be removed, either inadvertently or intentionally by the child. When the patient returns for the scan, anesthesia is commonly maintained at the author's institution using propofol (by continuous infusion) or dexmedetomidine. As described in the MRI section of this chapter, a bolus dose of 1 mcg/kg of dexmedetomidine over 10 minutes, combined with a single-bolus of 1 to 2 mg/kg of propofol at induction, is usually sufficient to complete the 45- to 60-minute painless scan. The patient may require an intermittent propofol bolus (0.5 to 1 mg/kg), especially as the 45-minute mark approaches. This technique has the potential benefit of a wide-awake patient at the conclusion of the scan, who may bypass the extended recovery phase of anesthesia and is ready for a prompt discharge.

Nuclear medicine bladder scans require placement of a urinary catheter to monitor elimination of radioactively detected urine. The radioactive material is injected *after* securement of the PIV and urinary catheter and the scan begins immediately. If a scavenging system is available, this could allow induction of general anesthesia by inhalational technique to facilitate PIV and urinary catheter placement, which are both painful and anxiety-provoking. The maintenance of anesthetic can be with propofol and/or dexmedetomidine, as described above.

Interventional Radiology

Procedures in the interventional radiology suite can vary from simple peripherally inserted central catheter (PICC) lines to interventions for patients with complex medical problems. Commonly performed procedures in this offsite location include diagnostic and therapeutic cerebral angiography, venography, sclerotherapy of lymphatic and vascular malformations, soft-tissue, bone, and organ biopsies, drain and tube placements, lumbar punctures, placement of larger intravenous catheters (tunneled central lines), joint steroid injections, and placement of nasogastric and nasojejunal feeding tubes. The variability of patient comorbidities and status can be dramatic. The proceduralists may vary from physicians, to physician assistants, to nurse practitioners. The anesthesia provider in this area should be flexible, communicate well, and expect the unexpected.

The anesthetic plan in the interventional radiology suite widely varies. Length of procedure, patient age, comorbidities, and maturity level will naturally affect the anesthetic choice.

Sedation, ranging from light to moderate, may suffice for simple procedures such as placement of PICC lines, peripheral joint aspirations/steroid injections, lumbar punctures, and placement of nasogastric and nasojejunal feeding tubes. Oral (benzodiazepines) or intravenous (benzodiazepines, opioids, ketamine, propofol, dexmedetomidine) medications are reasonable choices. Deeper sedation, and potentially general anesthesia, may be required for more painful procedures, such as bone and organ biopsies, tunneled central lines, and drain placements for abscesses.

Spontaneous versus controlled ventilation, and anesthesia with or without an airway will be determined by procedure type, length, and patient factors. Airway anatomy and physiology, patients with a full stomach, or those that are vomiting may necessitate placement of an endotracheal tube. An endotracheal tube is also necessary during procedures requiring manipulation of the end-tidal CO_2, such as cerebral angiograms and neurointerventions, which may require vasoconstriction or vasodilation of cerebral vessels. Angiography may additionally require intermittent breath-holds, necessitating controlled ventilation. This can be achieved with administration of either a muscle relaxant or a bolus of propofol.

During certain cerebral embolization procedures, as with injection of glue for arterial-venous malformations, the interventionalist may ask for a brief complete cessation of blood flow. The goal is to slow the flow through arteriovenous malformation feeding artery and to prevent systemic embolization of glue.[10] It is reasonable to first attempt this with a bolus of propofol to cause temporary hypotension and reduced blood flow. Use of sodium nitroprusside has also been described by Sinha and colleagues. If these techniques are insufficient, it may be required to administer incremental doses of intravenous adenosine to cause transient asystole. Cutaneous pacemaker should be readily available. Some advocate placement of cutaneous pacemaker pads prior to adenosine administration. While arterial line placement is not necessary for all interventional radiological procedures, it is absolutely recommended in cases requiring controlled hypotension.

