

CHAPTER 13

SPECIALIZED OPERATING ROOMS

Authors: Timothy S. J. Shine, MD, Department of Anesthesiology, Mayo Clinic, Jacksonville, FL; Bruce J. Leone, MD, Department of Anesthesiology, Mayo Clinic, Jacksonville, FL; David L. Martin, PE, Campus Planning and Projects, Mayo Clinic, Jacksonville, FL

Orthopedic Operating Rooms Authors: Sital Bhavsar, MD, Hospital for Joint Disease, New York, NY, and David Albert, MD, Hospital for Joint Disease, New York, NY

Pediatric Operating Rooms Author: Gordana Stjepanovic, MD, New York University School of Medicine, New York, NY

Introduction

The increasing complexity of procedures and patients has resulted in an increase in the monitoring and support systems required in specialized operating rooms (ORs). Considerations should include: 1) the size of the room; 2) the room orientation (the long axis is the orientation of the operating table, and the short axis is 90° to the long axis); 3) medical gases needed; 4) number and locations of electrical and medical gas outlets; 5) access to the room; and 6) location of the room. The planning process can be divided into four steps: programming, schematics, design development, and construction documents. The goal of programming is to determine the requirements of all users of the room, how much space will be required, and the optimal orientation of the room. Schematics are diagrams that define the relationship of the different spaces to each other and are usually prepared from the programming by the architect. Frequently, the diagram must be revised to accommodate flow. If scheduling dictates, schematics and programming may concurrently take place, but this is not suggested. The design development stage needs to be very specific, addressing the location of doors, lights, clocks, ventilation diffusers, electrical and medical gas outlets, millwork, scrub sinks, etc. Finally, technical diagrams and construction documents are created by an architectural design team and reviewed by the end user for completeness. Once all comments have been noted in the document set, the drawings are assembled, sent out for pricing, and then constructed.

Space Requirements

A standard OR occupies 400 sq ft. A room for cardiac procedures may require 600 sq ft, and a specialized OR for transplants may require 750-800 sq ft. Where possible, the room needs to have a clear area around the periphery. This may be achieved by using utility booms. The number of items placed against the wall should be limited to provide safety for staff and patients, with less risk of a plug being inadvertently disconnected. It is important that access is possible without crossing sterile areas.

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Different needs for equipment require additional space, so having some idea of the space required is useful in the programming and design development phase. In addition to machines, standard monitors, and intravenous infusion pumps, space allotment for additional monitors and supportive devices needs to be considered. Many liver transplant patients require some form of intraoperative renal replacement therapy (e.g., continuous venovenous hemofiltration [CVVH]), usually a continuation of therapy that was started in the intensive care unit (ICU). This requires a minimum of 16 sq ft for the machine and operator on the right-hand side of the head of the bed. Nitric oxide administration requires a 4 × 4 ft space at the right side at the head of the table. The anesthesia machine requires a minimum of 10 sq ft. A standard anesthesia cart with storage space requires a 2 × 5 ft space, while a double cart requires a 2 × 7-ft space. A transesophageal echocardiography (TEE) machine requires a 4 × 2 ft space. Rapid infusion machines require a 2 × 2 ft space. An airway cart requires a 3 × 2 ft space.

Access to the room needs to consider the size of the patient bed and any support equipment that may be brought into the room with the patient, such as a ventricular-assist device, balloon pump, etc. Having the entrance door at the head of the bed gives immediate access to the anesthesia workplace. A dual-leaf opening with an active 4-ft leaf and passive 2-ft leaf has proven adequate. Having appropriate support beams in the ceiling to bear the load of ceiling-mounted equipment (e.g., fluoroscopy screens; ceiling-mounted supports for microscopes; fluoroscopy lights on articulated arms; booms with medical gases, electrical outlets, suction, and data jacks; etc.) needs to be considered in the programming stage. Trying to install these supports after the fact may result in the support being too low and the ceiling-mounted devices being potential obstructions.

