Design for Critical Care:

Impact of the ICU 2010 Report

Kirk Hamilton, FAIA

Everyone is fully aware of the persistent demographic trend towards an aging population. As the "baby boom" generation approaches the age of 65, the numbers of patients requiring critical care will rise. These same baby-boomers are demanding consumers with a long history of getting what they want and expect in the marketplace. They will ask more of the medical system than did the generation of their parents. I believe the patients of my generation are more educated about medical choices, will demand a role in the decision-making about the course of our care, and we are more prepared to make end-of-life decisions than our parents.

This demographic imperative and the accompanying explosion of knowledge are among the influences fueling the trend toward patient and family-centered care, and the designs for humane therapeutic environments that support this trend.

On the clinical side, there seems to be a clear trend toward working in interdisciplinary teams under the leadership of intensivists. They will be working with a continually changing mix of case types. Many patients who might have been candidates for the ICU in the past are now treated on acute units, or sometimes as outpatients. Others who might have had no chance of survival can now be treated successfully. This continuous change due to medical advances will alter the types of patients and the treatment protocols seen in critical care units.

The interdisciplinary teams will be working with new and improved technologies. The various manufacturers are tending to merge and consolidate, as well as standardize protocols for integration of equipment devices. The continuing tendency for information systems to offer connectivity and integrated platforms will advance until almost any data will be available at any terminal device with the proper passwords. A single controller, like the universal remote for your home stereo and TV will control every device. Point-of-care testing systems will give you accurate and real-time readings for numerous physiological parameters, all of which can be automatically entered into the patient's electronic record. All of these technologies are available and in use today – the question is the speed of integration and adoption that may be expected for the typical ICU. Ten years is my personal prediction, which is actually fairly soon since most large projects have a 3–5 year cycle.

The trend to practice with evidence-based

Kirk Hamilton, FAIA

Mr. Hamilton is a founding partner of Watkins Hamilton Ross Architects, In., of Houston, a na-tionally and internationally recognized firm in healthcare architecture. He is president of AIA – The American Institute of Architects, the AIA's Academy of Architecture for Health and was elevated to the College of Fellows for his advocacy of excellence in architecture for health, innovations in design, as well as for research and his visions for the hospital of the future. Most recently he found the center for Innovation in health Facilities, a subsidiary nonprofit organization. He has authored numerous articles and recently authored "Innovations in Planning for Healthcare and Unit 2000; patient Beds for the Future".

Activity-Adatable room, Clarian Methodist, Indianapolis.

clinical pathways will continue with standards becoming available in many more types of cases. Standardized care will offer lower operating cost, better outcomes and help combat the trend towards a severe shortage of specially trained professional staff.

Unit Size

In my experience, units smaller than 5 or 6 beds are inefficient to operate and manage. It is important to suggest that units larger than 8–9 beds are difficult to design with high quality observation from a central position, which has been a fundamental principle of ICU design from the beginning. If larger numbers are required, I suggest breaking them into pods or clusters of 7 or 8 beds, grouped together to form a larger department under single management.

In the United States we are required by the Life Safety Code to design suites up to a maximum of 5000 square feet (approx. 500 square meters). In such a suite we may avoid the smoke partition and fire rated doors into patient rooms, allowing ICUs to have large areas of glass in the corridor wall, or large glass doors, or even open cubicles without a wall or door. This size limitation for ICU suites allows units in the range of 7–9 beds, but poses problems with intervening smoke partitions and “hold open” smoke doors for units of 12 or more.

Unit Geometry

Design of critical care units has always focused on visibility from the central nurses’ station. We have been expected to allow the nurse at the central station to see the patient’s face in each bed. The nurse was expected to be able to observe major problems, like a fall from the bed, as well as be able to perceive important changes in coloration of the patient’s skin as an indicator of changes in condition. This clearly limits the farthest bed position from that single point of observation. Some have proposed that closed circuit video cameras can provide the same information, and authorities in some jurisdictions have allowed them as substitutes for direct observation. Designs still reflect the observation requirement for the practical reason that there is a limit to the number of high acuity patients for which a staff may carry responsibility.

A second crucial factor in ICU design is the requirement for an outside window for each room. This means that the shape of the external perimeter can become a limitation on the numbers and arrangement of beds. The staff needs

Twin power columns MICU, Methodist, Houston.