It is common for larger pediatric hospitals to have a dedicated interventional radiology suite. The specialty though has diverse training and subspecialties, and a particular pediatric interventional radiology physician may not have subspecialty training in a particular disease process. While relatively uncommon, an example of this would be a child presenting with an acute thrombotic stroke requiring angiographic thrombus–directed tPA administration. At the author’s institution, the adult interventional radiologist travels to the pediatric hospital to provide emergency intervention. The anesthetic care of an emergent procedure such as this will require an established plan and critical communication, as multiple systems interact during the care of the patient, all while under time pressure.

Anesthetic emergence of patients at the interventional radiology suite may differ from those commonly cared for in the operating room. Placement, and subsequent removal, of large-bore sheaths for the procedure leaves puncture sites that are at increased risk of bleeding. Both intravenous and intra-arterial techniques are utilized, making bleeding risk variable, but nonetheless introduce the potential risk for significant postoperative hematoma and limb ischemia. Sheath sites and peripheral pulses will need to be monitored in the postoperative phase of care. Patients will need to remain flat and immobile for an extended period of time, occasionally for up to 4 to 6 hours. For the young and high-risk patients, it can be helpful to use dexmedetomidine, by either bolus or continuous infusion, to maintain post-procedural sedation at least for the first hour, when bleeding risk is greatest. A continuous infusion of dexmedetomidine will require continuous one-on-one monitoring by an experienced care provider, usually in an intensive care unit.

OTHER OFF-SITE ANESTHETIC LOCATIONS

Radiation Therapy

In all but the largest of pediatric hospitals, radiation therapy for oncologic diseases will occur at offsite locations, usually at adult hospitals. Targeted therapy for brain and brainstem tumors as well as intra-abdominal and pelvic tumors (neuroblastoma and sarcoma) are common. Conventional radiotherapy, shaped-beam radiotherapy, gamma knife, and high-energy proton beam therapy (cyclotron) have all been used in children, and have similar monitoring and anesthetic requirements.[3] The imaging and treatment, while non-stimulating and brief, can be accompanied by potential adverse events, as oncologic patients can be some of the most critically ill cared for by anesthesiologists.

Treatments are performed daily, often over a period of 4 to 6 weeks. The treatment itself may only last 5 to 10 minutes, but the patient will be required to be immobile during its entirety. Patients will have long-term intravenous access in situ, usually a tunneled central line or port. Adherence to sterile techniques with manipulation of these lines is of critical importance, due to the patient’s likely immunocompromised state. Anesthetics are generally intravenous based, as there are rarely scavenging systems in radiation therapy locations. Propofol, by either continuous infusion or intermittent bolus, is commonly utilized. For patients presenting with depressed mental status but still requiring some form of sedation to remain still, an intravenous midazolam or dexmedetomidine bolus may suffice.

A unique consideration in patients having radiation therapy is the requirement that all personnel must be evacuated from the radiation room during the treatment phase. This will require continuous live video monitoring of the patient and vital signs. Minimal monitoring guidelines, established by the American Society of Anesthesiologists (ASA) in the “Statement on Non-operating Room Anesthetizing Locations,” must be followed at all times.

Magnetoencephalography (MEG) Scans

This imaging technique is used to produce a magnetic source image to pinpoint seizure focus in patients with a refractory seizure disorder. Used in conjunction with MRI, the MEG scan allows a more accurate mapping of seizure foci. Compared to electroencephalography (EEG), the scan allows better spatial resolution in epilepsy foci localization.[11] The scanner is used to detect and amplify magnetic signals produced by the brain without emitting radiation or magnetic fields as do CT and MRI.

Children requiring MEG scans may require anesthesia for portions of the scan to allow completion. Propofol, which would be a natural choice, can produce high-frequency artifacts, making interpretation of the data by the neurologist difficult. A case series of patients reported in *Pediatric Anesthesia* by König from Cincinnati Children's Hospital describes a successful anesthetic technique using dexmedetomidine, which minimizes the interfering interictal activity.[11] They report using dexmedetomidine as the primary technique, either after sevoflurane induction to allow PIV placement or with an existing PIV line. Loading doses of 1.5 to 2 mcg/kg followed by infusions of 0.8 mcg/kg/h are reported in their case series. A similar technique is utilized at the author's institution, with good success.