Cardiac and Specialized Transplant Operating Rooms

Having the transplant rooms close to the cardiac rooms provides easier access for support services and services provided by specialized nursing. Ease of access to the cardiac catheterization laboratory, invasive radiology suites, blood bank, laboratories, and ICUs should be considered. Wide-access corridors will make transporting patients needing life-preserving technologies (e.g., balloon pump, ventricular-assist devices, etc.) to these rooms and the ICU easier and safer. Entrance doors should be at least 6-ft wide. Ceiling-mounted monitors and video screens allow easier access, create less floor clutter, reduce the number of wires running across the floor, lessen the risk of blowing fuses, and increase safety for OR personnel. An induction/line placement room adjacent to the OR allows the patient to be brought to the OR with lines in place, the patient being prepared while the OR is being prepared for the surgery (i.e., parallel processing). For complex pediatric and adult cardiac surgery (when deep hypothermic cardiopulmonary bypass is required), a system for rapid heat exchange needs an ice supply for transplant organ preservation, cooling devices, etc.

Liver transplant patients may require some form of intraoperative renal replacement therapy. Usually a continuation of therapy that was started in the ICU, CVVH requires a minimum of 16 sq ft for the machine and operator on the right-hand side of the patient at the head end of the bed. Space for bench surgery on the donated organ space for operating area and storage of the donated organ in ice will add 6 to 8 ft to the long axis of the OR table.

Requirements for Perfusionists

Listing the needs for electrical supply, medical gases, and vacuum gives an estimate of the minimum electrical and medical gas outlets and vacuum inlets needed. Such a list should include, but is not limited to, the following:

- The heart-lung machine needs an electrical plug, preferably on a dedicated circuit so the machine does not impact another device.
- The cardioplegic pump requires its own electrical plug.
- The heater-cooler system needs its own electrical plug.
- The cell saver needs its own electrical plug.
- A TEE machine draws a large electrical load and should not be plugged into the same circuit as the life-preserving pumps, ventricular-assist devices, and intra-aortic pumps.
- An intra-aortic pump or ventricular-assist device may require a dedicated electrical circuit to avoid disrupting power to other devices.
- The perfusionist may need to check the accelerated clotting time or other measure of the adequacy of heparinization, which may require an electrical plug.
- A space of at least 8 × 8 ft will be required for the perfusionist and his/her equipment. The perfusionist space is in the short axis of the operating table and, thus, adds to the short axis width by a minimum of 9 ft.
- At least three vacuum outlets (two vacuum and one waste anesthetic gas outlet) will be required for scavenging anesthetic gases and the cell saver.

Neurosurgical Operating Rooms

In addition to the usual space requirements for a standard OR, additional space around the operating table may be needed for new technologies (e.g., a Stealth navigation system) used by neurosurgeons. The Stealth system requires a 3 × 3 ft space, and the detection system, which is on a stand close to the patient's foot, needs minimum of 8 sq ft so that the system is not moved or bumped. Motor-evoked potentials and somatosensory-evoked potential (SSEP) monitoring systems require space for the monitor, the operator, and an electrical outlet. Fortunately, electroencephalography and SSEP machines are becoming smaller. A data jack port will be necessary for information storage. Spinal surgery requires a large nursing back table for the array of screws and other hardware that the surgeon needs to choose from during the case. The specialized Jackson table that sandwiches the patient between supports will require space.

Other Specialized Operating Rooms

Laparoscopic and Robotic Surgery Rooms

An OR designed for laparoscopy and thoracoscopy improves productivity and convenience. Laparoscopic rooms ideally have piped carbon dioxide (CO₂) to inflate the abdomen so that personnel do not need to handle a CO₂ tank. Lasers often have special electrical requirements and may need special electrical circuits. Robotic surgery requires a 5 × 5 ft space at the foot of the table where the robot is placed. The console where the surgeon controls the robot is set off to the periphery of the room, either on one side or behind the anesthesia equipment, and requires a 6 × 6 ft space. Ceiling- or wall-mounted screens allow easy visualization of the laparoscopic or robotic images and decrease the need to move rolling carts with screens in and out of the room. Care must be taken to ensure that booms for the surgical lights and screens can be moved into the appropriate positions required by the procedures to be performed in the specific room and will not interfere with other equipment in the room. Using computer software or mocking up a demonstration room should be encouraged since visualization of actual sight lines and competition for space by both equipment and staff is difficult to visualize on architectural plans.