Legacy Good Samartin – Portland OR.

access to all of the various supplies, equipment and medications needed in the delivery of care, and they need it to be close at hand. For this reason, designs have generally come in a variety of recognizable simple, compact geometries with a high ratio of external perimeter. The typical shapes for these units include semicircles, boxes, horseshoes, vee and linear or staggered configurations.

Illustrations of these simple geometries include an 8-bed classic semicircle design from Arkansas Methodist Hospital and the 9-bed open-sided box design at University Hospital in Hershey, Pennsylvania. A V-shaped project from the SCCM (Society for Critical Care Medicine) Design Awards program shows a 9-bed plan with a single observation point. These simple configurations can be combined in larger projects, as in the case of the M.D. Anderson Cancer Center in Houston that has 50 beds on the same floor, configured in six pods varying from 8–10 beds in size.

Griffin Hospital – Derby, CT ICU.

Departmental Relationships

The most important departmental relationships for a critical care unit will include access and/or proximity to Emergency, Surgery, Recovery, Invasive Imaging, Cath, Telemetry or Step-down Units, Pharmacy and the Laboratory. The illustration shows the relationship between critical care and other departments on the same level at St. Michael Health Center in Texarkana, permitting the horizontal transfer of patients from surgery or cath directly to the appropriate ICU.

The relationship to Pharmacy and the Lab are often resolved with the use of a satellite pharmacy and state lab directly associated and co-located with critical care. Dr. Roger Anderson, the Director of Pharmacy at M.D. Anderson in Houston, has said that as few as 8–12 beds may be an adequate number to financially justify a satellite pharmacy. The trend in higher acuity critical care settings is for pharmacists to serve as part of the interdisciplinary team, making rounds with the other professionals.

Advances in point-of-care testing with technology available today may allow a less direct relationship to the Lab in the future. Point-of-care modules can be plugged into the typical ICU monitoring system, directly linking physiological monitoring to the real-time patient record.

Specialized versus General Units

The issue of specialization in critical care is volume-driven. Specialization of units offers the advantage of specially trained staff, delivering consistent and standardized care to a consistent clinical population.

A small hospital, like the 16-bed rural Heber Valley Medical Center in Utah, can provide oversized, flexible rooms that serve as an ICU when needed by adding the "ICU cart" with special supplies. The bed is monitored, but the room can also serve as a birthing room or an oversized acute care room.

At the other end of the spectrum, I would offer the example of the Medical College of Virginia in Richmond that has seven different and highly specialized ICUs on one floor. These include a General Surgery ICU, a Cardiac Surgery ICU, a Coronary CCU, a Respiratory ICU, a General Medical ICU, a Neurology ICU and a Neurosurgery ICU. In a large, complicated teaching hospital the decision to divide the appropriately sized critical care units into specialized units serving specialized patient populations is responsible. If, however, specialty units cannot justify an economical volume of patients, they should not be permitted to be separated solely for "turf-building" or political reasons.

Some New Ideas in Facilities

Trauma centers have developed ICU beds. Examples might include the Maryland Institute for Emergency Medical Services (MIEMS) in Baltimore. The Ryder Trauma Center in Miami by HKS is another. These high acuity environments may be models for critical care spaces intended to serve the increasing acuity of critical care patients. They feature redundant life support utilities in the form of wall-mounted or overhead systems with large numbers of outlets and gas connections. Their monitoring covers multiple parameters continuously and the rooms are sized for aggressive clinical interventions when necessary.

The "Universal Room" concept has been proposed and tested by Space Diagnostics and Shepley Bulfinch Richardson & Abbott at Massachusetts General Hospital in Boston. The study, with strong support from industry, was ultimately rejected and not built. The concept included designing all patient rooms for the highest level of acuity and flexing them down to less intense levels of care as the patient's condition improves. Appropriate staff would move to the patient, rather than incur a transfer to another unit. The design features decentralized positions in the corridor, just outside of each pair of rooms. If I read their drawings correctly, the room is capable of bed positions away from the wall for critical patients and a more normal position against the wall for the lower acuity situations. Monitors are plugged in or out as required, but every room is wired for monitoring. Another variation is that entire units could be reassigned as the census changes, because the rooms would be "universal" and therefore capable of suiting any service that required beds.