Anesthetizing on the Wards

Anesthesia providers will occasionally be asked to provide sedation for children requiring procedures such as lumbar puncture, nasogastric tubes, and dressing changes. Some procedures may be considerably painful, and some patients may have repeated procedures on sequential days. The goal for these procedures should be to complete them with the minimal amount of stress as possible while keeping the patient safe. Anesthetic choice should be tailored to the procedure and any relevant patient comorbidities.

Critical Care Unit

Postoperative patients being managed in the critical care setting often require further procedures but may not be stable enough for transfer to the operating room. Cardiac patients requiring cardioversion, or those with an open chest requiring closure, may be best suited to have a bedside procedure. Neonatal patients can have specialized management strategies, including high-frequency oscillation ventilation (HFOV), which make transportation difficult.

Neonatal emergency surgery may also require bedside procedures, which will require a mobile anesthesiologist. Space is often limited and time is crucial. Communication is vital when this occurs, as there will be many providers involved—surgeons, surgical technicians, anesthesiologists, nurses, anesthesia technicians and possibly trainees.

REFERENCES

1. *Standards, Guidelines, and Practice Parameters*. Available at www.asahq.org.

2. Davidson AJ, Morton NS, Arnup SJ et al. Apnea after awake regional and general anesthesia in infants: the general anesthesia compared to spinal anesthesia study—comparing apnea and neurodevelopmental outcomes, a randomized controlled trial. *Anesthesiology*. 2015;123(1):38–54. [PubMed: 26001033]

3. Holzman RS, Mancuso TJ, Polaner DM. *A Practical Approach to Pediatric Anesthesia*. 2008; Philadelphia, PA: Wolters Kluwer Health/Lippincott Williams & Wilkins.

4. Frankville DD, Spear RM, Dyck JB. The dose of propofol required to prevent children from moving during magnetic resonance imaging. *Anesthesiology*. 1993;79:953–958. [PubMed: 8239013]

5. Koroglu A, Demirbilek S, Teksan H, Sagir O, But AK, Ersoy MO. Sedative, haemodynamic and respiratory effects of dexmedetomidine in children undergoing magnetic resonance imaging examination: preliminary results. *Br J Anaesth.* 2005;94(6):821–824. [PubMed: 15764627]

6. Koroglu A, Teksan H, Sagir O, Yucel A, Toprak HI, Ersoy OM. A comparison of the sedative, hemodynamic, and respiratory effects of dexmedetomidine and propofol in children undergoing magnetic resonance imaging. *Anesth Analg.* 2006;103(1):63–67. [PubMed: 16790627]

7. Mason KP, Zurakowski D, Zgleszewski SE et al. High dose dexmedetomidine as the sole sedative for pediatric MRI. Pediatric *Anesthesia*. 2008;18(5):403–411. [PubMed: 18363626]

8. Estkowski LM, Morris JL, Sinclair EA. Characterization of dexmedetomidine dosing and safety in neonates and infants. *J Pediatr Pharmacol Ther.* 2015;20(2):112–118. [PubMed: 25964728]

9. Singh J, Daftary A. Iodinated contrast media and their adverse reactions. *J Nucl Med Technol.* 2008;36(2):69–74. [PubMed: 18483141]

10. Sinha PK, Neema PK, Rathod RC. Anesthesia and intracranial arteriovenous malformation. *Neurol India*. 2004;52:163–170. [PubMed: 15269462]

11. König MW, Mahmoud MA, Fujiwara H, Hemasilpin N, Lee KH, Rose DF. Influence of anesthetic management on quality of magnetoencephalography scan data in pediatric patients: a case series. *Pediatric Anesthesia*. 2009;19: 507–512. [PubMed: 19453583]