Bronchoscopy Unit Design for Advanced Procedures

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Introduction

Interventional pulmonology is a rapidly evolving field with new diagnostic and therapeutic technologies available. Advanced bronchoscopy unit design has become a topic of interest with the creation of many dedicated units around the world. No guidelines exist regarding optimal unit design, and when faced with planning such units, the "wheel" needs to be reinvented every time.

The challenges faced are to provide for current volume and types of procedures and to have flexibility in the design to accommodate for future growth. Specific area design must be considered as well as the flow throughout the unit.

Integration of the Procedure Unit with the Rest of Medical Center

Before embarking on the actual design of the physical space, one should consider very importantly where the unit will exist relative to other departments. By the nature of the acuity of patients served, there needs to be easy access to members of the code team, radiology, and even possibly surgery. Decisions should be made as to the types of procedures performed in this unit considering the safety of the patient. You may have tremendous plans for the grandest of procedure suites, but regulatory bodies in and outside the hospital may not deem it safe to perform these in this location. There exists the possibility that the more routine procedures are allowed to be performed initially and then more complicated ones added after safety measures are followed and the procedure unit has "proven itself" over time.

As important as where it will exist is how it will exist with other departments. This unit does not function as an independent space but relies upon the coordinated efforts of many departments throughout the hospital system. Consideration needs to be made of the following for the seamless transaction of the patient experience.

1. **Administrative Workflow**
   (a) Registration of patients
   (b) Obtaining medical records
   (c) Telephone communications between administrative offices scheduling procedures
   (d) Scheduling of patients via any software program used assuring it also gets on physician and unit schedules
   (e) Billing and required documentation submission
2. **Clinical Workflow**
   (a) Physical space issues between where patients may be seen in OP clinic and procedural unit
   (b) Waiting area for patient's family members; general waiting area used vs. a dedicated area for these patients
   (c) Use of transport system for the movement of inpatients to and from the procedural unit
   (d) Laboratory services including phlebotomy, IV
   (e) Radiology services
   (f) Anesthesia services
   (g) OR services should patient require this during a procedure

Philosophy of How This Procedural Space Functions

I am going to make the assumption that this space is strictly used as a procedural unit and any outpatient clinic visits will be conducted elsewhere.

Determining Procedural Volumes and Space Needs

To be able to determine the size of the procedure space required, you need to establish the number and type of

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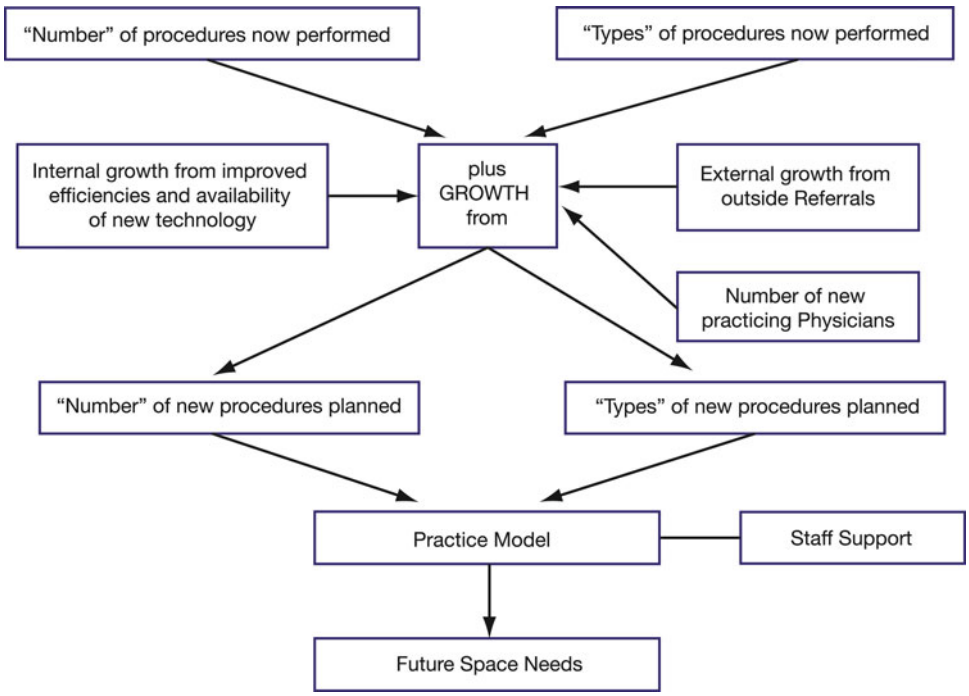