If multiple screens are being mounted from equipment booms, serious consideration should be given to designating one screen as a slave for the anesthesia monitor, enhancing the anesthesiologist's ability to face the surgical procedure and patient and still easily see the anesthesia data without turning. With ceiling-mounted equipment, additional supports will be needed in the ceiling. Lighting systems with the ability to switch from a normal room-lighting pattern to specially colored fluorescent lights may enhance visualization of images projected on room monitors and should be considered in the design phase. New room installations now have a variety of integrated equipment available, from lights and monitors to voice-activated audio control of equipment and integration with distant locations, like pathology or a conference room for distant education. Besides the surgical images, computer feeds from the rest of the hospital can interface with these systems, allowing patient information, like x-ray images, to be displayed at the OR table. As the complexity of these systems increases, so does their cost and complexity of use. During the design, all of the participants using the room need to be involved in order to maximize the room capabilities yet prevent unnecessary expense.

Orthopedic Surgery Rooms

With the increasing advances in orthopedic surgery and the increasing requirements of the aging population, there is undoubtedly a need for ORs that can accommodate the wide range of needs for orthopedic surgery, from simple arthroscopic procedures to complex surgeries on the spine with neurophysiologic monitoring and large radiological equipment. Orthopedic surgery is one of the surgical subspecialties demanding the most varying type of equipment and surgical instruments. Many orthopedic procedures also necessitate the use of both general and regional anesthesia. An OR that is designed to facilitate both the choice of anesthetic(s) and the surgical procedure can greatly increase ease of patient care and the productivity and efficiency of OR personnel.

Preoperative Block Rooms

Preoperative block rooms have a definite role in the efficiency of OR turnover. A well-designed block room would have to be in proximity of the ORs for immediate transport and must have adequate resuscitation equipment available. This includes an ability to monitor patients and treat any emergencies that might occur. The doorway must be the appropriate size to allow easy entry and exit, and in addition, the ideal stretcher must be adjustable in both height and position. Furthermore, appropriate personnel must be available to remain with the patient after block placement and transport to the OR. Since many regional blocks are now being performed with ultrasound guidance, the block room should be designed to accommodate this imaging equipment.

Intraoperative

Surgical equipment. Interestingly enough, as the surgical incisions become smaller and less invasive, it seems as though the surgical equipment required gets larger and more cumbersome. Many of the computer-assisted devices, robotic and arthroscopic instruments, and video screens necessary to perform orthopedic procedures are large and require many wires, cables, and electrical outlets in order for them to be functional. A design plan for the OR would ideally involve rooms sufficiently large enough to accommodate this equipment and dedicated electrical outlets for surgical instruments. One option is to suspend equipment, such as cameras and video monitors, from ceiling booms that also provide anesthetic gases, suction, and electrical outlets.

Operating table. Obtaining proper surgical access to the patients for orthopedic procedures entails multiple position options, such as supine, sitting, lateral decubitus, and prone. These positions many times require special beds, such as a captain's chair, Jackson flat, fracture table, Andrews frame, Mayfield head frame, etc. A thorough understanding of the limitations and advantages of each of these tables will improve patient safety and minimize morbidity. Moving and storage of these beds can become a process in and of itself, and beds that are interchangeable may be the wave of the future.

Electrical needs. Due to the large volume of irrigation fluid used in arthroscopic procedures, ORs must be appropriately wired. Line isolation monitors and alarms that warn/prevent the risk of microshock and macroshock are vital. Sixty-cycle (60 MHz) interference from various electrical equipment can lead to an inability to interpret electrocardiogram readings.

Orthopedic ORs can become dangerously slippery as water accumulates during arthroscopic procedures. This, obviously, can pose a threat to all OR personnel, both from a physical (e.g., falling and slipping as a result of the water) and an electrical standpoint. These rooms may have to be considered "wet ground" and may need specialized electrical wiring to prevent short circuits and the possibility of electrical shock for anyone in the OR. Careful attention must be paid to any electrical cord that lies on the ground and may come in contact with water that puddles on the OR floor.

The increasing use of neurophysiologic monitoring for spine operations can impose further electrical demands on the OR and may also need to be taken into consideration. There are companies that manufacture monitoring equipment with the ability to reduce electrical interference from other OR sources (e.g., electrocautery, anesthesia monitors, etc.)

Furthermore, the presence of the water that may accumulate would call for rooms with drainage systems that would more effectively remove the water from the procedures. It may be wise to use designated rooms that are electrically wired and have specialized drainage systems exclusively for arthroscopic procedures.

