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The Effects of Combined Imaging Technology on Healthcare Planning and Design

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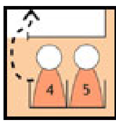


Introduction
The new frontier in medical imaging technology is in combined modality systems, or fusion imaging. On this leading edge are the new hybrid imaging devices that combine CT scanner and Positron Emission Tomography (PET) scanner functions. CT scanners employ a well-established technology, using X-rays taken at regularly spaced angles around the body to produce computer-generated graphic projections and anatomic slices of the region of interest. Because the imaging technique uses X-rays, the imaging is sensitive to bone and hard structures but relatively insensitive to soft structures. Diagnostic CT images provided excellent patient geometry and scale but show only structure with no information as to function.

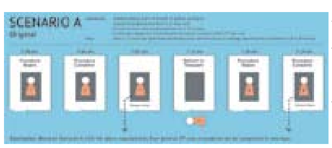
PET scanners are a relatively new clinical technology, using the decay properties of injected, high-energy nuclear medicine isotopes to generate graphic projections of metabolic activity in a region of interest. Because the imaging technique is based on the detection of metabolic activity, it is very sensitive to living tissue but completely insensitive to rigid structures. PET scanning is becoming the method of choice in detection and classification of cancerous tumors because of their uncharacteristic high metabolic state. Diagnostic PET images provide excellent information about cancerous tumor size and response to treatment but lack the necessary patient landmarks to accurately locate the tumor for precise surgical or radiation oncology treatments.

Major medical imaging vendors are now introducing hybrid devices that combine the CT scanner functions and the PET scanner functions into a common gantry. Parallel-processing image analysis and volume-rendering computer systems have produced merged images that superimpose PET metabolism on CT structures. These images provide much more diagnostic information than either of the images viewed independently.

Capability and Reality
As healthcare facilities begin to respond to the clinical pressure to provide combined PET/CT capabilities, the first question will always be, "How much is this thing?" The second question should be, "What do we need to do to get our money's worth out of this thing?"

The traditional single-slice-per-rotation CT scanner costs $400,000 to $800,000 and produces one image per one-second rotation of the X-ray tube in the gantry. A traditional CT study would be scheduled every 30 minutes and have a radiology staff member transport the patients to and from an outpatient waiting room or their hospital rooms. The waiting period is often 40 to 60 minutes. A typical day would produce 16 patient studies of 60 to 80 images each. The traditional CT scanner is rapidly being replaced by the multislice CT scanner. The multislice scanner will fit in the same procedure room with little modification except for the addition of a dedicated chiller unit for the X-ray tube.

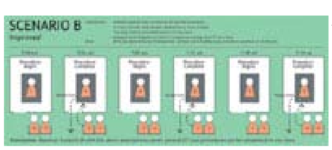
The multislice CT scanner is the new standard in healthcare and will produce 4 to 16 imaging slices per rotation and operate at two rotations per second, or 8 to 36 images per second, at a cost of $1.2 million to $1.6 million. When a multislice scanner simply replaces a single-slice scanner (see Scenario A), however, facilities seldom see the expected increase in use. A multislice CT study would require only 6 minutes per procedure, but patients are still scheduled every 18 to 20 minutes because a radiology staff member still transports the patients to and from an outpatient waiting room or their hospital rooms. The waiting period is often 20 to 40 minutes. A typical day would produce 24 patient studies of 600 to 800 images each-only a 33 percent increase in total procedures performed but a 330 percent increase in the number of images to be interpreted.



Scenario A

Although the multislice scanner can be much faster, it still takes a fixed amount of time to move the patient into the room, position the patient on the table, and move the patient out of the room when the study is complete. Traditional departments that assign one technologist to the CT scanner expect the turnover time between patients to be 10 minutes-to allow for patient removal from the scan room, changing the table covering, bringing the next patient into the room, instructing the patient, and positioning the patient on the scanner table. This turnover time has led facilities with the much-faster multislice scanners to provide two or even three staff members per scanner. While one staff member takes the patient from the room, another can change the table covering and set up the control console data for the next patient, while a third is bringing the next patient to the scan room, instructing the patient, and positioning the patient on the table. A staff of three often can cut turnover time from 10 minutes to 3 minutes. With the much shorter examination and turnover times, patient holding areas often become the limiting factor in department efficiency. If the patient is not yet in the department, or the last several patients are still waiting to leave the department, patient unavailability will negate any advances from faster machines and more staff.