Fig. 4.1 Determining procedural unit space needs

procedures that will be performed over the useful life of the unit. In formulating a plan as to the procedures expected to be performed now and in the future, one must look at historical data to determine the types of interventional procedures and the volume to be expected going forward. Depending on whether this is an established practice and there is some history that can be drawn from, you may or may not have data to support the number and types of procedures as well as the staff support needed. It is much easier to justify your requests for new or additional space if you are able to show the administration 5 years of historical data with growth of revenue as opposed to the practitioner just starting a practice. In this case, you must rely on demographic information derived from hospitals databases regarding the disease populations that would lead to referrals, the referral patterns for surrounding practice groups, and the competition for patients in the population area.

As well as this information, it is necessary to project as accurate as possible the expectations to be accomplished over the next 5 years. These volumes will be the benchmark with which you will be measured.

Considerations need to be made of at least the following to allow for predictions as to the numbers and types of procedures before space requirements can be made:

1. The number of practicing physicians (now and in the future) and the practice model used to allow for optimal use of space, equipment, and staffing
2. Level of procedures to be performed:
   (a) Flexible bronchoscopy with some intervention
   (b) Rigid bronchoscopy
   (c) Medical thoracoscopy
   (d) Other chest procedures (thoracentesis, Chest ultrasonography, Pigtail drainage catheters, etc.)
3. What level of anesthesia will be administered (may be limited by hospital policy)
   (a) Topical anesthesia
   (b) Conscious sedation
   (c) Deep sedation
   (d) General anesthesia

Staff Support

It is equally important to the success of this procedural space to match the level of staff support required in the environment we are considering in this specialty.

Interventional pulmonology relies heavily on a variety of highly technical procedures and the associated equipment. New technology is developed at a very fast pace, and the staff needs to be able to operate and troubleshoot all modalities. This is especially true because physicians in this profession are operating on a compromised airway, and time can be critical should a piece of equipment malfunction. Depending upon the use of the unit, a decision needs to be made as to the utilization of a dedicated staff for IP procedures vs. endoscopy nurses cross-trained in advanced pulmonary procedures (Fig. 4.1).

General Requirements of Procedural Area

Hospital procedural suites must adhere to many regulatory bodies including but not limited to internal and external groups. An interventional pulmonology advanced procedure suite may be subject to the control of some of these:

1. ***Internal Regulatory Groups***
   (a) Life safety
   (b) Infection control
   (c) Radiation safety
   (d) Invasive procedures committee
2. ***External Regulatory Groups***
   (a) Department of Public Health (DPH)
   (b) The Joint Commission (TJC)
   (c) Centers for Medicare and Medicaid Services (CMS)

General Information that Should Be Available Regarding the Procedural Unit

Scope of services provided
List of physicians approved to perform specific procedures
Qualifications of staff support
Policy and procedures manual

Spaces Required for Procedural Unit Design

1. Reception
2. Preop and recovery
3. Procedure
4. Nursing workstation
5. Physician workstation
6. Storage
7. Reprocessing
8. Other?

Flow of Patients, Staff, and Equipment

Before we discuss the actual procedure spaces, we should consider the optimum flow through the unit for patients, staff, and equipment. In a perfect world, patients would experience their procedure by stopping at the reception area for a very short time, answering a couple of simple questions, and proceed to the procedure suite with no interruptions or delays and with no exposure to anything else going on in the unit that does not have to do with their own care. So, at least to address the last part, in a perfect world, we might have a procedural unit that has separate flows for the patient, staff, and equipment.

