CHAPTER 2 – THE ANESTHESIOLOGIST'S OVERVIEW OF THE OPERATING ROOM

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Checklist:

* A single anesthesiologist should be designated to consult with the architects throughout the design and construction process.
* The operating room should be designed to facilitate the flow of patients, family, staff, and equipment.
* Operating rooms must be large enough to permit the procedures that will occur therein.
* Operating room lighting design should consider the specific requirements of surgical procedures, surgeons, nursing and anesthesia personnel.
* Adequate storage space for present and future equipment is crucial.
* Security measures to control access to the operating suite and to the sterile area should be considered as part of the design process.

Many health care facilities are currently in the process of building new operating rooms, remodeling old ones or converting existing space into general work areas (such as one-day surgicenters). Anesthesiologists are frequently called upon to participate in the design and development of the new operating rooms. This is important for both safety and practical reasons. Unfortunately, most anesthesiologists have little or no experience in working with architects, interpreting blueprints or designing new operating rooms. It is therefore imperative that the anesthesiologist obtain as much advice as possible before assisting in this process. By the time the anesthesiologist is asked to participate in such a project, it is likely that many of the preliminary decisions -- such as the size of the project, the site, the budget, and selection of the architect -- will already have been made. Nonetheless, it is extremely important that the anesthesiology department be prepared to participate from the outset. To facilitate that process, the department should select one of its members to represent it at the various meetings, and grant to that individual decision-making authority.

Although several members of the anesthesiology department may be involved in various aspects of the project, it is vitally important that one person be the spokesperson and decision-maker for the entire project. That person must be aware of what is happening in every subcommittee and must be provided with the time away from clinical duties to attend the numerous meetings.

The architects and administrators will be present at all meetings, and if a member of the anesthesiology department is not present at each meeting, decisions will be made without the department's input. Since many changes will take place during the design phase of the project, it is necessary to carefully assess and understand the impact of the changes so that any problems arising from them can be corrected at the next meeting. The anesthesia representative should have a long-term commitment to the institution, because the time from the initial meeting until the completion of construction will be at least two and possibly as many as eight years.

Architects

If possible, the spokesperson for the anesthesiology department should meet with the hospital administration prior to the selection of the architectural firm. The architect who is selected should have experience and expertise in the design and development of health care facilities and especially operating rooms. Because there are particular challenges unique to operating room design, it should not be assumed that architects who

have previously built health care facilities are capable of designing an operating room. The operating room is completely different from other hospital areas, and it must be designed with particular regulations and requirements in mind. It is also crucial to review the architectural firm's prior work. For example, the anesthesiology department representative should speak with and/or visit members of the anesthesiology department in facilities where the architect has previously designed and built operating rooms.

The architectural firm that is selected should have expertise in all aspects of operating room design. This includes the initial planning (schematic and design development), drafting of the blueprints and room layout (floor plans, electrical, heating, ventilating and air conditioning, and plumbing coordination), and the development of the construction documents (especially development of the specifications). The firm should be able to provide examples of previous operating rooms it has designed and make recommendations about what has worked well in the past.

The architect must deal with an additional set of problems if the existing operating rooms that will be used during construction are adjacent to the construction zone. The operational part of the operating room must be isolated from the construction area, and plans must be made for infection control, dust containment, noise abatement, and establishment of negative pressure in the construction zone.

Initial Planning

Once the scope of the project has been defined, the initial planning can begin. The size of a project can vary from the remodeling of a few operating rooms to the building of new operating rooms, delivery rooms and ambulatory surgical centers. If there will be multiple new or remodeled areas, it is crucial that the same architect be responsible for designing all of them. The importance of this cannot be overstated. Dealing with two or three different architects means having to "reinvent the wheel" with each one. This wastes time and leads to costly mistakes.

The members of the anesthesiology department's design team and the architects will have a great deal of interaction. They must learn from each other, and they will have to set standards and make compromises throughout the project.