By providing adequate area design and technical support, a multislice CT scanner can schedule patients every 9 minutes for general procedures. This requires a two- or three-place prep/holding area that is staffed for patient transport (see Scenario B). The holding area provides a staging area to maximize the availability of the scanner and minimize the radiology technicians' nonproductive time in moving patients. With proper design and staffing, the same CT scanner can produce more than 54 patient studies per day-a 200 percent increase in total procedures performed. Although the multislice CT costs twice as much as the single-slice unit, it can triple the number of procedures performed in one day, with adequate planning and design. The increase in patient volume also reduces the need for additional CT scanners and the associated construction, maintenance, and staffing costs.

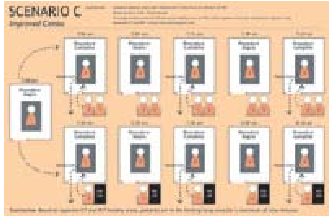


Scenario B

A fixed PET scanner currently costs $2 million and produces one study every 30 minutes. Data acquisition times are long because enough data must be captured to identify the source of the metabolic activity. Occasionally, studies cover the patient's entire body to detect possible metastasis of the primary tumor to other secondary sites. An adequate whole-body scan can take up to 45 minutes. PET scans and CT scans have similar turnover times, ranging from 3 minutes for a well-staffed department to 10 minutes for a minimally staffed area. The PET scanner also requires a nuclear isotope "hot lab" to prepare and calibrate the isotope to be injected. Besides the technician to staff the hot lab, a nursing staff member must start an IV in the patient to administer the isotope. Therefore, in terms of scan efficiency, a prep/holding area for the PET/CT patients is even more important than for CT-only patients (see Scenario C).

A combined PET/CT scanner currently costs $3 million and generally produces one PET/CT study every 30 minutes or a simple CT study every 9 minutes. The ability of the CT image to anatomically locate the sources of the PET metabolic data allows a much shorter acquisition time for diagnostic-quality images. The geometry of the PET/CT allows both modalities to acquire data simultaneously and ensure the accuracy of the image alignment. There have been attempts to study patients by taking independent images with a CT scanner and a PET scanner, then trying to index the images together. This is a much longer and more expensive process, with questionable results.

Impressive Equipment Speed Upgrades Are Not Enough
Any benefits from the speed of the technical procedure may not be realized without appropriate planning for the



Scenario C

prep/holding areas and staffing. The fixed time to move the patient and to prepare the room for the next patient can be optimized. If it is not, however, the entire throughput of the equipment is lost and the expected revenue gains will not be realized. In turn, without the revenue gains, there will additional pressure for more equipment, staff, and space to meet growing demands in the department. These interrelated factors can render the financial projections involved in equipment justifications and department budgets null and void.

Planning Methodology Changes

In the 1980s and 1990s, the planning methodology for radiographic rooms was quite simple. When the patient examination and study time was in the range of 30 to 60 minutes per procedure, turnaround time and transport time were not critical factors. With this procedure time range, a waiting room was considered adequate, and equipment speed was always the limiting factor in department production.

In the 2000s, the planning methodology must focus on keeping the machine in use due to the tremendous increase in speed and the decrease in procedure time. A comparison of Scenarios A and B shows the increase in patient throughput and decrease in patient waiting times that can be achieved through provision of holding areas and transport personnel to support the speed of the multislice CT scanner. The small additional cost of providing a double-stretcher holding area and a nontechnical staff member increases machine use by 100 percent.

The technology of a combined PET/CT scanner requires two holding areas with different functions to enable more efficient patient flow through the scanning area. The two holding areas are preferred over a single combined area because the PET prep area has the hot lab and requires that the IV line and isotope injection be administered by a higher-level staff person than would be needed in the routine holding area.

Another critical design factor is the physician's reading room. One radiologist can read, interpret, and dictate the reports for daily procedures on a single-slice CT scanner. A multislice CT scanner, however, often requires two radiologists. The combined PET/CT scanner requires the reading function of nuclear medicine and CT with radiation oncology experience. Therefore, the reading room demands will increase even though the equipment space requirements may not.

Conclusion

Upgrades in medical technology affect the success of healthcare planning and design even when the physical space requirements to accommodate the equipment do not change. An understanding of the changes in technology is critical to providing a design that will best achieve the advantages promised in the glossy sales presentations. Failure to properly support new technology with functional design might both limit the productivity of the installation and result in demand for additional equipment purchases that should not be necessary.

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