Patient flow may be designed to have patients begin their experience at the reception center and complete the required administrative duties, while family members are escorted to a nearby waiting area. From there, the patient is brought to the preoperative area in privacy through a corridor that is dedicated for patient transport only, unexposed to other patients or family sitting in waiting areas or equipment being rolled by the staff. Then, through the same hall to the procedure suite for their case and after, brought back to the recovery area in privacy to their bay to recover until it is time to be discharged. The patient is then reunited with family via this separate corridor to either the reception or waiting area.

Staff would use a more common hall to flow from their nursing station to the area that they are responsible for, whether to care for patients in the preop area, the procedure suite, or recovery. On this common side would also house the physician workroom and storage areas for nursing supplies and technical equipment. This hall would by its nature be much busier than the private hall used to escort patients. Nurses might be moving from one area to another and technical staff shuffling equipment and supplies to and from the storage, preop, recovery, procedure, and reprocessing areas (Fig. 4.2).

Realistically, space restrictions and funding may not allow this ideal flow to occur. Hopefully, there will be some middle ground that will be found to allow minimum exposure to the workings of the procedure unit for patients while providing the staff with the most efficient way to perform their roles. This means providing storage areas that are in proximity for nursing supplies to the areas that need them and other areas for storage of technical equipment that does not require movement over large distances.

Procedural Unit Requirements

1. ***Reception Area to Greet Patients***
   (a) Allows for administrative responsibilities to be completed/registration verified
   (b) Provides area where family members are directed toward waiting area
   (c) Space to direct inpatients to preop area (Fig. 4.3)
2. ***Preop and Recovery***
   (a) Number of beds required depends upon number and utility of procedural rooms.
   (b) Staff requirements depend upon above and practice model used (dedicated staff for this area vs. same staff used to prep/recover and assist in procedure).
   (c) Requires a private area for outpatients to change from street clothes to hospital garments.
   (d) Necessary equipment for area includes hemodynamic monitoring which should be flexible (modular) to adjust for acuity of patient served.

