healthcare design **insights**

Welcome to the second edition of *Healthcare Design Insights*

Our second issue delves into fascinating developments in surgery. Hospitals are seeking to improve health outcomes, increase revenue, create "marketable" differentiation, and recruit talent—each increasing the push toward "non-traditional" surgery. This issue offers tools for understanding impacts to the design process and construction results of new surgery techniques, while providing pointers and suggestions for those embarking on projects.

This issue includes the following:

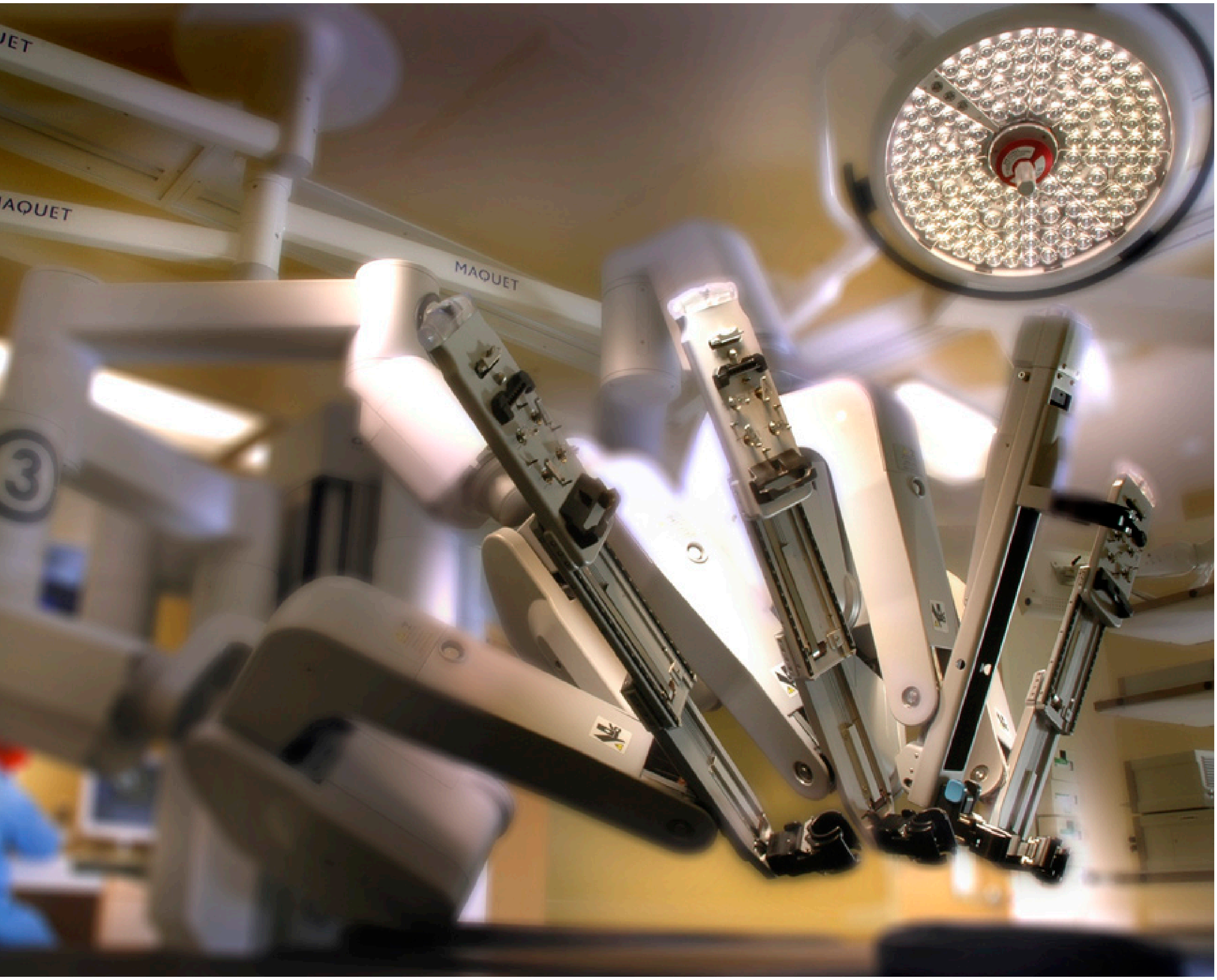
Definitions, examples and details of the three major types of innovative, technology-based surgery: Robotic, Interventional, and Interoperative.