The initial phase of the project will consist of having all of the users submit: (i) a list of their needs; (ii) the amount of space required for those needs; and (iii) projections for future needs. Each user should state how he or she will function in the space and what the anticipated flow patterns will be within the space. Projections about future needs are difficult, since needs can change dramatically over time. The percentage of outpatients can change, equipment can change, and even changes in managed care can impact future needs. For example, it would have been difficult for anyone to have predicted the development of the surgical robot, which occupies a very large amount of floor space. However, if an architect, who previously designed an operating room, had considered the possibility that future developments in technology might require the use of significant amounts of floor space, the introduction of this type of technology would not have been a problem. Indeed, changes in technology -- or anything for that matter -- only become a problem when the design fails to account for future needs. This list is essentially a "wish list"; rarely will all requests be fulfilled. One should therefore not underestimate his or her needs at this stage.

After all lists are completed, an initial plan will be devised and the cost of the project estimated (some projects will have the cost predetermined). The plan will then be scaled back so that it comes within the projected budget and available space. Once the initial plans are drawn, it is vital to determine exactly how much of what was initially requested remains in the plans. This will be the best and probably the only opportunity to reinsert into the budget something that was removed. The architect's initial drawings may consist of several designs with different ideas on how

best to satisfy everyone's needs and stay within the allotted space and budget. Space for future expansion must also be included at this time. Key representatives from anesthesiology, nursing, surgery, biomedical engineering, and administration must work with architects to create a space that will best meet the needs of all groups and the proposed budget. Compromises will be necessary.

Anesthesiologists must ensure that adequate space is allotted for the department to carry out its functions. In particular, space must be allotted for an anesthesia workroom and storage (for bulk supplies and spare equipment). At this time, there should be agreement as to the total number of operating rooms and postanesthesia care unit (PACU) beds that will be developed. In addition, space must be allotted for a preoperative holding area, locker rooms, call rooms, lounges, offices for the nursing and anesthesia staff, storage areas, waiting rooms, a control desk and possibly a biomedical repair shop. At this stage, all desired space must be designated in the plans. Failure to do so will result in severe space constraints when the final compromises are made.

This is also an excellent time to discuss general design principles with the architects. An often-overlooked principle is the overall flow of patients, staff and materials into and out of the operating room. A good example of efficient design is illustrated by a theater. There, action takes place on a stage and is visible to the entire audience. This corresponds to areas that are utilized by patients and their family members. Also, an enormous amount of activity takes place backstage and is not visible to the audience. This corresponds to areas that are used primarily by staff, which patients and their families normally do not see. There should be a method to bring materials into the operating room and remove trash and soiled linen without these items coming in contact with the public. Also, the physicians and staff should be able to enter and leave the operating room without having to encounter the families in the waiting area.

Security is also a major issue today. If the space is not going to be used on a 24-hour basis, there must be a way to secure it easily when the schedule is finished. It is also essential to have a method of controlling access to the operating rooms so that unauthorized personnel do not intentionally or unintentionally wander into the sterile area. Cameras in the front desk area and waiting room are an important part of any security plan. Hallway surveillance may similarly be indicated.

Finally, it is important to remember that most anesthesiologists are not familiar with the construction process, and will therefore require "on-the-job" training. One has to work with tiny diagrams in which one-quarter of an inch represents a foot, and it is very hard to visualize from a two-dimensional drawing exactly how the facility will look when completed. It is very helpful if the architects can provide some kind of mock-up of the space before the plans are finalized.

Operating Room Size

A general-purpose operating room must have a minimum of 400 square feet, and a special procedure room (e.g., a heart room) must have at least 600 square feet. Although 400 square feet may seem like a large room, in many instances it is inadequate for contemporary surgical and anesthetic practice. Ideally, the minimum size room should be 600 square feet, with special procedure rooms sized at 800 to 1000 square feet. There is more equipment in operating rooms now than ever before, and the process is not slowing down. The result of more microscopes, X-ray machines, video carts, surgical robots, etc., being introduced into the room is that the anesthesiologist is crowded into a continuously decreasing amount of space. Be weary of the argument that a room can be designed to be small because it is "just for out-patients or pediatric patients." There is a common misconception that pediatric patients need smaller operating rooms, or that ambulatory procedures require less equipment. The equipment used for

arthroscopy can occupy more than one-third of the available floor space. The fact that the room is intended to be used for only one purpose at the time of the design phase does not reflect the fact that needs might change or that the room will be used for many functions and surgical services over time. Obviously, the larger the room, the easier it is to work in it (Figure 1).