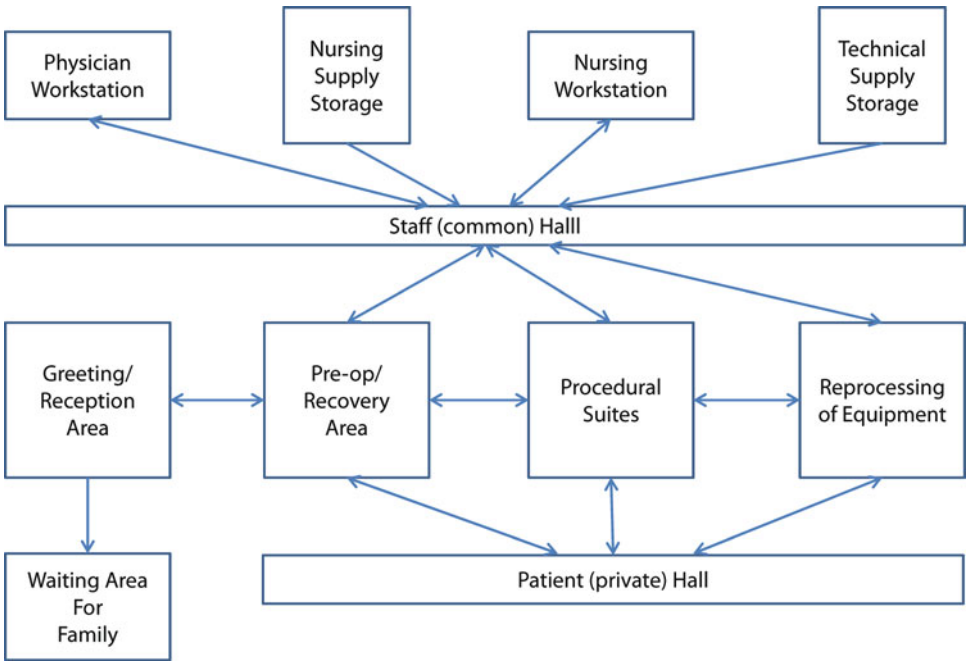

Fig. 4.2 Flow of patients, staff, and equipment

Fig. 4.3 Reception area

(e) Isolation room with negative airflow for potential of infectious airborne disease transmission.
(f) There are minimum standards for room sizes but must consider occasional equipment that may need to be placed there (x-ray, emergency equipment in event of cardiac arrest).
(g) Need to consider in the design the use of fixed walls for privacy vs. curtains which offer flexibility in their use. We have found that the combination of fixed walls on the side and a curtain across the front provides the advantages of both.
(h) Consider flexibility in cabinet design for the ease of restocking should product selection change over time. Also the use of portable storage carts for nursing supplies allows for carts to be replaced in there entirety and restocked at a location that does not interfere with patient care (Fig. 4.4).

3. ***Procedure Space***

Before design plans can be considered, one must decide upon how the room will function. For instance, the location of medical gas lines in the room cannot be determined until you know where the patient will be positioned in the room.

Fig. 4.4 (**a**) Nursing workstation centered around preop and recovery and (**b**) view of isolation room from nursing station

The architectural team cannot proceed with their drawings until the clinician makes this decision. You do not want to leave these decisions up to someone else and be left in a situation that you had control over but decided not to act upon. Too many times, a standard cookie-cutter model is selected, and the end users are left tripping over gas lines, extension cords, and video cables that were not placed in the best locations.

Therefore, the key to this space is the location of the patient bed with regard to movement into and out of the room; the flow of staff during the procedure as well as the required movement of equipment in and around the patient after patient is on the procedure bed.

Considering that there will probably be only one door used to move the patient to and from the room, then this area from the door to the procedure bed should be kept free of any permanent fixtures. I also think it is very helpful to be able to see the operator from the entrance to the room. This allows for easier communication and may allow for a sense of the progress of the procedure.

Given the above information, I believe it makes the most logical sense to locate the head of the bed toward the left hand wall as one would look into the room. Because bronchoscopy equipment connects to their processors and light sources on the left side, then any booms incorporated into the design to hold this hardware need to be positioned on this side of the patient. If the patients' location was reversed and the head was at the right hand with the feet facing the left as you looked into the room, then the boom used to house the processors and light sources would obstruct the entrance to the room, and visualization of the operator would be compromised.

If one wanted to locate the head of the patient at the rear wall with feet facing the entrance to the room, then the boom (or booms) for the video monitors would obstruct the view and may be a bit more obstructive moving the patient. We have found that locating the patients head toward the left hand wall works best for most of our applications. But equally important in the design is to have the flexibility to modify the locations of these booms for different applications. The logistical flow of staff positioning and the determination of equipment locations including booms all hinge upon how you decide to position the patient for their procedure.

Whether you have one procedure room or several, each must accommodate the needs of that particular patient at the time of that procedure as well as any equipment that could be anticipated, should any adverse event occur without having to scramble for equipment elsewhere in the unit. In a room that does complex airway cases, you must have the necessary backup supplies to support the maintenance of the airway should that be needed.

The size of the rooms must be large enough to accommodate the function of the room but not so large as to waste time getting supplies from a cabinet that is uncomfortably distanced on the other side of the room.

An early discussion needs to be made with the designers and the radiation safety office to determine if special considerations must be taken for the procedure space regarding the anticipated use now and in the future for radiology services. Some programs use fluoroscopy on a routine basis and depending on the use may require the procedure room to be isolated to protect those outside it from excessive radiation exposure.

There must be adequate counter space along the perimeter of the room for additional supplies that may be required during the procedure which should be readily available without having to hunt through cabinets. The counter space should include a designated area for specimen handling and enough space for computers needed for video documentation, PACS, or hospital information systems. We have found that there generally needs to be some form of system for image capture directly at the bedside even if the majority of video documentation is planned in the physician workstation.

As mentioned, there should be consideration as to the location of medical gases and vacuum to accommodate the movement of staff and patients.