A "Super Acute" concept similar to the universal room has been designed by Perkins & Will and built at Southeast Georgia Regional Medical Center. I do not yet have a report on the results, but am told that the State of Georgia refused to permit an undesignated ICU. They apparently insisted that the ICU be specifically identified, and that a few additional ICU support spaces be located in the designated unit. The universal room size and design elsewhere in the hospital is supposed to have been accomplished.

An "Acuity-Adaptable" concept has been designed by Boyd Sobieray and constructed at Clarian Methodist Hospital in Indianapolis. This was concept was implemented for the Cardiology service and provided rooms capable of adapting to different levels of patient acuity ranging from critical care through step-down monitored beds. Preliminary data suggests that there are savings associated with the absence of costly transfers and the ability to manage a fluctuating census within a single service's components. Their rooms are very attractive, non-institutional in character and feature a nicely appointed family area towards the outside window wall.

Each of these concepts is another way of attempting to build adaptive flexibility into a critical care environment. Adaptive flexibility is the ability to accommodate change without a physical change in the room or unit. I'm sure we will be seeing more creative solutions to the address the important issue of flexibility.

Pendleton Memorial – New Orleans, LA.

CVICU, Methodist Hospital – Houston, Texas.

Life Support Systems

The most common life support systems in use for critical care include headwall configurations, power columns away from the headwall and ceiling-mounted systems to supply utilities from overhead. We are soon going to see a new generation of mobile life support systems that will use the bed as a platform for the technology. The headwall model is by far the most common in use, with power columns as a secondary choice in growing numbers of units. The overhead systems are less common, but are also increasing in number.

The traditional headwall design has been the standard from the origin of ICU designs as modified recovery rooms through the mid 1970s. Medical gasses, vacuum and electrical outlets are mounted on the headwall, behind the patient and usually distributed on both sides of the patient. Some installations will include wall-mounted equipment such as blood pressure cuffs and shelving for supplies. The monitor is normally wall-mounted, on the opposite side of the bed from the door, above the working zone, but with reachable controls for staff. Problems occur if the monitor is mounted at a height which shorter staff cannot reach.

Headwalls can be custom-built in the field. The architect specifies the locations of outlets and mounting brackets required by the staff to be installed by a contractor. Custom designs are actually significantly more economical than manufactured headwalls, but offer less flexibility in subsequent adjustment. Manufacturers have offered a wide variety of factory-built headwall products for the critical care market. As these products have evolved, they have grown to include “rails” to allow horizontal relocation as well as “snap-in or snap out” features for outlets and connections. A good headwall today can be changed easily to a new configuration of gasses, utilities and equipment mounts.

The problem with headwall designs is the requirement in a “code” situation to move the bed away from the wall. At the moment of crisis, when the team is actively administering intensive care, the bed must be physically relocated to allow access to the patient’s airway. The respiratory therapist, nurse or intensivist must carefully step over the various lines and umbilical connections to life support systems and monitoring interfaces in order to stand over the head of the bed to reach the patient.

In the mid-70s a few ICUs experimented with overhead supply for these life support systems. My first experience was at a Neuro ICU in Michigan where we wished to solve the problem of access to the head. In 1973 we used the example of operating room overhead connections to anesthesia machines as our conceptual model and custom-built an overhead column for the ICU room. The monitor was mounted on the column; electrical outlets and gas connections were available on the sides and bottom. It did not extend below 6 feet off the floor. Others were involved in similar experiments which industry rapidly converted into the "power column" concept.

The power column is a manufactured utility and equipment-mounting column fixed at the floor and the ceiling that brings the utilities from above the ceiling down to the level where they may be effectively used for the patient. It can contain any configuration of power supply, medical gasses, vacuum, communications ports and equipment or monitor mounts. These installations are not currently as changeable as headwall products. They have a relatively small "footprint" in the room and are normally positioned diagonally behind and to the side of the patient's head. Among the advantages of the power column is the ability to position the bed in a variety of locations arrayed around the column's position. In particular, the most appealing feature is direct, continuous unrestricted access to the head of the critical care patient.

