Cardiac Catheterization Laboratory Facility Design and Equipment Selection

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Offered by both tertiary and community hospitals, diagnostic and interventional cardiology is fast becoming a common service. It has become an area of growth for many facilities, resulting in an explosion of interest at healthcare facilities nationwide. Hospitals not currently offering diagnostic and interventional services are reviewing facility and capital equipment expenses, hoping to increase revenue growth by adding these services. Similarly, organizations that have been offering diagnostic and interventional cardiology services for years are periodically reexamining their programs for potential improvement and eventually replacing older equipment. Often, due to program growth, organizations are re-designing or expanding their facilities.

There are many practical concerns that must be addressed in order for a facility to create or expand their diagnostic and interventional cardiology services. In this article, we will examine two main questions:

1. What is the best facility design for efficient and safe, cost-effective care?
2. What equipment and equipment features are most appropriate to meet program needs?

Facility Design for Efficient and Effective Care

While facility design is often limited by available space (square footage) and its location, there are some design features that are critical to the efficient use of space. It is essential for the procedure room and control room to be adjacent to each other, with storage space as well as the clean and soiled utility areas located within the immediate cardiac catheterization suite area. However, if there are space limitations, additional storage, patient holding areas, the family waiting area, staff locker/lounge area, offices, image archival storage and physician changing areas may be located nearby. The ideal situation is to allow for all areas to be located in one centralized suite.

Procedure Room. The catheterization laboratory procedure room should provide ample space for the equipment, in-room storage and movement of the patient into and out of the room via stretcher or patient bed. The American College of Cardiology recommends 500–600 square feet for the procedure area and 150–200 square feet allotted to the control room. These recommendations allow for adequate space, but are overridden by any state regulations that define space allocation.

Items for consideration in the procedure room include in-room storage cabinetry, standing-height counter space, a clinical sink, and positioning of computer drops for hospital information system terminals. Multiple computer drops should be installed at the time of construction or renovation, even if there is not an immediate plan to install terminals. Likewise, at least one phone line into the procedure room itself is recommended.

If your lab is performing permanent pacemaker insertions or some of the more advanced percutaneous aortic repair procedures in this setting, ventilation and airflow must meet operating room standards.

The placement of gases and suction outlets in the procedure room should also be given attention. Often, in positioning equipment to allow for full movement of the C-arm, gases off the wall are too far away from the table, requiring the use of tubing extenders that can loop across the room and pose a safety hazard. There are several solutions to this problem, including under the table gases (coming off of the equipment table base), power columns, and overhead swing-arm booms or overhead retractable booms. Often, room design, equipment specifications, and layout will determine the best method to supply gases.

As with the gases, the positioning of electrical outlets is critical. Several should be included in the boom or column selected for the gases, several placed below or on the procedure table base, and multiple additional outlets need to be placed throughout the room, including several above the countertop.

Consider the use of an automated medication distribution system (e.g., Pyxis [San Diego, CA]) located either in the procedure room or shared in the equipment room. This allows for security, easy access, and better inventory management and charging of medications.

Equipment Storage Space. If two procedure rooms are being designed, a side-by-side configuration with a shared equipment storage space between the two rooms provides for equipment ease of access and allows for streamlined inventory management. The equipment storage space should be lined with an electrical power strip to allow for multiple plug access to keep any battery powered/charging equipment accessible. The equipment storage area should also be configured with cabinetry to hold catheters, guiders, balloons, stents and guidewires. Many laboratories prefer to use movable wire shelving that allows for changes in configuration as a result of changing inventory and/or changes in supplies.

Control Room. The control room is another critical space. The room should be of adequate size to allow staff movement and required equipment (such as imaging control panels and hemodynamic monitors), but an overly large control room invites visitors (vendors, other staff, other physicians) who can be a distraction during a case.

While procedure rooms may be side-by-side or back-to-back, it is not advisable to have a single control room that supports multiple procedure rooms. Again, this can be a distraction when the activity in one of the rooms is of an urgent or high-risk nature. Some state regulations prohibit a shared control room.