Considering the trend in endoscopy suite design for ease of use, flexibility, and infection control advantages, the use of equipment booms, which removes any equipment contact from the floor, has become more and more popular in procedure suites outside of the operating room environment. Generally, there is one equipment boom to house the larger stationary hardware that will be used during most cases in that room and one or two additional booms to support the video monitors needed for a variety of positioning during different procedures. These equipment booms do not come cheap and may cost well over $100,000 but are worth every dollar spent on them. A central switching system can be integrated into the room at an additional cost which will allow for different devices to be imported to the selected video monitor outputs without having to hardwire these separately for each case.

The total number of video monitors available should be sufficient for all endoscopic views as well as radiology images required during a particular case and should be able to be visualized by both the operator and assistant without having to turn their heads from the position they are in during the procedure. This may include several images including endoscopic, ultrasound, and CT scan which may be needed simultaneously. Our own personal experience has taught us that trying to determine the number of monitors required by viewing some cut sheets left us short of what we truly needed.

After considering every situation that we could think of to determine an adequate number of monitors (and the procedure rooms were functional), not only then did we realize that the assistant did not have an endoscopic view unless that person rotated their head 90 ° to the right. This required that person to take their eyes off the tool they were using to see the accessory on the screen. Consequently, an additional monitor was installed for the assistant (who is normally positioned looking at the bronchoscopy operator). This monitor was located on the equipment boom to the left of the operator directly in line with the assistants view. I would suggest that those responsible for the decisions on the room design actually gather the staff in a role-playing scenario to best determine the location of the patient, equipment, and monitors for optimum function (Fig. 4.5).

Whether one chooses to use an operating room table or stretcher depends upon the procedure planned and what you are comfortable with. There are advantages to each but expect to pay $30,000 for a fully equipped electric OR table compared to around $1,000 for a stretcher.

Adequate and flexible storage should be a priority demanded in each procedure room. Designers seem to leave this as an afterthought, and the end users are left with a lot of extra supplies that have no place to call home and usually are then placed in some corner away from the procedure room until they are desperately needed during a case. Then the scramble is on to remember where they were put.

Whatever the room is designed to be used for should have ample supplies in the room. I would consider the use of wall-mounted storage cabinets. They are very flexible, and you can easily change the shelving bins to accommodate supplies whose dimensions change over time. Some of the newer ones

Fig. 4.5 Procedural suite

Fig. 4.6 Storage cabinets

are mounted on a rail system and can be moved along the wall for flexibility should the room design needs change and also are off the floor for infection control advantages (Fig. 4.6).

There also needs to be a sufficient number of procedure tables for each procedure room. I would suggest at least two and they should be on wheels to allow for movement in close enough to the procedure area with enough surface area to prevent any supplies from being too crowded or falling off the table (the primary table should be at least 5 ft by 3 ft).

In anticipation of the need for multiple size or style bronchoscopes during a single procedure, there should be communication in advance of the procedure from the staff attending or fellow as to the potential need for such. That way, support staff is not put in the awkward position of having to leave the procedure room to search for the required additional scope. Also, if it was reserved for this case, there would not likely be the chance that it was being used for another case during the same time.

Fig. 4.7 Bronchoscopy inventory

On the topic of bronchoscopes, we must consider what the correct inventory should be for the entire interventional pulmonology program. The proper number and types of bronchoscopes on hand are crucial to the success of an IP program. Many factors will determine the necessary inventory to avoid shortages which affect productivity. Some of these factors include:

(a) The number of practicing physicians
(b) The practice model which will determine how many physicians will be performing procedures at the same time
(c) Whether other services in the hospital system have access to the same bronchoscopes
(d) How scopes are reprocessed (where and how this is done determines turnover time)
(e) The types of scopes used (diagnostic, therapeutic, ultrasound, pediatric, ultrathin) and more importantly, the combination of multiple scopes that may be used during the same procedure
(f) The current age of the scopes in service and useful life expectancy (Fig. 4.7)

4. ***Nursing Workstation***

This central workstation would be located along the common hall where staff would use this space as a command post to monitor patient status, write notes, and communicate with physicians and other staff. Here will reside hemodynamic data for all patients along with that available at the individual bedside. It would be centrally located in such a way as to visualize all patients in the preop and recovery areas, since this is the primary focus. Separate nursing staff and physicians monitor the status of patients while undergoing procedures in the actual procedure rooms. A call system from patient's bedside would alarm in this area along with visual cues outside of each patients bay. This workstation is physically located close enough to the procedure rooms as well to offer assistance should the need arise.