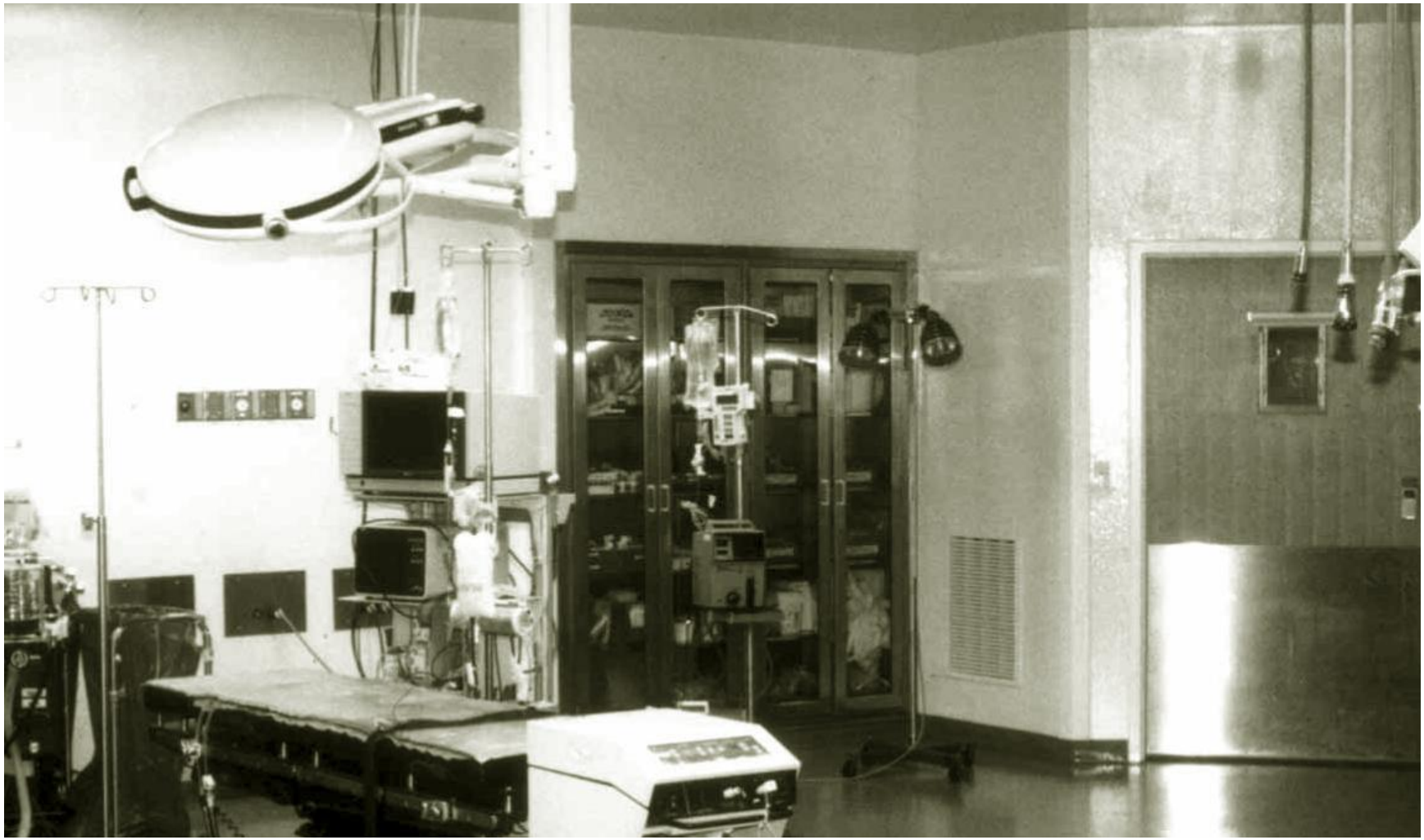

Figure 1: A large multipurpose operating room that is designed for special procedures such as cardiac surgery. The room is large enough to accommodate any equipment that is needed. Note the extra gas and electrical “drops” for use by the pump team.

