The Catheterization Lab of the Future

An integrated interventional suite with a practical design and modern imaging equipment will save time and costs and will benefit patients and interventionists alike.

BY PATRICK PEETERS, MD; JÜRGEN VERBIST, MD; KOEN DELOOSE, MD; AND MARC BOSIERS, MD

Traditionally, there are three different working areas for radiologists, cardiologists, and vascular surgeons. Radiologist activities typically take place in an angiography suite, cardiologists perform their interventions in the cardiac catheterization lab, and most vascular surgeons make use of a mobile C-arm within a regular operating room setting. The drastic evolution that has been made in the management of peripheral arterial disease during the past 2 decades, and that will definitely continue during the years to come, will soon put an end to this tradition.

There are three main reasons why the need for better images has increased. First, we have grown into a situation in which the application of endovascular materials and techniques is no longer restricted to a few pioneering vascular centers but has become common practice throughout the world. Second, diagnosis of peripheral arterial disease is not so much based anymore on looking at the anatomy itself as it used to be but relies predominantly on the interpretation of images from MRI, computed tomography (CT) angiography, and on-table angiographic images in the catheterization lab. Third, the aging population implies that we as specialists have to deal with more challenging cases, more difficult and tortuous arterial anatomies, and an increasing amount of patients who are in weak health and require close monitoring and extensive surveillance.

Figure 1. Room 9 in the operating quarter at the Imelda Hospital, Bonheiden, Belgium.

ROOM 9

Being a vascular surgeon and a true believer in the benefits of endovascular therapy for our patient population, the shortcomings of performing endovascular procedures in a classic operating room with a mobile C-arm became more obvious and pressing by the day. Three years ago, out of this need to update our workspace, the Department Cardiovascular & Thoracic Surgery of the Imelda Hospital in Bonheiden, Belgium officially inaugurated Room 9 (Figure 1). It integrates a dedicated catheterization laboratory imaging system into a surgical operating theater.

BENEFITS OF AN INTEGRATED SUITE

A fully integrated interventional suite combines surgical sterility with flat-panel vascular imaging, a linked workstation, postprocessing, and storage facilities. The size of the room allows anesthesiology facilities needed for full-patient monitoring, which is a must considering the bad general condition of many patients. Furthermore, any type of supportive equipment is available in the room, such as machinery required for intravascular ultrasound, atherectomy devices, or laser treatment.

Current peripheral suites are fitted with many interesting features to make certain procedures easier. An on-table duplex ultrasound makes puncturing easy and is a good guide during endovenous laser therapy. The possibility of storing several reference points to which the C-arm can be automatically relocated at any time during the procedure facilitates the management of even extremely complex procedures.

It is obvious that routine endovascular and open surgical practice both clearly gain from performance in this dual-capability working environment. For example, classic open bypass creation is immediately controlled on-table. When improvement of inflow or outflow becomes necessary after bypass surgery, balloon dilation with or without additional stent placement can be rapidly performed without dramatically prolonging procedure time. It is also an optimal venue for hybrid open-endovascular procedures, such as percutaneous aortic valve replacement.

The use of an integrated endovascular suite, however, stretches beyond hybrid procedures and opens doors to new diagnostic and treatment possibilities. Three-dimensional reconstructions generated by integrated CT or rotational angiography can make a real-time visualization of vessel morphology in any direction and improve the visibility of vessel structures. Application of three-dimensional reconstruction during treatment of intracranial aneurysms, for instance, is a must to ensure optimal positioning of catheters, coils, balloons, and stents.

An important benefit for patients of the endovascular suite is that diagnosis, treatment, and follow-up is performed is the same room by a specialist who is trained in the pathology, natural history, surgical options, periprocedural complications, and medical management, in addition to imaging-based therapy, for their specific disease state. Thanks to the high-quality equipment, patients are not exposed to high radiation dangers. Of course, the low radiation level is also beneficial for the operating team. Moreover, an integrated setting means saving time and personnel because more procedures can be completed in the same room by the existing staff without increasing the strain on the team and without relocating equipment or personnel from another area.

PRACTICAL DESIGN OF THE ROOM

Fixed systems are preferred when designing an interventional suite when compared to mobile systems. They offer more comfort and efficiency for capturing images and have better technological capabilities. They comprise a C-arm, a separate processing unit, and a workstation to perform postoperative biometrical activities. Patients are moved on a floating angiography table underneath the C-arm, which remains steady, in order to change the field of view.