The control room floor should also be elevated by one or two steps to allow for full visualization of the field. An elevated floor also allows for computer and monitor cables to be run underneath. The window for viewing into the procedure room should be as large as the space will allow, making sure that the viewing space is also low enough to allow visualization of the table from the elevated angle. The preferred position for the control room in relation to the procedure room is at the "foot" end of the patient table. This allows for full viewing of the field, regardless of whether the physician works on the left or right side of the table. From this foot position, the staff member in the control room has a view that is unrestricted by the backs of staff members working at the table or overhead hanging monitors, as is sometimes the case in control rooms positioned on one side of the procedure room.

As with the procedure room, multiple computer drops and a minimum of one phone line should also be installed in the control room. Multiple phone lines may be beneficial when dictation of reports is provided by phone access.

Patient Holding. Additional space for patient holding to provide pre-procedure assessment and immediate post procedure care is essential and can be designed in several ways. Many cardiac catheterization laboratories provide only Stage I recovery (immediate post-procedure vital sign and anesthesia recovery monitoring) in the holding area. If that is the case, a minimum of two beds or stretchers per procedure room is needed to facilitate patient flow in and out of the lab. Some facilities admit outpatients directly to the cath lab area and recover Stage I and Stage II (ongoing monitoring for the remainder of the recovery period) patients as well as discharge outpatients from this area. In the latter case, the number of beds required should be based on average daily case volumes and should allow for efficient patient flow, eliminating "waiting for a bed" situations. (Space constraints often limit the ability of a facility to use the holding area in this manner.)

The holding area should contain a small "nurses station" area to allow for documentation, computer terminals, a scheduling secretary, etc. Patient bays should preferably be walled cubicles with breakaway doors. This will allow for increased patient privacy in light of the newest HIPAA regulations. The patient bays should also be equipped with gases, call light, monitors (including EKG, NIBP and SaO2), stretchers and a small storage cart or cabinet. Multiple computer drops and phone lines should also be installed at the nurses station area. Consideration should also be given to providing for computer drops in each patient bay to allow for bedside terminals, if not currently, then in the future. Many cardiac catheterization holding areas have added televisions and tranquility lighting to create a more patient-friendly and soothing environment.

Family Waiting Area. The final area to be discussed is the need for a family waiting area that is in close proximity to the procedure room. This allows the family to feel they are close to the patient and makes it easier for the cardiologist to visit the family post procedure to explain procedure results and treatment options. Again, keeping in mind HIPAA regulations related to patient confidentiality, there should be at least one private "consult room" to which the family can be directed for confidential physician/family discussions. Many facilities are also equipping the consult room with a phone and a computer terminal/review station so that the cardiologist can actually show the patient's procedure images to the family. This consult room would require a lock mechanism (either a key, keypad or digital) to maintain equipment security and patient confidentiality. Computer drops and phone lines should be added to the family waiting area as well.

Three other issues that do warrant mention here are:

1. The need for automatic doors into and out of the suite
2. The need for extra-wide doors into the procedure room
3. The need for several types of room lighting.

Automatic doors allow for ease of stretcher and bed movement with a single staff person. They are also useful in emergencies, when additional hands need to be focused on the patient. Extra-wide (usually two-panel) doors leading into the procedure room allow for ease of patient movement. The doors will more easily accommodate a patient in a critical care bed or utilizing adjunct support equipment such as a ventilator or intra-aortic balloon pump requiring multiple staff for transport.

In-room lighting should include not only the usual overhead fluorescents, but additional soft perimeter lighting with dimming capability (used during the procedure) and an overhead surgical spotlight (usually provided by the imaging equipment vendor). It is preferable to have tableside foot controls for the lighting as well.

A final major consideration is the proximity and size of the elevators that will service this area. Quick access to elevators to receive patients is essential. The

elevator size must be able to accommodate patients on beds or stretchers with support equipment such as intra-aortic balloon pumps and IV poles, as well as transport personnel.

Equipment Selection for the Cardiac Angiography Suite

The major pieces of equipment for the cardiac catheterization laboratory can carry a price tag of more than a million dollars and have numerous options and configurations. Making an informed decision on these items is critical to the usefulness of the room as well as the satisfaction of the users, physicians as well as staff. While there are several pieces of equipment to be placed in the procedure room, this article will concentrate on the imaging equipment, hemodynamic monitoring equipment, and data/imaging archival. These pieces of equipment should be reviewed through an RFP (Request for Proposal) process that will allow the equipment to be compared on an apples-to-apples basis as much as possible. The RFP pricing should be followed by individual vendor presentations and site visits to see the equipment in use. Included in the RFP process should be a request for a list of contact names and phone numbers of hospitals currently using the equipment under consideration.