My firm has recently been involved with a unique installation of dual power columns in a just-opened unit at Methodist Hospital in Houston. I look forward to learning whether the staff feels there will be additional advantages. The concept allows for thinner profiles and smaller footprints for the columns while offering positions on both sides of the bed for these utilities. The drawback could be that the positioning of the bed is more limited than with a single column.

Another concern with the power column and overhead pendant designs is orientation. Studies have shown that patients can be negatively disoriented in irregularly shaped rooms due to perception difficulty. "Normal" rooms have normal rectilinear shapes. It can plausibly be inferred that bed positions away from the wall and in orientations other than aligned with a simple rectangular room might cause disorientation in some patients.

I first became aware of overhead pendant products about ten years ago. The overhead aspect was nothing new. I believe a case can be made that the power column has no real need to come to the floor, or to a height that would hit the bed, for that matter. Some staffers request access to the patient from beneath the column. The real innovation in these products is the ability to swing the orbiting arm to a variety of locations and improving on the fixed nature of the more common power column designs. The original designs for these orbiting overhead arms again came out of the needs of the operating room. Very high acuity settings like trauma ICUs were the first users.

There is a wonderful design featuring overhead pendants by Tom Sagerser for the Kern Critical Care Unit at Legacy Good Samaritan in Portland, Oregon. This unit is notable for a variety of features, and well worth a benchmarking tour. The twin pendant mounted orbiting arms allow for a wide variety of bed positions, locations for monitors, power, gasses, and equipment mounts. Beds can be rotated to face the garden, or turned towards the decentralized staff positions along the corridor. When a line insertion is performed in the room, the life support system swings away to allow for a portable C-arm fluoroscopy unit and can support the monitors needed for the procedure's imaging requirements. I believe these pendant devices represent today's most flexible life support systems.

The prospect of using the bed frame as a platform for life support, power supply, point-of-care testing and physiologic monitoring modules is real. These robust, high tech beds would be designed to dock with utilities in the room and be self-contained during transport, without disengaging life support and continuous monitoring. They will probably be designed to work with some sort of motorized tug, allowing a single staffer to complete whatever transport assignment is required.

Room Size

In spite of miniaturization of some equipment components and the integration of some information systems, I believe that room sizes will continue to increase. Larger room sizes are not necessarily controversial, but no one likes to hear that more square footage and the accompanying cost will be needed.

The 1996 version of the *AIA Guidelines for Construction of Health Facilities* requires a minimum size of 150 square feet (approx. 15 square meters) with no dimension less than 12 feet clear (about 3.65 meters). This minimum standard is clearly inadequate for the ICU of today, much less the high tech ICU of tomorrow. The task force currently working on the 2001 revisions to the *Guidelines* is considering a possible change to a minimum of 200 square feet (about 20 square meters), along with another proposal to increase the minimum headwall width from 12 feet to 13 feet (about 4 meters).

To consider the real needs within the patient room, I would suggest that the ability to pass equipment past the foot of the bed requires a head-to-foot dimension more like 15 feet (about 4.55m). Should you be planning for a power column design or provide access to the patient's head, that dimension becomes 17 feet (4.75m). Providing access for staff and equipment in the work zone on both sides of the bed suggests a width of as much as 19 feet 6 inches (5.95m). A room of this size has an area of about 330 square feet or 33 square meters, considerably larger than the regulatory minimums and larger than the typical room size today.

Provision for Isolation

Charting for a pair of rooms. Royal Alexandra Hospital – Edmonton, Alberta.

Frederick Ognibene, MD, an infectious disease expert and critical care physician from the National Institutes of Health in Bethesda, Maryland, participated in last year's *ICU 2010* conference. He described the issues surrounding resistant strains in the critical care setting. He advised participants to plan for surfaces that will not allow standing water or any harboring of moisture. Ognibene reminded us that handwashing compliance by anyone in contact with the patient is the single most effective method to reduce transmission of infectious organisms.

The strong recommendation would be to provide multiple locations for handwashing sinks, including in the patient room near the door, in the toilet (or near whatever toileting or bedpan disposal solution is associated with the room), as well as at frequent intervals in the corridor outside the patient rooms.

