OPTIMAL OPERATING ROOM DESIGN Ⅲ

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Operating rooms planned and built today must be considered to have a working lifetime measured in decades. Predictions about the details of future ORs are neither accurate nor useful. However, principles can be followed to give any design a more successful working lifetime:

- Think about how practices have changed over the last ten years and then consider how design can accommodate a like amount of change.
- Flexibility is fundamental to robust design.
- Participation in future technologies should be phased.

Surgery Department become old and must modernize in order to improve the quality of patient care. Regardless of the age of a facility, healthcare facilities must continually change in order to meet patient demands, support new procedures and technologies, and remain competitive.

I. DESIGN PROCESS

Like other healthcare design, operating room design is a multi-constituency environment. Under-standing the roles of key players is an important part of success, involving:

- Steeling Committee
- Clinical Staff
- Surgical Services Managers
- Surgeons and Anesthesiologists
- Administration
- Contractors
- Architects
- Engineers
- Equipment Planners
- Bio-medical Personnel
- Infection Control
- Hospital Facilities Maintenance

Early clinical input is important to the success of the project. All staffs involved directly in the design process must be made to realize that they must also act as ambassadors to all of the staff not able to participate directly. "Who designed this place?" are the last words planners, programmers, architects, engineers and contractors want to hear. Senior level staff should be engaged early in the process with line staff becoming involved as greater levels of detail are reached.

II. CULTURE CHANGE

Major projects represent an opportune time to implement culture change - although not without drawbacks. Changing both culture and environment is disruptive and unsettling to many in the organization. Fundamental characteristics of the desired culture must be identified at the inception of the project. Organizational structure must be congruent with the proposed function of the new environment. This raises questions for each individual about their place in the new structure. These questions must be answered. The management challenge is to:

- Build consensus among competing interests
- Allocate resources
- Identify and harness existing expertise
- Communicate with multiple constituencies

Change is encouraged by examining how everything is done and by researching "best practice" models. Enthusiasm for change can be developed by involving staff in data collection regarding existing conditions, data collection and analysis regarding utilization, and definition of operational assumptions. Guiding questions might include:

- What new services should the hospital offer?
- How can patient satisfaction be maximized through good departmental layout?
- What inconveniences and inefficiencies in the current department layout might be eliminated?

New Processes must be created before moving into new space. The expectation must be that changes will be implemented from opening day.

III. DESIGN TRENDS AND CHALLENGES

During the design of Surgery Department project, following six topics should be significant design decisions:

- Patient Needs
- Equipment
- Utilities
- Space and Room Sizes
- Telecom/Data
- Air Quality and Infection Control

Each of these topics possesses its own trends and conventions. Each poses particular risks and challenges for the institution but in these challenges lies the opportunity to develop superior design solutions. The key characteristics are:

Let' s look at each of these individually before examining how they interact as design opportunities.

TOPIC	TREND or CONVENTION	RISK/CHALLENGE	OPPORTUNITY
Patient	Sicker but expecting Every-larger health gains	Patients are in more critical condition, Procedures more aggressive	Gains in health of community served, distinction and reputation of the hospital
Equipment	More of it, most Mounted on carts for	Increased congestion, entrapment	Rethink the conventional ergonomic solutions
Data	More objects generate data that needs to be transmitted, displayed and recorded	Fragments, proprietary systems	View data as part of OR infrastructure, as infrastructure need
Utilities	Expanding number of types, increasing quantities	Room walls as utility infrastructure no longer serves well	Find alternatives to delivering utilities to point of use
Space/Room	Ever-larger rooms	Costly, does not serve to put needed items in optimum locations	Use "Human Factors" approach to reorganize the OR workplace
Heating, **Ventilation, Air Conditioning**	Greater air volumes, empirical design rules	Costly energy usage, little assurance of effectiveness	Apply objective analysis to improve performance and reduce cost

Patients

In design projects, it is a good general practice to periodically and intentionally bring together all points of view for a decision validation review - "balance" is the goal. In these reviews and in the day-to-day decision making, particularly where there is intense competition for resources, it becomes easy to overlook the patient's point of view.

If patients don't have the designated advocates, then appoint one. Never forget that all of this effort is ultimately about the patient and doing the best that can be done for them.

From the standpoint of judgments patients will make, the spaces most relevant to them are the intake waiting and registration spaces, the prep or pre-operative space and to a less extent the recovery space. Undersized or poorly designed pre-operative spaces can significantly impact the throughput of operating rooms. With the possible exception of the Perioperative Manager, it is patients who suffer the most stress when operating rooms are delayed. Therefore the size, capacity and efficiency of the pre and post-operative spaces impact the patient experience as much as do finishes, lighting and color. Other important characteristics of the pre and post-operative spaces are:

- Patient Bays that are hard wall on three sides.
- Division of the PACU (Post Anesthesia Care Unit) into 10-12 bed modules.
- Planning for the use of beds instead of stretchers.
- Individually controlled lighting in each patient bay.
- Provisions for companions before and after surgery.