Imaging Equipment

Imaging equipment is the core of the cardiac catheterization laboratory. An early decision regarding this equipment and its features is essential to allow the architects to best utilize its specifications in the procedure room layout. The specifications are also needed to determine power supply needs as well as air cooling considerations. While architects need this information for planning and design purposes, they will work with and accommodate whatever selection the facility makes regarding the vendor. The facility should select equipment based on program needs (current and long term) and physician/staff preferences, while still keeping in mind the hospital's financial constraints.

Image Intensifier (I-I) Size. Cardiac imaging systems typically have a smaller I-I size to provide a more concentrated area of focus. If the procedure room will also be used for peripheral studies, consider a dual I-I system that will allow for larger areas of focus (as in peripheral run-off studies) or purchase of the larger single I-I that will allow for magnification. Likewise, if peripheral work is to be done in this setting, the C-arm/table should allow for full table panning to include the legs. Optional bolus-chasing features should be considered.

Flat panel technology. While conventional digital imaging is the standard today, flat panel technology is now available and may be evaluated. Conventional digital imaging uses a fluoroscopic imaging chain including an analog image intensifier, while flat panel imaging converts the x-ray signals into digital images. The point of acquisition eliminates the artifact and distortion associated with the image intensifier chain. Flat panel technology also reduces the radiation dose required for imaging. This technology is not available from all vendors at this time, and it may be more useful to those performing peripheral work (due to panel size) at present. However, this technology will most likely become mainstream in the next 3–5 years. It is certainly worth discussing with vendors, as well as taking a site visit to discuss any pros and cons with the end-user.

Rotational angiography, which allows for 3-D imaging of the arteries, is another equipment option offered by most of the major vendors. Again, most of the initial use for this option has been in peripheral angiography, but the technology is now being applied to coronary diagnostic and interventional work as well.

Table options. Make sure that the table weight capacity is as high as possible. Previous tables accommodated 325–350 pounds, which created some limitations for patient imaging. Most vendors will offer a table with a capacity of up to 450 pounds.

To allow for stretcher positioning, the table should also be able to rotate laterally a minimum of ninety degrees. Tables may be floor or ceiling-mounted and are generally selected as to what is available from a particular vendor (not all offer ceiling-mounted tables) and what is required by the room's physical limitations. There are situations in which the ceiling height, amount of support and weight bearing will not permit the use of a ceiling-mounted table.

Standard equipment options that should be packaged with the imaging equipment include:

- Table accessories such as armboards and extenders
- Overhead and table lead shielding;
- Overhead surgical light;
- The power injector.

While most of these items can be purchased from other vendors, having a single vendor responsible for the installation of all equipment helps ensure everything will be mounted and interact properly. Imaging archival, available in several configurations from many vendors, can be purchased as part of the imaging package and will be discussed later in this article.

Hemodynamic Monitoring Equipment

Hemodynamic monitoring equipment is essential to the cardiac angiography suite and several products are available for consideration. Several imaging equipment vendors also offer hemodynamic monitoring systems. There are some advantages to having a single provider for both major pieces of procedure room equipment. However, if the vendor's hemodynamic equipment is not user-friendly, does not have database capabilities and is not upgradeable, a separate vendor may be preferable. While every hemodynamic system

records waveforms, calculates shunts, gradients and other required parameters, there is a wide spectrum of capabilities among products for data entry, report generation, databasing and integration with hospital information systems. Some monitoring systems will also archive images from the x-ray system. When comparing these systems, it is essential to know what you want the system to be able to do today as well as in the next five years. For example:

• Perhaps there is no immediate plan to interface the hospital information system with the cath lab system, but is the system capable of future system integration?

• Perhaps the hospital is not currently participating in the American College of Cardiology database, but is the monitoring system approved for and capable of handling the database should the hospital decide to participate during the next several years?