Since the amount and size of equipment that is brought into the operating room is ever-increasing, building a larger room today will undoubtedly pay dividends in the future. The size of the door to the operating room is of particular importance. Very large items such as specialty beds, orthopedic fracture tables and heart-lung bypass machines must be brought into the operating room. It is therefore advisable to have a large main door and a second, smaller door that can be opened when needed (Figure 2).

Figure 2: A two-part operating room door. The main part is used for regular stretchers, while the additional section can be opened to accommodate special operating room tables or extra-wide beds. Note that the wooden doors have no protection from damage by stretchers and movable equipment.

The two-part door works very well because the entryway can be enlarged when needed, but it does not have to be opened for regular beds. If windows are going to be placed in the doors, then provisions should be made to cover the window with a shade. Also, when using wood doors, the lower door panels and edges should be protected with a stainless steel overlay or a kickplate with edge guards (Figure 3).

Figure 3: The same type of operating room door, where stainless steel overlays have been added to protect the doors.

Otherwise, the movement of beds in and out of the room will damage the wood.

Another consideration in new construction is patient movement. How patients are going to be moved on and off of the operating room table should be considered in the design phase. Since bariatric patients are an increasingly large segment of the patient population, consideration should be given to installing some mechanical lifts in some of the operating rooms.

Heating, Ventilation and Air Conditioning (HVAC)

The number of air exchanges in the room must be at least 20 per hour; at least four of these exchanges need to include fresh outdoor air. Relative humidity can be as low as 30 percent but cannot exceed 60 percent. It is best to have a separate system for scavenging that is independent of both the ventilation and vacuum systems. The air return ducts should have a HEPA filter built into the system.

The ability to change the room temperature easily is very important. As recent studies have shown, keeping the patient warm is highly beneficial during most types of surgery. The heating and air conditioning systems must allow the individual room temperature to be raised or lowered rapidly as needed for patient and surgeon comfort. This must be accomplished without large “overshoots” in the desired temperature and can be accomplished by using individual “reheat coils” in each operating room. Also, it may be beneficial to have the temperature sensed at several different points in the room.

Lighting

Often the architects are very concerned about the amount of room lighting. However, excessive fluorescent lighting can be problematic. With the vast increase in the amount of endoscopic surgery, the entire concept of room lighting needs to be carefully planned. It makes more sense to have lights on dimmers or to provide separate switches for different lights so that some can be turned off during a procedure. In rooms where all the lights must be turned off (i.e., where the operating microscope is being used), special procedure spot lighting can be installed, for both the anesthesia staff and the scrub nurse (Figure 4).

Figure 4: A special procedure light (spot light) that can be adjusted for use by the scrub nurse or anesthesia staff.

This lighting can be directed at areas that need illumination, such as the instrument table or the drug cart.

Another technique is to install two banks of fluorescent tubes in each fixture. A separate wall switch would control each bank so that half of the lights can be turned off while the other half remains on (Figure 5).

Figure 5: Special fluorescent lighting whereby half of the lights can be turned on or off as needed. Note that excessive lighting causes glare on the remote monitor, making it difficult to see.

Some of the newer operating room integration systems have lighting controls that can be configured for different lighting schemes; these schemes depend on what lights fixtures are switched together as one unit or switched separately. In addition to light intensity, glare on monitor displays

from room lights can be a major issue. The greater the individual control over different lights, the more adjustable the work environment will be. The downside is cost and complexity of use. A battery-powered source of emergency lighting must also be installed. Lighting can be dealt with in many innovative ways during the design phase, but if it is not planned, it is difficult to add it later.

Fire Safety

Fires continue to be an ever-present danger in the modern operating room. This is true even though virtually all operating rooms in the United States are designated as nonflammable anesthetizing locations (i.e., no flammable anesthetic agents or medications are allowed). The ECRI Institute estimates that there are between 500 and 600 operating room fires each year in this country. The combination of three factors commonly found in the operating room can easily result in a fire: (i) an oxidizer, such as oxygen or nitrous oxide; (ii) a flammable substance or fuel, such as paper drapes, plastics, alcohol based prep solutions, or gel pads; and (iii) a heat source, such as electrosurgical pencils or lasers. When designing or remodeling an operating room suite, fire safety should always be considered. This includes locating fire extinguishers and fire alarm boxes near each operating room. In addition, zone valves to shut off medical gases and electrical panels should be placed conveniently outside each operating room.