Ognibene surprised the interdisciplinary audience of *ICU 2010* when he proposed that separate anterooms are not necessary for properly designed isolation rooms. He requires the appropriate negative airflow in the room itself and suggests that an isolation cart or alcove directly outside the patient room door for isolation supplies is sufficiently effective to allow deletion of anterooms and their cumbersome sets of doors in the future. I think he is right and all my clients are concurring. Where the regulators will allow us, we are putting alcoves for the isolation cart outside the isolation room and we are not building anterooms.

The Private ICU Room versus the Open Ward

I am led to believe that the private room may be a controversial issue in Europe. I expect that to be less controversial in the critical care setting than in the acute patient unit because of the prospect of higher acuity patients at greater risk to transmit infection or more susceptible to nosocomial infection and resistant strains. There is a clear trend in the United States towards a higher proportion of critical care beds to be found in individual private rooms or isolation rooms.

It is still common to encounter open bay or ward-type accommodations in trauma or surgical ICUs. The premise is that the high level of observation and clinical intervention required offsets the risk and loss of privacy. These patients are often comatose or presumed to be unaware of their surroundings. The counter argument is that ICU patients are routinely assigned staff on a 1:1 or 1:2 ratio which suggests that each pair of rooms can be designed for high level observation without compromising the ability to isolate patients from each other. Open bay designs now commonly include individual computerized workstations for the staff at each bed position.

It is much less common to find open bay or cubicle designs in medical ICUs or coronary CCUs. There is a long tradition of private rooms in the CCU where quiet and rest is more likely than continuous clinical interventions. Many of these units are carpeted and feature upscale décor for patients who are "awake and aware." I would make you the prediction that individual rooms will increasingly become the norm in critical care.

Observation versus Privacy

Observation and privacy could be described as incompatible polar opposites. You might be expected to choose one or the other. At one level the discussion about a private room versus a multi-bed room would illustrate the extremes. At another level the degree to which the patient is visible from the corridor is an issue. Is the patient in a fishbowl, or protected from public view?

There are, however, gradations available with the presence or absence of fixed walls, windows of differing sizes and doors of various sizes, including those with different areas of glass. Many doors available for the critical care setting behave like a glass wall, some with the ability to swing away, leaving a large open front to the patient room.

The medical case is easily made for a high degree of observation from the staff to offer patient safety. Many request a wide-open character in the ICU to allow staffers to know what is going on everywhere, at all times, and to readily summon help in a crisis. There is an obvious need for staff to be able to visually monitor the patient's condition and situation. Similarly, we know many patients are reassured to see the staff and to know that they are being watched by a skilled professional caregiver.

The case for privacy and dignity for patients and family is less well understood by the clinical staff, but has been demonstrated to be a real need. In moments of extreme crisis the fragile psyche is tested at its limits. There are many instances where the experience would be less traumatic for patient and/or family if a measure of privacy could be provided. Not all patients are comatose. Reducing traumatic stress is a positive physiologic outcome strongly inferred to be associated with privacy.

I personally suggest that a higher level of privacy should be made available when appropriate with walls, doors, blinds or curtains in an environment which features enough glass to ensure that clinical observation requirements can easily be met as necessary. Good designs should be able to deliver the extremes of high observation and protected privacy, as well as various intermediate levels of visual and acoustic privacy.

Centralized versus Decentralized

The original designs for critical care always featured a central nurse's station from which every patient could be observed. This related to the single paper patient record and the advent of central monitoring. It was important for physicians and nurses to know where to find the record, and older practice models encouraged this in a central location. The central monitor allowed a single nurse or technician to observe the cardiac monitors for several patients at once. Screens were capable of showing eight lines from eight patients, and in some cases more than one parameter might have been monitored.

Simultaneously centralized and decentralized ICU.

A station might have had two monitors to cover every patient in a larger unit. As technology progressed, we saw many more parameters being displayed on the monitors, improvements in monitor alarms and new methods for charting, such as flow sheets that illustrate the continuous progression of monitored parameters.

The central station also allows for centralized clinical management, staff interaction, mentoring and socialization. On the other hand, the central monitoring function has been less important as the parameters from any patient can be called up from multiple locations, including the terminal or monitor in a different patient's room. More direct nursing activity has moved closer to the bedside.