Radiography and microscopic requirements. Many orthopedic procedures require radiographic imaging in the form of plain film x-rays, computed tomography images, or real-time fluoroscopy during the procedure. Again, these needs call for the ability to move sometimes large and bulky x-ray equipment in and out of the OR many times during the course of one operation. This can be facilitated with advances and investments in smaller, more efficient x-ray machines and with fluoroscopy machines that work with mountable c-arms in the designated ORs. Ceiling- or wall-mounted fluoroscopic equipment is an option that can save valuable OR space but limits portability and options. Strict adherence to “code” is vital. Walls must be lead lined when necessary to prevent unintended exposure to radiation to all personnel within the OR suite and in adjoining rooms and facilities. Providing and storing the lead aprons used by OR personnel are other issues to consider when using radiographic techniques. Having a “closet” type of space or rack in the substerile area would allow for people to quickly protect themselves without having to spend time finding the lead aprons for each and every case. Along with radiographic needs, there are many procedures that call for the use of a microscope, which is yet another consumer of precious OR real estate.

Anesthetic requirements. Surprisingly, as the equipment that orthopedic procedures require increases, the need of the anesthesia for these cases has undergone only minimal changes. In addition to the basic setup of any OR, including the anesthesia machine, monitors, anesthesia cart, and scavenging system, an ultrasound machine for performing regional nerve blocks is probably the one piece of additional equipment that is most used in this subspecialty. Ultrasound machines can be rather bulky, but newer machines provide more efficient and compact designs that make their use easier. Another design aspect that would benefit the administration of anesthesia would be the presence of two wall sources for anesthetic gases, which would allow the anesthesia machine to be moved if the patient were to have complex positioning requirements.

Patient warming devices, such as forced-air warming, fluid warmers, and heating blankets, are essential for orthopedic procedures, as surgeries can be long and incisions extensive, and the possibility of rapid patient heat loss exists.

Air flow and temperature regulation. Air flow is another important operative issue, especially for joint replacement surgeries. The normal flow of air in most types of buildings entrains room air into the supply air stream. This allows the two types of air to quickly mix and develop a comfortable air supply and temperature. This, however, is not desirable for a hospital due to the fact that this would spread airborne contaminants throughout the building. Airflow systems are designed to use laminar flow in order to minimize the spread of the airborne germs. This is necessary in order to prevent perioperative infections in patients. The OR design must take into account airflow direction and exchange rates so as to ensure proper movement of air and, thus, minimize infection risk.

It would be advantageous to allow each OR to control both room temperature and humidity. Pediatric surgeries require quickly and efficiently warming rooms, and then these rooms need to be quickly cooled down for ensuing adult procedures.

Pediatric surgery rooms

Since “the only constant is change,” many health care facilities that were state of the art a decade or two ago are rapidly becoming functionally obsolete due to exponential progress in new technologies, clinical services, and operational trends. Changes are dramatic not only in clinical fields but also in fields integral to the delivery of health care, such as communication, new materials and technologies, demographic changes, and the state of the economy.

When building new or renovating existing facilities, one should follow the concepts of:

- **Lean:** Lean “is an approach to reduce waste and streamline operations. Lean is based on the concept of continually increasing the proportion of value added activity to a business through ongoing waste elimination. A Lean approach provides companies with the tools to survive the demand for higher quality, faster production time and lower prices in a global market. Lean implementation is therefore focused on getting the right things to the right place at the right time in the right quantity to achieve perfect work flow, while minimizing waste and being flexible and able to change.”

- **Green:** “A sustainable building, or green building is an outcome of a design which focuses on increasing the efficiency of resource use -energy, water, and materials - while reducing building impacts on human health and the environment during the building’s lifecycle, through better siting, design, construction, operation, maintenance, and removal. Green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:
 - Efficiently using energy, water, and other resources
 - Protecting occupant health and improving employee productivity
 - Reducing waste, pollution and environmental degradation”

- **Flexible:** Due to accelerated advances in science and technology, it is very difficult to have a long-term vision of the future OR, which means when building a new or renovating an old OR, emphasis should be placed on flexibility and adaptability. The OR design must incorporate the necessary space and infrastructure that will adjust to future trends. This includes interstitial spaces for structural, mechanical, electrical, and information systems, which need special layouts to allow for system modifications and upgrades. Flexible designs include accessible ceiling systems, grouping of similar modalities, and sharing of equipment spaces. “The challenge to all involved in planning, construction and management of healthcare facilities, is to anticipate, to the greatest degree, where changes are most likely to occur and to consider ‘flexibility’ throughout all stages of the planning, design, construction and post-occupancy phases to ensure that the ultimate goals of client satisfaction, desirable clinical outcomes, efficient work environment, and effective use of limited capital dollars, are all achieved.”