Space for storing numerous compressed gas cylinders needs to be provided. These cylinders must be in a proper holder because rupture of a tank can flood an area with an oxidizer such as oxygen and create a hazard from high-velocity metal projectiles. Depending on the size of the operating room suite, compressed gas cylinders may need to be stored in multiple areas. Gas storage areas have specific fire-rating construction needs.

While every operating room will have a smoke detector and sprinkler system, the location of these items is important. Since a fire is most likely to start in the vicinity of the patient, the smoke detector and sprinkler should be placed as close as possible to the operating room table. Operating room fires frequently produce a lot of smoke and toxic fumes but not a lot of heat. Therefore, if the sprinkler is placed in the back of the room, it may not activate until very late in the course of the fire. The National Fire Protection Association provides many other useful ideas and guidelines regarding fire safety in its publication “NFPA-99: Standard for Health Care Facilities.”

Substerile Area (Scrub Rooms)

There are four basic items that will occupy the substerile area: sinks, an autoclave (but note that newer recommendations suggest that all autoclaving be done in a central sterile area which may greatly reduce the need for autoclaves in each operating room area), storage for supplies, and a telephone/intercom. Other possible items include a blanket/fluid warmer, ice machine and refrigerator. Scrub sinks are not of equal quality. Some are far better at containing the water in the sink, which avoids a wet and slippery floor. Many surgeons are used to having a window above the scrub sink, so they can watch the patient while scrubbing. While this may seem like a good idea, the reality is that the window occupies a large amount of valuable wall space. Often it will not be possible to place all the necessary cabinets, electrical panels, etc. in the walls and still have a window. In addition to the autoclave, some operating rooms need a warming cabinet for solutions and blankets. There may also be a sink for decontaminating instruments prior to autoclaving, but if the autoclaving activity is in a central location, this may obviate the need for a decontamination sink adjacent to the operating room.

Finally, most substerile rooms will have some storage space. This can be used for general supplies or equipment that is unique to that operating room suite. If a pass-through cabinet is going to be installed, then sliding doors should be avoided. Although they do not require swing out space, sliding doors tend to come off the tracks, and oversized items will inhibit the ability to open or close the doors.

Storage Rooms

Storage space is one of the most important requirements for the modern operating room. However, it is often overlooked or reduced in the cost-cutting phases of the project. The amount of equipment that is in the operating room today is probably double that of 10 years ago. The introduction of video surgery has resulted in numerous TV monitors, carts and videocassette players that have to be stored in and moved to different rooms. There are specialized operating room tables, microscopes, instrument carts, lasers, coagulators and a host of spare devices (such as anesthesia machines, monitors and electrosurgery units) that need storage space. This does not include the supplies and materials that are needed on a daily basis, as well as set-ups for emergency cases. Future storage needs are difficult to predict -- the more storage space that is planned for, the less likely the hallways will be jammed with equipment and supplies two or three years later. Because operating room space is very expensive, it may be possible to provide some storage room in close proximity to the operating suite. In addition, some services that are traditionally in the operating room may be moved to create additional space. For example, the area for processing and sterilizing instruments can be located outside of the operating suite. That area can be on a different floor (above or below the operating room) and have two dedicated elevators to bring in sterile supplies and take out dirty supplies. This would allow one central processing area to serve several of the inpatient and outpatient operating rooms as well as the labor and delivery rooms. It is best if the operating room and the anesthesiology department have separate storage areas. There may need to be one or two large areas and several smaller areas spread around the operating room suite. If there is a room for large movable equipment, provisions need to be made for getting equipment into and out of the room easily.

Communication

Communication is another important aspect of operating room design. Telephones, intercoms and computers are all necessities for any modern operating room. Also, television cameras and monitors may be used for teaching or teleconferencing. The amount (and location) of each of these devices should be determined by the nursing, surgical and anesthesia staff.