A few years ago I began to notice that nurses frequently moved an overbed table to a location just outside the patient room to provide a writing surface. They often laid out the unfolded flow sheet on these temporary desktops. Sometimes they would bring a chair. Another visible trend is the use of a roving supply cart that may include a writing surface, to get needed supplies closer to the patient. These practices have become common in older units with no provision for writing or access to a computer at the patient's room. In my practice nurses are now requesting supplies in the room itself, or a return to Gordon Friesen's 1970s "nurseserver" concept of cabinets in the room stocked through the outer door in the corridor.

There is a strong trend in newer designs to include a decentralized nursing position either just outside the room, or just inside the room. Stations outside the room are frequently paired to permit observation of two rooms. The typical staffing ratio of 1:1 or 1:2 suggests that a robust set of decentralized support functions can make the clinician's work more efficient. Typical functions in these positions usually include a writing surface, communications and access to the information system. Other items which may, or may not, be present include medications, supplies, handwashing, imaging view boxes. There is often a place for one or sometimes two people to sit. The most elaborate of these stations are truly decentralized models of the old nursing station.

Transitional designs have effectively employed both the central station and the decentralized nursing positions. The residual central station is best called a "team workstation" because the nurse has moved to the decentralized locations. The team station serves the larger interdisciplinary team that includes respiratory, pharmacy, dietary, social work, chaplains and so forth. In my experience the central station does not usually need to be as large as it might have been in the past.

Can the unit eliminate the central station and become completely decentralized? Perhaps. I can point to projects at Methodist in Houston and Royal Alexandra in Edmonton as strong examples of decentralized models, but I don't know of a unit that has been completely decentralized.

It is my personal opinion that for the next generation of advanced designs we will see fully decentralized staff support positions that include information systems, communications, medications, supplies, a writing surface and handwashing, all with direct observation of two patient beds. At the same time, I predict the central team station will serve the intensivist-led interdisciplinary team. I would suggest a model that offers both, rather than the models that offer one or the other.

Flexibility versus Custom Design

Management prizes flexibility because it appears to offer the prospect of fewer and less frequent changes that might result in saved capital dollars. The clinicians prize flexibility because their experience tells them that advances in clinical practice will lead them to inevitable changes in protocols, equipment and best practices. Flexibility is desired because the adjustment to change theoretically allows a superior clinical response, as soon as it can be justified. Architects are asked to deliver increased flexibility in their designs, but flexibility has a cost.

We have had a recent history of providing "tight-fit" designs for money-conscious clients to deliver the absolute minimum responsible area and lowest cost materials in an effort to trim capital projects to their tightest. These custom designs to precise specifications suffer from more rapid obsolescence and are less prone to successful conversion to other uses.

Webster defines "flexible" as adjustable to change or capable of modification. I would propose that there are two types of flexibility: adaptable flexibility and convertible flexibility. It is important to distinguish between "adaptable" and "convertible" forms of flexibility.

The ability to accommodate changing conditions without any change in the environment itself is "adaptable" flexibility. The environment is adaptable to the new requirements. This is Webster's "adjustable to change."

The ability to accommodate a change after a simple and/or inexpensive physical alteration is "convertible" flexibility. The environment is converted to the new purpose without drastic cost, effort or time. This is Webster's "capable of modification."

When change can be accommodated at a lower cost of time, money or human resources, it is more palatable in a time of significant financial restraints. A hospital's census and patient mix can be expected to fluctuate frequently and significantly. Facilities that can quickly adapt to these changes are better positioned, both now and in the future.

An example of adaptable flexibility in critical care is the ability to plan a somewhat larger space to accommodate the equipment needed to perform line insertions in the patient room. No change is required to adapt to the new or temporary use. Adaptable flexibility for a patient room to become a procedure room means it must accommodate mobile C-arm fluoroscopy.

An example of convertible flexibility for critical care would be the progressive care units at St. Michael in Texarkana, located one floor above the ICUs. These units follow the same geometry as the ICUs on the floor below and have been designed to convert to an ICU after a relatively simple addition of gas outlets and power from pre-plumbed and wired systems behind the wall. This planning permits an inexpensive conversion to a higher acuity intensive care unit at any time in the future.

Shell space and identified growth zones for expansion are all examples of convertible flexibility. Planning for future capacity in power systems or larger diameter piping are other types of flexibility choices.

An example of custom design is the patient room at the Burn ICU at the University of Cincinnati which features a concrete step across the headwall. This fixed, or non-flexible, element serves as a raised step for the respiratory therapist to reach over the headboard for access to the patient's head and airway, and it also serves as a bed positioning device. It is useful because it makes it easier to reach the critical work area.