All said, whether within a children’s or general hospital, pediatric ORs should be seen as part of a pediatric OR complex that consists of:

- Pediatric operative suites
- Preoperative area with activity room (i.e., playroom) with age-specific activities
- Premedication room or area
- Postanesthesia care unit (PACU) or area
- Family resource center with preoperative learning programs
- Support facilities (e.g., bathrooms with infant changing tables, pump room, waiting room, etc.)
- Blood bank
- Laboratory

Three major components of this complex are personnel, equipment, and patient care facility.

Personnel

Required personnel include anesthesiologists, surgeons, nurses, OR technicians, and all other health professionals with expertise and experience, such as pediatricians, radiologists, respiratory therapists, electrophysiology therapists, pharmacists, child life specialists, and administrative staff.

Whenever possible, care of pediatric patients should be consolidated into a separate facility staffed by specialty-trained anesthesiologists. Studies demonstrate that this improves efficiency and patient and staff satisfaction.

Equipment

Preoperative area equipment is required to be age and size appropriate for preoperative preparation and evaluation of pediatric patients. It should be situated in a comforting environment that provides privacy to the patients and their families.

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In order to maximize safety and efficiency, OR equipment should be strategically situated. There is an increasing trend in the use of booms, which are ceiling-mounted articulating arms that support equipment, gas and electrical outlets, and communication and video displays. This promotes decluttering, better space utilization, and sterility and reduces maintenance and equipment damage. Booms must be coordinated with the ceiling lighting, ventilation, heating, and electrical systems.

The American Society of Anesthesiologists Closed Claim study has found a greater incidence of equipment-related problems in pediatric patients in comparison to adults, with almost 50% in children aged less than 2 years.

The American Academy of Pediatrics states: “There should be a full selection of equipment available for application to the pediatric patient. This equipment should be easily accessible and well maintained.”

Airway equipment includes positive-pressure ventilation systems, ventilation masks, endotracheal tubes, laryngeal mask airways, oral and nasal airways, and laryngoscopes, with a wide range of pediatric blades.

Standards in pediatric and adult breathing circuits were established in 1963 by the American Society of Anesthesiologists and in 1967 by the International Anesthesia Standards Committee. There is no anesthesia machine specifically developed for pediatric patients; all anesthesia machines should deliver precise volumes and concentration of anesthetic gases. However, use of anesthesia machines with a pressure-control ventilation option is preferable in the pediatric population.

Equipment for intravenous administration of fluids includes intravascular catheters, pediatric volumetric fluid administration systems, and kits for intraosseous access. Space must be available to store a wide variety of sizes of disposable equipment within easy reach of providers.

Maintaining temperature is critical, particularly for neonates and infants. Therefore, a variety of equipment (for age and size) must be available to maintain normothermia, including warming lamps, circulating warm air devices, air humidifiers, and fluid warmers. Again, storage space for this equipment must be readily accessible.

Storage must also be available for other specialized equipment, including:

- Equipment for invasive monitoring of arterial and central venous pressures
- Infusion pumps
- Regional anesthesia equipment for performance of neuraxial and peripheral nerve Blocks

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- Resuscitation cart with equipment and medications appropriate for pediatric patients of all ages, including pediatric defibrillator paddles; written pediatric dose schedule for the resuscitation medications should be immediately available
- Readily available, fully stocked, difficult airway cart with specialized equipment for management of the difficult pediatric airway; content should include, but not be limited to, fiberoptic bronchoscope and emergency tracheostomy and cricothyrotomy equipment
- Readily available, fully stocked, and regularly maintained malignant hyperthermia cart; contents are the same for patients of all ages
- Transport equipment, such as transport monitors and portable equipment for oxygenation

Specialized equipment and sizes of equipment must also be readily accessible in the PACU area. Each bedside location should have sufficient room for storage of a wide variety of airway and resuscitative equipment.