There are many different ways to design a communication system. An effective communication system can greatly enhance the safe and efficient running of the operating room. Every hospital has unique needs, and the system for a particular operating room requires careful planning to achieve the desired goals. Well-designed information technology is essential for the efficient operation of the modern operating room. A robust wireless and wired network are needed for communication, access to the Internet, cell phones, and various patient management tools. Some sort of electronic patient management system (such as NaviCare{tm}) can greatly enhance the timely coordination of patients and staff.

In a large operating room, it may be preferable to have a dedicated operating room intercom as well as a telephone in each operating room, and one on the anesthesia machine. The communication system must provide for a simple and reliable way to obtain extra help in an emergency. This can be accomplished with a dedicated operating room page system or a separate alarm system.

Materials Management

One often overlooked aspect of operating room design is materials management. This encompasses all sterile and nonsterile supplies, dirty

instruments, trash and any materials to be recycled. The operating room should be designed to allow the smooth flow of materials into and out of the area. If possible, clean and dirty supplies should not mix and the delivery and removal of supplies should not interfere with patient movement. There needs to be space to unpack crates and boxes of supplies as well as storage for enough supplies until the next delivery. This is true for operating room as well as anesthesia supplies. Complete isolation of pathways is impossible but careful planning can minimize the interference.

Special Functions

There are a number of special functions that may require space in or near the operating room. These include space for the pathologist to do frozen sections; an area for the perfusionists to assemble, clean and test the cardiopulmonary bypass machines; and space for blood bank refrigerators. It may also be advantageous to have a laboratory to perform a selected number of tests and a dedicated area for a biomedical technician. Space may also be required for a drug dispensing machine(s), a narcotics return lock box and a scrub suit distribution system. These functions must be considered during the design phase, or something will have to be deleted later on to make room for them. Other support functions such as call rooms, locker rooms, lounges and offices are covered in other chapters of this manual.

Security

This is a subject that has increased in importance in recent years. It is important that only authorized personnel gain access into the operating room suite, especially the sterile areas. There needs to be a means to ensure that visitors and family members do not wander into sterile areas. Also, the operating room personnel need to feel safe during nights and weekends. In addition, family members will want access to the front desk personnel. Controlling who has access to the operating room area should be part of an overall security plan.

Quality of Materials

It is important to consider what types of materials will be used. This should be determined during the planning process because higher quality products will be more expensive. Operating room cabinets are a good example of this: stainless steel cabinets with glass windows are more expensive than laminated particle board with plastic windows (Figure 6).

Figure 6: Stainless steel operating room storage cabinets with glass doors. These cabinets are easy to clean and will last for many years. Also, any supplies stored in them are easily accessed from the swing-out doors. Other equipment must be kept far enough away from the doors to allow access to the supplies.

Over the life of the operating room, the stainless steel will be the better value.

The materials for the operating room walls and floor are also important. They should be easy to clean, blood- and stain-resistant and maintain their appearance for many years.

Also, the floor and the wall should not meet at right angles, as this creates an area that is difficult to clean. Rather, the floor should continue seamlessly up the wall for 4 to 6 inches (Figure 7).

Figure 7: Example of an operating room floor that extends several inches up the wall. This floor is easy to clean, since dirt cannot collect at the junction of the floor and the wall.

Construction Documents

Once all of the different components of the room have been determined, the architects will prepare the construction documents. These are the detailed plans that show exactly where everything will be in the walls, ceiling and floor. At this time the nursing, surgical and anesthesia staff should carefully examine each operating room to determine if the placement of the operating room table, the cabinets and any special equipment makes sense. Even though many rooms are the “same,” each one must be inspected, since important components may be left out or changed.

The nurses need room to set up their sterile tables in a location that does not interfere with the patient entering the room or the staff members obtaining supplies from the cabinets (Figure 8).

Figure 8: This room has the anesthesia supply cart located in front of the storage cabinets, making it difficult for the nursing staff to access the supplies. The room should have been designed so that movable equipment was kept away from the supply cabinets.