Patients are sicker, and surgical aspirations are more ambitious, which combine to keep average inpatient case times from declining much if at all. Companions are going to be guests in your waiting rooms for longer durations. In addition to a pre-registration system which will hopefully speed patients through registration and on to prep and holding, thought has been given to support for families and companions who will later help form the overall opinion of the quality of the stay. Amenities include:

- Higher Level of Finish.
- A "Business Center" with desk space for individuals to make calls, work on laptops, etc.
- Sequestered Television Areas.
- A Coffee and Refreshment Bar
- Lockers large enough to hold the suitcases many patients still bring with them.
- Video-Consult Booths to reduce travel, particularly for intra-operative updates.

Equipment

Regardless of the size of the room, the limitations of doctors' and nurses' convenient reach and vision have not increased over the last hundred years. To be used efficiently by the surgical team, instruments, supplies and equipment must enter a zone immediately adjacent to the operating room table. Anything outside this "reach zone" must be remotely operated or must be moved before being put into use. The "space within reach" is the most valuable real estate in the operating room.

To enhance flexibility, the conventional practice of instrument and equipment manufacturers has been to place equipment on a cart. Low-density, cart-mounted equipment wastes the most valuable real estate in the operating room, the "space within reach". Common operating room equipment such as IV poles, light sources, suction canisters and electrocautery can waste as much as one-third to one-half of the "space within reach". A design approach which recognizes human factors and which raises the density of equipment around the operating room table is a key factor in designing efficient operating rooms.

Utilities

Remember when placing that one, special-voltage outlet was a key design decision? Contemporary operating rooms demand enormous amounts of power, special circuitry, easily a half-dozen different medical gases, data, communications, video, just to name the basics. As operating rooms become larger, continuing to use the walls of the room as the infrastructure to carry all of these utilities simply means that "what you need" is further and further away from the operating room table. Draping dozens of cords and hoses across the floor is neither a safe nor efficient workplace. Changing the physical location of those utility connections requires the involvement of the contractor, creation of dust and closure of an operating room. Even the conventional medical gas column is limited in its ability to meet current demands. Materials and methods, and design techniques that deliver "what you need" where it is needed, is another key factor in designing efficient operating rooms.

Data

Take a minute for a mental count of the number of different systems that carry information to, from and through the operating room suite. How many come to mind? A dozen? Two dozen? For a recent project, knowledgeable constituents were asked to assemble a comprehensive list; it has 52 systems listed. It is time to quit thinking of data as a few wires snaking through the walls or even as your data network. Data should be thought of as part of the infrastructure and should be addressed as such by the design and construction teams. Further, there is growing recognition of the need within the operating room to record data, to receive data from outside the operating room and to send data to other points in the hospital. Potential data sources include:

- Anesthesia Equipment
- Physiological Monitoring
- Minimally Invasive Equipment
- Archived Images
- Real-Time Images
- Cameras Coaxial with Operating Room Lights (and in other locations in the room)
- Pathology (video from microscope)
- Lab Information System
- Hospital Information System
- Clinical Documentation

Data destinations include:

- On-Service Boom Monitors
- Wall-Mounted Monitors
- Recording Devices (DVD, CD and a VCR)
- Pathology (view of the surgical site)
- Teaching
- Clinical Conferences
- Consultation
- In-Room Documentation

A few manufacturers have recognized that collecting, routing and recording both data and video presents a growing need in the operating room. A more comprehensive view which takes into account the multiple relationships operating rooms have with the hospital and which attempts to project recent trends into the future quickly comes to the conclusion that a "digital switching" system will become a requirement of designing an effective operating rooms.

Room Size

The growth of cart-mounted equipment in the operating room has already been remarked upon. This equipment is important because it has been a factor supporting new and evolving surgical techniques. Placing equipment on a cart has been both a convenience and an economic response. New (highly specialized and often expensive) equipment was not always intended to be used one procedure after another in the same room. Moving it from the room when not in use was a clear need, as was the ability to relocate a special item from one room to another.

Even though the usage pattern of many types of equipment has changed, the practice of placing it all on individual carts has not. This has two consequences: 1) this places all of the equipment at roughly the same working plane across the room, and 2) the volume of each cart sequesters space that is then typically unusable for other purposes. This creates the low-density arrangement described earlier. One response to this trend has been to make operating rooms increasingly larger. In turn, larger operating rooms trigger other conditions: 1) all the utilities and other items mounted on walls keep moving farther and farther away from the table, and 2) poor, low-density use of the "space within reach" around the operating room table fosters inefficient design and function. After description of just one more issue, we will begin discussion of design approaches that turn these dilemmas into opportunities.