Facility

Studies have shown that the establishment of dedicated pediatric ORs results in decreased variability of anesthesia-controlled time (significantly shorter times of induction and emergence), allowing for better case scheduling as well as surgeon and patient satisfaction.

When designing and planning for the construction of a new or renovation of an old OR suite, early engagement of the infection control (IC) team is crucial. Issues to be addressed include space constraints, storage and equipment cleaning areas, hand-washing facilities, air-handling units, ventilation and environment control, barrier systems, medical waste containers, appropriate finishes, specific products with infectious implications, traffic flow, specifications on temperature and humidity ranges, applicable regulations, and necessary budgets. The IC team should ensure that major design components are addressed as appropriate and justified by relevant guidelines, codes, standards, and regulations.

The operating suite needs to be adaptable, with the capacity to maximize the use of space, time, equipment, communication devices, and personnel in an affordable manner. It needs to be structured for controlled access and traffic flow. The OR suite cannot be a passageway to other rooms. It should be located in close proximity to support facilities/services (e.g., neonatal ICU, pediatric ICU, blood bank, laboratory, etc.). The patient and staff entry points into the OR are crucial in design, since they will dictate the sterile field location and, in turn, flow of sterile materials. In order to ensure that clean areas will remain clean, pathways of clean supplies must not intersect pathways of contaminated supplies.

The Facilities Guidelines Institute and the American Institute of Architects 2006 Guidelines for Design and Construction of Healthcare Facilities sets a minimum of 400 sq ft for a new general inpatient OR and 600 sq ft for specialized ORs. For an ambulatory surgery/Class A minor surgery room, the requirement is 150 sq ft. Requirements for OR storage space is 50 sq ft per OR, with a minimum of 150 sq ft total.

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Room floors, walls, and finishes should meet standard requirements for OR cleaning, maintenance, and durability and be aesthetically pleasing. Floors must be able to support the weight of the “permanent” furnishings and equipment while considering future installation of imaging systems. For that reason, ferrous reinforcement needs to be minimal in order to allow for proper function of those systems. Use of reinforced concrete, rather than steel beams, will eliminate vibrations. Different levels of lighting should be available through a control workstation, with consideration of additional occupancy sensors and voice control capabilities. Ceiling-mounted equipment requires access to above-ceiling services. Walls, ceilings, and floors must be sealed. All booms must be gasket sealed. Heating, ventilating, and air conditioning must have a velocity of 25-35 ft/min. Temperature control and maintenance is one of the crucial elements of care for the pediatric patient population. Temperature and humidity control panels for the pediatric ORs must be easily accessible to OR personnel and should not be placed in a remote area in order to allow for prompt adjustments.

Preoperative and waiting areas should provide quiet environments with ergonomic furniture, television and computer stations, a play room, and lockers. Evaluation and consultation rooms should have double entries to allow for separate entry of medical staff and patients and their family members. Ideally, these rooms should be equipped with computers to allow medical staff to communicate preoperative and postoperative findings and images to the family.

When planning for space, increased recognition of family members’ and caregivers’ contribution to the healing process and gradual acceptance of the benefits of nontraditional modes of therapy (e.g., massage therapy, music therapy, and acupuncture) should be considered as well. Perioperative areas need to address the needs of patients of varying ages. Healthy toddlers waiting for day surgery procedures should have age-appropriate play areas decorated to appeal to young children. Adolescents, on the other hand, will be uncomfortable in a setting for young children and should have a more private area for waiting and recovery, as well as private areas for changing. Families of young infants often appreciate a more quiet and private setting. Preprocedure anxiety in children often has a profound effect on postoperative psychological problems (e.g., night terrors, enuresis, etc.), so it is worth the extra investment in specialized perioperative areas that appeal to patients and families.

Many pediatric procedures take place in an ambulatory setting. Access to nourishment prior to discharge is another important issue. Typically, juices or ice pops are offered to determine that the child is well enough for discharge (and to help signal this time-for-discharge) to patients and parents. This area needs to be separated from the waiting area, where children are fasting prior to procedures. Distinct areas for different ages are postoperatively important as well. Young children need to be with parents in a familiar environment, perhaps an area with available age-appropriate videos. Adolescents often prefer a more quiet area and feel particularly uncomfortable in a large open room that precludes privacy. Optimizing flexibility in perioperative spaces is key to meeting the needs of all ages.

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