It is advisable not to place operating room supply cabinets behind the anesthesia team; however, if it is unavoidable, then the anesthesia gas drops should not interfere with obtaining supplies from the cabinets. It is desirable to have a mock-up of the operating room so that people can walk through and actually see where the architect has located the various components. A full- or small-scale wooden mock-up can be done. Alternatively, the room can be laid out with chalk on the floor and the actual pieces of equipment brought into the area. Cardboard cut-outs can be used to represent various pieces of built-in equipment. It is much easier to visualize the setup in three dimensions rather than the two dimensions of the blueprints. Using computer software, the architect may be able to simulate the three dimensional aspects of the space. This may provide additional insight into the future function. Potential mistakes and conflicts can be resolved before construction is actually finished (or even started).

One place where this is particularly important is in a room where there is a fixed piece of equipment, such as a microscope. Having a microscope mounted and fixed to the ceiling markedly limits the function of the room. If a microscope is going to be mounted to the ceiling, it should be on a track so that it can be moved aside when the room is used for other types of cases. This takes a lot of planning so that the microscope, operating room tables and anesthesia machine are all in the best position to minimize congestion and interference with other equipment and to facilitate transporting the patient into and out of the room.

All of these basic principles should be applied to all other areas of the operating room. The preoperative holding area, PACU, locker rooms, lounges and offices should all be scrutinized for appropriate size, setup and flow.

If the facility being built has special needs such as a labor and delivery suite, a pediatric suite or an outpatient surgicenter, then the previous discussion can be applied and tailored to that specific area. For instance, a pediatric operating suite may require several different preoperative holding areas so that children of different ages can be segregated. Outpatient surgicenters have unique requirements including modifications for recovery in order to ensure that the patients are able to ambulate before being discharged.

Construction

Once all of the design and construction drawings are finished, the actual work will begin. This is not a time to sit back and hope everything will go according to plan. It is vitally important that members of the anesthesiology department and nursing staff make frequent and comprehensive visits to ensure that the construction is proceeding according to plan. It is also a time to resolve minor problems and add forgotten items before the suite is finished (Figures 9 and 10).

Figure 9: The automatic doors leading from the preoperative holding room into the operating room require a plate to be pressed in order for the doors to open. The plate was originally located on the wall next to the doors (note blank cover plate to the right of the doors). This made it impossible for a person pushing a stretcher to open the doors.

Figure 10: The plate to open the doors has been relocated to approximately 8 feet in front of the doors. This allows a person pushing a stretcher to operate the door control without having to leave the patient.

It is important that the people who helped during the design phase stay active with the project during construction. It is almost impossible for someone else to take over at this phase. There needs to be an agreement between all the parties that any changes will be presented to and agreed

upon by the group. Agreed-upon changes need to be put in writing and distributed to the group. The meetings need to be scheduled (so that everyone has a reasonable opportunity to attend) and should be long enough to get the necessary work done. The representative from the anesthesiology department needs to realize that this will entail being out of the operating room for many hours during the day.

No matter how similar some rooms are they must be treated as individual projects. One cannot assume that all of the rooms will be done correctly just because two or three rooms are correct. For instance, our project involved building three new delivery rooms. All were supposed to be done the same way. However, we found that one room had no suction for the surgeons. If such a mistake is identified early, it is easy to fix; if it is discovered on the final inspection, it is very costly to rectify.

Once the construction is finished, the anesthesiologists should do a final checkout and safety inspection. The gas lines should have a certified report of testing. Ideally, this is part of the gas piping installation contract. The contractor must provide a test of both proper installation (i.e., brazing and purging of impurities) and proper function (i.e., correct gases in the correct pipelines). Numerous disasters can occur if this has not been done. The anesthesiology department should also perform its own check to be sure that oxygen is in the oxygen lines and nitrous oxide is in the nitrous lines. A complete test of all systems must be done before the room is used for patient care.

A tremendous amount of work is required in order to have an excellent (functional) finished product. The difference between an operating suite that is workable and usable and one that is not frequently depends on how much attention is paid to small details. As always, a vigilant anesthesiologist (as well as nursing, surgical and operating room staff) is required in order to have a satisfactory outcome.

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