Each critical care project should consciously choose components that represent fixed, adaptable or convertible components of the design. Each of these decisions will have an associated cost.

Evolving Technologies

Kathryn Pelczarski of ECRI, the non-profit healthcare research institute known for technology assessment, has said, "Technology should never be the focus in the room. The patient should always be the focus." She identifies several categories of devices, including: life support devices like ventilators or heart pumps, integrated rather than stand-alone monitoring devices, direct care devices like infusion technology, diagnostic testing equipment ranging from ultrasound scanners to mobile C-arms, video equipment and information devices. She reminds us that a procedural cart, such as an endoscopy cart, bronchoscopy cart or metabolic cart may accompany many of these items.

Some of these devices have been improved or reduced in size, as in the case of ventilators. Multi-line infusion pumps have replaced single line pumps. Many of these devices, like sophisticated EEG machines, are wheeled in and out of the room as necessary, rather than requiring permanent housing in the patient's room.

Some of the most significant changes are occurring in information technologies, including a broader range of available capabilities that are more likely to be integrated on a single monitor or CRT screen with improved displays and graphics. Physiological monitors are improving with a modular capacity to accept additional functions or parameters and to enhance their integration with other devices and information systems.

Innovations in point-of-care testing may be among the most dramatic new technologies in the ICU. We are now able to bring sophisticated, accurate testing directly to the critical care patient, and to do so with smaller and smaller devices. Countertop devices are readily available, and handheld devices are becoming more common. According to Neil Halpern, MD of Memorial Sloan Kettering in New York City, some of these testing devices can be miniaturized to fit as a module into the open slots of a monitor, or similar modular slots in the bed frame. He describes the testing of blood inside the thickness of a conventional CD-ROM disk that also serves as a centrifuge for the sample. This kind of immediate testing, with integrated reporting in real time on the physiologic monitor or medical information system will allow for more rapid decision-making and more precise and timely interventions.

Toilets for the ICU

Choosing the correct solution for toileting or disposal of human waste in the critical care unit is a major problem for the design team. In my opinion, there are no demonstrated models that solve all of the potential problems. Michelle Burrington, RN has a good paper on this topic.

There are rooms with or without toilets. When toilets are present, they may be individual, or shared between rooms. When a toilet is used, the issue of distance from the bed is important because of the typical condition of monitoring leads connected to the patient and the need to move multi-line infusion pumps with the patient.

There are conventional toilet fixtures and there are fold out toilets contained in cabinetry. In nearly every case, the toilets are used most often to dump bedpans, rather than as a site for the patient to eliminate. Unfortunately none of these devices has a contained disposal method. The washing and spraying activity of disposal is a major source of aerosol contaminants and a source of infectious organisms. Burrington's paper reviews the literature and describes some of the most common types of problems with organisms and nosocomial infections whose source is bedpan disposal and washing.

A common alternative to a toilet is the mobile commode chair that contains a bedpan. Clipson and Wehrer's 1973 study of cardiology patients at the University of Michigan told us that the commode chair was the strong preference for that type of patient. The ability to move the chair directly adjacent to the bed allowed the toileting to occur without disconnecting leads or which contributed to patient confidence. Sitting was preferred over using a pan while prone in the bed. I believe we could hypothesize that the result would be similar for any type of ICU patient capable of leaving the bed to use a toilet.

If the commode chair is best for those who can get up, what is the best disposal method for the bedpan, whether used in bed or a chair? I suggest that the toilet with some inadequate “bedpan washer” spray nozzle is a biohazard danger to both patients and staff. The next choice would seem to be a clinical sink with sufficient size to properly clean a bedpan in a deep bowl. Even a clinical sink, sometimes called a “hopper,” produces a contaminated aerosol. The only safe system is a closed system.

Europeans have developed a closed disposal system that macerates disposable papier-mache pans and the waste inside a sealed chamber. The device is about the size of a household dishwasher, and may offer a new alternative to North American designers interested in a different and safer disposal method. The design question is whether they might be shared between a pair of rooms, as has been done at the University of Iowa, or as a unit in a utility room that serves a larger number of beds. My prefe-