5. ***Physician Workstation***

This private space for physician staff (also positioned on the common hall) allows an area for them to congregate between procedures for dictation of notes, access to viewing and printing reports, and for discussion with other physicians.

This form of a command center also allows communication throughout the unit with two-way audio and video feeds to the actual procedure rooms. For the purpose of visualizing procedures in other areas, the communication system here can direct the cameras in the procedure rooms to other conference rooms in the hospital system and through its own video conferencing system to anywhere there is a system at the other end. In this space, any video documentation can be edited and finalized before attaching to the final reports.

For many years, still images were the only options available but in recent years, the quality of video clips have improved tremendously and are in formats that are easy for the endoscopist to share with referring physicians.

While there are many stand-alone systems available for capturing video and stills from the procedure as well as proprietary systems to record the procedure notes, the challenge still lies in finding a system that can integrate all of these needs into a seamless program together. As advanced as our

Fig. 4.8 Physician workstation

program is, in order to get the highest quality for our images, we have to rely on different systems to import these images into our dictation system (Fig. 4.8).

6. ***Storage***

Over the past several years, it has become more obvious that space in medical centers is at a premium with the need to keep inventories at the leanest margins possible; consequently, every effort must be made to conserve expenses by anticipating use of accessories and supplies. Hospital purchasing and budget departments can provide records on past expenses to gage what anticipated needs may be, moving forward.

With this in mind, I would envision having two main storage areas along the common hall with efficiencies of staff and conservation of supplies in mind. One would contain nursing and general medical supplies in an area of close proximity to the preop, recovery, and procedure suite, while the other would be used for storage of technical equipment and be located close to the procedure suites and reprocessing area. The storage of supplies would utilize par level stocking which through distribution services will provide the least amount of inventory required based on prior usage and will assure rotation of inventory to minimize the risk of using expired supplies. Both will also offer the most efficient use of staff time by minimizing the distance and time required to travel to these areas for replacement supplies or equipment.

7. ***Reprocessing***

There are no specific standards related to bronchoscopy reprocessing. All recommendations come from our peers in the GI profession and specific hospitals' infection control departments. But as much as it is similar, the equipment is different in many ways, and I believe that there needs to be similar standards for infection control issues related to proper handling of bronchoscopy equipment. Bronchoscopes are generally smaller in size and have consequently smaller diameter working channels which may make cleaning potentially more difficult. One upside is that most bronchoscopes utilize single-use disposable suction and biopsy valves which have the advantage over reprocessing the valves used in GI which mainly use reusable valves.

Consequently, we are left with figuring out for our own patients what is the best way to properly care for them in terms of preventing cross infection between patients as well as contamination of the equipment after proper reprocessing.

A separate discussion on infection control with regard to transport of soiled and clean bronchoscopes should be considered. We need to determine how to best move the instruments that have been reprocessed from their storage area to the procedure room thereby protecting the patient from contamination from the environment and soiled surfaces and also protect the health-care practitioners from diseases related to a contaminated bronchoscope during the postprocedure period until the scope is moved to the reprocessing area.

There are many solutions to these issues, but one that seems relatively simple is a system we have incorporated into our practice which uses a tray or plastic bin that has sterile liners used to carry scopes from the clean storage area to procedure rooms. A cover, which is labeled as "clean," is placed over the top during its trip to the procedure room, and after the procedure, the scope is placed in the same tray and the cover is replaced with another provided that is labeled "contaminated." This should eliminate any confusion as to whether a scope has been used or not.