Ventilation and Air Quality

A couple of years ago, Dr. Farhad Memarzadeh of the US National Institute of Health presented his use of computed flow dynamics to analyze the optimum ventilation design for an operating room. Computed flow dynamics was used to track the path of airborne particles, establish clearance rates and tabulate the number of times airborne particles landed on critical locations - the surgical site and the instrument table. In addition to heating and cooling the room, optimum ventilation design has several distinct characteristics:

- The optimum exchange rate is approximately 20 changes per hour and the surface area of the delivery plane must be sized to discharge air at 30 to 35 feet per minute.
- Air should be supplies from a laminar flow field in the ceiling that has minimum interruption and fully covers the operating room table. (We have concluded that this air will also be HEPA filtered.)
- Return air is taken from grilles located both in the conventional position close to the floor and from high returns at or near the ceiling. This additional return location reduces re-entrainment of suspended particles.

It is important to note that controlled velocity allows laminar flow to carry particles around solid objects and prevents simple momentum from driving particles onto the surgical site. This arrangement represents "best practices" in ventilation design. It places some constraints on the geometry of items in and near the ceiling.

I will now discuss the integration of this into operating room design.

IV. GETTING TO EFFECTIVE, FLEXIBLE OPERATING ROOMS

An effective operating room design springs from these observations:

- Best use must be made of the most valuable space in the room - the "space within reach" immediately adjacent to the operating room table.
- Utilities must be available within reach without creating a snake's nest of tripping

hazards.

- Attributes of ventilation design place some constraints on room and ceiling geometry.
- Technologies to enhance flexibility can be borrowed from other industries.

As I worked through design solutions for projects, it became clear that the issues of equipment, utilities, technology infrastructure, room size and spatial efficiency were interrelated.

The use of service (utility) booms has increased steadily over the last half-dozen years. During visits to other facilities, I noted configurations that began to address the issues of equipment, utilities, technology infrastructure and spatial efficiency. Configurations which were rich in appropriate utilities and which took as many small pieces of equipment as possible off of carts and stacked them on shelves represented particular potential for increasing the planning density. Intelligent use of utility or service booms is an important aspect of effective operating room design because:

- They serve to recapture space lost to carts, IV poles, canister stands, electrocautery and other small, common devices.
- They can route utilities directly to the point of use, keeping floors clear.
- They can also bring data, communi-cations and imaging to the point of use.
- They can be configured to move assemblies of bulky items to and from the reach zone while hovering over floor interferences.
- Mounts for operating room lights can also hold one or more booms appropriate for lightweight, flat panel displays. Lights can be configured with coaxial video cameras in order to capture images that can also be displayed in the space immediately surrounding the operating room table.

The key characteristics of "optimal" operating rooms are:

- Ability to carry multiple surgical lights as well as service booms for flat panel displays.
- Air delivery is via a laminar air-flow field which covers the table and immediately adjacent spaces.
- In addition to the common, central mounting point, every room will have installed at least four additional mounting points, positioned on the axes of the room. In almost every case, the mounting point at the patient head location will receive an anesthesia boom. Almost every operating room will also receive at least one additional service boom, configured to carry equipment common to the specialty and located to support that specialty's particular set up.

- General illumination surrounds the operating room table. In addition, the size of the operating room mandates separately controlled perimeter lighting.

V. OTHER ELEMENTS OF OPERATING ROOM DESIGN

Several types of adjunct spaces are conventional in OR design:

- Sub-Sterile
- Scrub Sinks
- In-room Storage

New spaces/uses are evolving and are crucial to effective design:

- Equipment and Supply Storage space adjacent to but outside the operating room.
- In-room documentation station for procedure records, real-time information and electronic recording.
- Area within the operating room is being marked explicitly to indicate working zones.

Ample and handy storage (think of an area one-fourth to one-third of the OR square footage) aids in focusing the operating room as a procedural space and avoids marking it a storeroom. In-room documentation provides a dedicated and well-equipped space for manual as well as electronic record keeping and provides a physical focus for locating myriad communication systems.

Modern operating rooms that are expected to be a good chassis for future processes need to be designed in the 600 to 650 square foot range. With high-density arrangements immediately adjacent to the operating room table, sufficient space exists in most plans to create three zones that are sometimes literally marked by changes in the flooring:

- A central zone centered on the table to denote the surgical area. It serves as a prompt to be certain there is a purpose in approaching the operating room table.
- A 30” to 36” zone along the walls which is the parking place for items not immediately engaged in the operation such as specialty carts, imaging equipment, and students.
- The annular space between these two becomes the circulation zone of the room. It should be clear of most, if not all, tripping hazards.

Lastly, no single idea will lead to the creation of an effective operating room. Maintain a comprehensive view of everything, from culture to carts, and continually assess how all elements function together. 2004