• When considering the hemodynamic system, also consider if the procedures to be performed in the cath lab include electrophysiology (EP) studies, since additional software and equipment will be required and may require interfacing or additions to the system's current software.

• Finally, consider documentation and report generation from the system. Determine if documentation in the system could potentially replace current manual documentation.

Other questions to ask include:

• Will the system pull hemodynamic parameters (BP, P, HR, SaO2) at automated intervals and enter them in the notes, eliminating the need for manual vital signs flowsheets?

• Will entering supplies used during the procedure allow for case volumes, volumes by physician, complications, etc., to be reported in both routine and customized reports?

Data/Imaging Archival

A critical component to the catheterization laboratory is rapid, easy access to patient information and images. Historically, paper reports have been filed and stored, and require manual labor and time to retrieve, copy, mail, fax or carry the information to where it is needed. Images were captured on film and more recently to a CD, filed, stored and retrieved in much the same way. Often the paper report and the images were not stored together, resulting in two separate filing systems. Today, these systems are rapidly disappearing with the emergence of on-line image and report archival, which allows the hospital to save time, space and personnel costs associated with hard copy storage. There are numerous ways to accomplish on-line image and report archival, from the simple to the complex, and likewise, the price tag can range from reasonable to cost-prohibitive. Before deciding on an archival system, the facility should review current archival and storage systems, determine a long range plan for archival and storage, whether additional departments such as EKG and echo are to be included in the archival system, and the capabilities of any current hospital systems.

There are some vendors who offer system-wide archival allowing for not only cath lab images and reports, but EKG and echo images and reports to be archived into patient files with access to the patient's entire cardiac history. Some of these systems will also interface with hospital information systems. Then images can be brought up on-line on any hospital IS terminal. In some cases, with the correct access codes, images can be accessed from remote PCs in the physician's home or office. As one can imagine, a system this flexible requires several interfaces, is pricey and usually requires the addition of a system administrator to maintain, upgrade and assist with system problems. When considering a system that interfaces with the hospital information system, it is critical to have the vendor outline (in writing) the type of interfaces required, costs associated with that interface and a clear definition of who (vendor vs. hospital) is responsible for the interface development and costs. It is also important to gain a clear understanding of what equipment and software is considered proprietary by the vendor and cannot be shared or used with other equipment and software. Proprietary equipment/software is sold exclusively for the use of the purchaser. It cannot be copied or added to other systems in the institution without additional contracts or fees. Likewise, this equipment/software is usually not able to be altered in any way without negating warranties and servicing contracts.

Many hospitals cannot afford systems such as the type listed above, but do want to store images in such a way that they are easily retrievable and take little or no storage space. In that instance, many of the imaging systems discussed earlier offer archival systems ranging from individual patient CDs, to online jukebox storage of multiple cases, to the system-wide archival just discussed. Some hemodynamic vendors will also offer image archival within their systems. To ensure that equipment interfaces are workable, involve personnel from the Hospital Information Department in the archival equipment discussions. Many hemodynamic systems also have limitations, as the size and number of cases that can be archived temporarily on the system and a permanent archival system must be provided. It is vital that any equipment selected for image archival and image transfer be DICOM (Digital Imaging and Communications in Medicine)-compatible, meaning the digital images and information are stored in a format that is compatible with and transferable to other medical devices. The American College of Radiology and the National Electrical Manufacturer's Association have developed the DICOM standard to encourage vendors to construct their equipment and software so that images and data

can be transferred without loss of integrity. Most major vendors comply with DICOM standards. Finally, each system of archival must be reviewed for terms of access and patient file security. When purchasing an archival or database system, time must be allotted for system install, development and testing of any required interfaces, and ample time for staff training.

Summary

Facility design and equipment selection for the cardiac catheterization laboratory involves time, money and people. A good cath lab physical layout is essential to efficient workflow and can enhance the patient's experience. To determine the best catheterization laboratory design for the allotted space, the hospital should involve not only the architect, hospital planner and department manager, but the cardiologists and staff as well. Likewise, to choose the best equipment fit for the program, the hospital needs to review current cardiac program needs and determine the program direction over the next 3-5 years. For additional information regarding cardiac catheterization laboratory facility and equipment standards, visit the American College of Cardiology website at www.acc.org

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