There are separate infection control steps that should be taken at the end of the procedure to initially clean the scope at the bedside to decrease its bioburden which are out of the

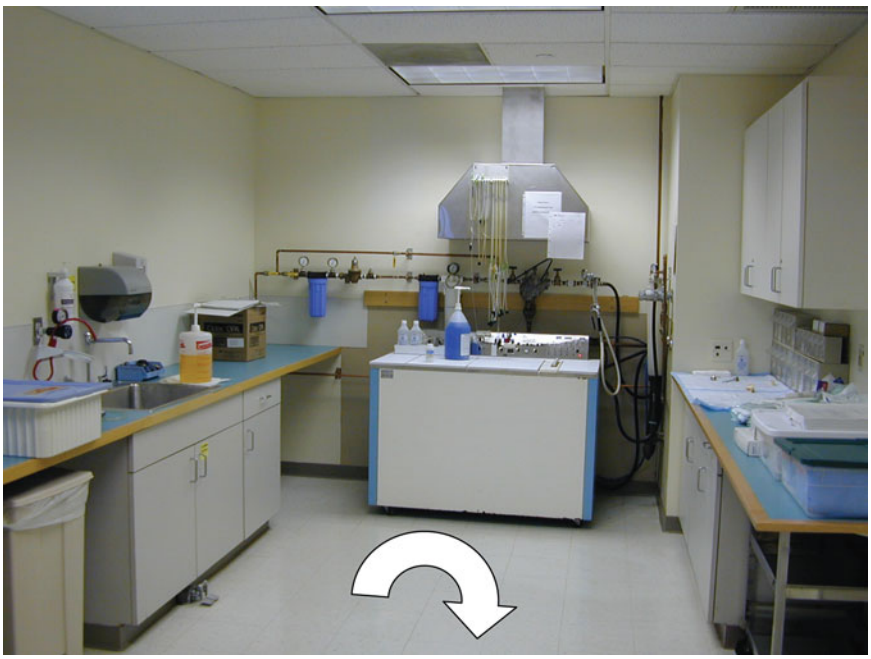

Fig. 4.9 Reprocessing area with directional flow

context of this publication but should be part of any hospital's infection control policies on endoscopy-related procedures.

There should be segregated areas in the reprocessing suite specifically for precleaning, reprocessing, reassembly, and clean storage and should flow in a circular fashion to prevent any crossover of soiled equipment into clean area and vice versa (Fig. 4.9).

Ideally, the reprocessing area should be in close proximity to the procedure suites for ease of transport and to prevent the instruments from having to sit for periods of time and allowed to dry out and make the reprocessing more difficult.

An additional step in the prevention of the development of bacteria in the reprocessed scope is the proper drying of the scope. Standard recommendations suggest the use of a postreprocessing alcohol flush to allow for better evaporation of the working channels. One additional method of drying the working channels that has been recommended is to place the scope in a drying cabinet which uses a desiccant to remove moisture from the air that is pumped through the internal channels of the scope.

8. ***Other Spaces?***

You may want to consider an additional space in the procedure suite that would be dedicated for the training of junior staff and an area that could be used for what we like to consider "technology development." It is very helpful to have a space which is in the suite itself where hands-on training can take place immediately prior to or even after a procedure to demonstrate a technique to better utilize ones skills. We have found in the past that if this space is located outside the suite itself, it tends to not be used because of time and distance limitations.

As the development of technologies continue evolving at such a rapid pace, we find more and more equipment being trialed with the need for reviews on a regular basis. This space is perfect for this purpose as it does not hamper the flow of patient care since it is not in the procedure room itself and staff are not felt rushed to learn while the room is being turned over for the next case (Fig. 4.10).

Additional Equipment Needs and Spaces to Be Considered for Procedure Unit

(a) Emergency equipment – code cart with portable oxygen and portable vacuum for transport of patients.
(b) A secure area for medications with refrigerator if needed.
(c) Shut off for medical gases used in the adjacent area.
(d) Negative airflow system for specific rooms in preop, recovery, and procedure suite.
(e) An area immediately outside procedure rooms for storage of personal protective equipment and inside for disposal of such as well as sink.
(f) An area set aside for the storage of specimens prior to transport to their respective labs. The initial prep should take place at the bedside to prevent mislabeling of specimens with other patients. There also should be a location used to hold specimens which can be used to log them out.

Fig. 4.10 Training/technology development space

Suggested Reading

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