When designing an interventional room, a choice has to be made between a ceiling-mounted system and a floor-mounted system, of which the former is preferable because they offer greater maneuverability. Another advantage of ceiling-mounted systems is that they are easier to clean. One should always take into account that sterility levels of an integrated endovascular/surgical suite should be as strict as those in a surgical operating theater. Maximum asepsis and antisepsis should be obtained at all times by controlling temperature, air pressure, humidity, and ventilation. Walls, ceiling, floor, and instruments should be easy to clean. It is of utter importance when designing a room to take into account the fact that electric cables need connection points and that they have to be out of the way for maneuvering tables, C-arms, and possible additional equipment. The risk of spilling blood or other bodily fluids in the immediate surroundings of the operation table is very realistic. This means that rough surfaces, seams, corners, or any other type of unevenness should be avoided as much as possible. Any place where the equipment connects with the floor is difficult to clean and should be considered potential breeding grounds for bacteria.

IMAGING EQUIPMENT

A discussion and detailed comparison of all technical specifics of the different imaging systems on the market

goes beyond the scope of this article. Also, the rapid technological evolution makes it nearly impossible to keep track of all the latest developments and, even if we could give a complete overview of all the current technological options, this article would be outdated very soon. Still, there are a few simple basic requirements that one may consider when choosing the best-possible imaging equipment.

A top-quality C-arm is the cornerstone of a state-of-the-art vascular suite. In contrast to a typical cardiology catheterization laboratory, a peripheral intervention suite requires a wide field of view. When performing peripheral vascular interventions, vascular surgeons need to have the opportunity to have an overview of inflow and outflow while treating a certain lesion. Also for endovascular aneurysm repair, it is imperative to have the entire endoprosthesis on the screen. Currently, classic analog detectors have been surpassed by new digital flat-panel technology. Perhaps the greatest advantage of flat screens is that images are not distorted, so that analysis of lengths and degrees of stenosis can be performed more accurately. Moreover, they offer the wide field of view needed for performing peripheral endovascular interventions and render images in enhanced resolutions, which visualize even the smallest vessels. The better systems on the market also work with minimal radiation doses, beneficial for both patient and working staff and have limited heat generation, which is appealing for sterility issues.

Further requirements of the suite's imaging system are a processing unit, a workstation, and a central image storage unit. The potential of any C-arm equals the weakest link of each of these last three elements. While performing a procedure, smooth and fast graphic abilities are a must. Using large-size, superb-quality images from a C-arm implies that a powerful processing unit is needed. The higher the image quality, the more working memory the processing unit needs.

Images from a C-arm are stored in DICOM format files, which can then be used for biometric postprocessing, such as quantitative vessel analysis or three-dimensional reconstruction. The higher the quality of the images obtained from the C-arm, the larger the size of the files that have to be processed by the workstation. It goes without saying that a high-quality workstation is also a must.

Permanent storage of the DICOM images on the hard drive of the workstation is not recommended. High-quality images take up a large amount of disk space, and consequently, it will not take long until the storage capacity of the workstation will be surpassed. Therefore, a central hospital image storage facility must be assembled. As an additional benefit, a centralized image database makes all images accessible for all services within the hospital and makes it easy to trace all medical images of one patient.

FUTURE PERSPECTIVES

Although mobile systems currently do not offer the same high quality and speed as fixed systems do, they will in the near future. Thinking one step further, it should be possible to develop a wireless system in the not-so-distant future. Wireless devices offer easy cleaning and, therefore, optimal sterility. Also, they would overcome the direct limitations that are now present due to wire connection points. In a wireless setting, the operating table, C-arm, and other equipment can be rotated a full 360° (and beyond) at any location within the surgical/endovascular suite.

Wireless equipment would also save time in case one piece of equipment needs to be repaired. A broken piece of equipment can be temporarily removed from the interventional suite and replaced by a spare. The vascular surgeon or interventionist would not lose valuable operation time, and patients would not need to be put on hold. The technical team would not have to wait for spare parts or specialized tools for a certain repair because the broken piece could easily be shipped to a central repair point. Moreover, this approach would save time and costs related to the mobility of a highly specialized technical team. ■

Patrick Peeters, MD, is with the Department of Cardiovascular & Thoracic Surgery, Imelda Hospital, Bonheiden, Belgium. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Peeters may be reached at +32 1550 61 97; patrick.peeters@imelda.be.

Jürgen Verbist, MD, is with the Department of Cardiovascular & Thoracic Surgery, Imelda Hospital, Bonheiden, Belgium. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Verbist may be reached at +32 1550 61 97; jurgen.verbist@imelda.be.

Koen Deloose, MD, is with the Department of Vascular Surgery, AZ St-Blasius, Dendermonde, Belgium. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Deloose may be reached at +32 5225 28 22; koen.deloose@telenet.be.

Marc Bosiers, MD, is with the Department of Vascular Surgery, AZ St-Blasius, Dendermonde, Belgium. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. Bosiers may be reached at +32 5225 28 22; marc.bosiers@telenet.be.