Guidelines and suggestions for hospital facility, maintenance and capital professionals, a list of major impacts to both design process (how it's designed and built), and design results (physical form and systems).

Some thoughts about future developments in healthcare technology, and the potential impacts to buildings and facility and systems design.

In this Issue:

The Current Future (below): The four interactive arms of a da Vinci surgical robot.



Providence Sacred Heart Medical Center Robotic Surgery Suite (below)
Located in Spokane, Washington, Providence Sacred Heart is a pioneer in the adoption of surgical innovations for cardiac procedures. Built in 2009, this suite (the hospital's fourth) illustrates the key components of a robotic surgery: the head-in view port for the surgeon to monitor the patient, Velcro "finger-ties" to manipulate the robotic arms, the surgery bed, and the monitor above for additional display.

Robotic Surgeries

With over 1,000 systems installed so far, da Vinci Surgical Systems are the best known platform for robotic assisted surgery. The surgeon views patient imaging and manipulates surgical instruments through robotic arms, all from a station typically within the surgery suite.

Robotic surgery combines minimally invasive techniques and advanced imaging, including miniscule cameras and lights inserted through robotic fingers into the body. Optionally, robotic equipment allows the surgeon to be located away from the actual surgery, across the hall, or, as advanced data communication reduces lag time, even across the country. Intially focused on cardiac surgery, use of the da Vinci has grown rapidly in urology, and more recently, gynecology.

A Medical Marvel
Heart Beat Magazine (Winter 2010)
Providence Sacred Heart Medical Center

(Note: A Medical Marvel begins on page 16 of the above link.)

An expanded operating room and advanced robotic equipment keep Sacred Heart on the forefront of surgical excellence.

Providence Sacred Heart Medical Center (above)
Built around the Artis Zeego imaging system, this facility performs virtual computed tomography and continuous 3D imaging while also serving as an operating table. A significant advantage is not having to move the patient for better imaging angles; as the machine calibrates and allows "real time" imaging during surgery for significantly improved precision.

Hybrid Cardiovascular Facility Clinical, Facilities Overview (Executive Summary)
The Advisory Board Company (2009)
D. Black, A. Ford, S. Rutstein, P. Wynn

Much of the technical information in this webletter derives from research via *The Advisory Board Company,* a source for performance improvement services to healthcare, including research in best practices, management techniques, and technology. Mahlum is a Healthcare Industry Member of The Advisory Board, and participates in organization research. This specific report provides clinical, facililty, and technology analysis, plus a road map for healthcare systems considering hybrid surgeries. Mahlum was one of three architectural firms whose projects were the basis of analysis.

Interventional/Hybrid Surgeries

Like robotic surgeries, interventional/hybrid surgeries combine sophisticated imaging and minimally invasive surgery. Currently used primarily for endovascular procedures, these facilities typically include both the equipment and resources of a cathertization lab and full surgical suite with all equipment, including anesthesia, heart lung machines, and more. This set up allows for both angiography and cathertization procedures, either separately or at the same time.

The surgery table and equipment are coordinated so that the imaging device—not the patient—moves as different or additional images are required. Hybrid surgeries first became popular with vascular surgeons; growth is seen with the introduction of synthetic percutaneous valves and surgery by cardiac surgeons and cardiologists.

Intraoperative Surgeries

Intraoperative facilities combine traditional and/or minimally invasive surgery with large imaging equipment. Intraoperative suites can include mobile intraoperative MRIs (IMRIs), CT scanners, and other forms of computer assisted imaging. Pre-surgery scans can be imprecise because wheeling the patient from diagnostic rooms into surgery and opening the body and affecting bodily fluids may change the geometries of targeted surgical areas. With equipment immediately adjacent to surgery, the "real-time" imaging fosters greater precision and patient safety. This equipment may be dedicated to one surgery, or shared between two rooms, allowing use of the equipment for both surgery and pure diagnostic services.

Architecture for Image-Guided Neurosurgery
Healthcare Design (2010)
P. Macheske & L. Matejowsky

This article details an intropperative suite at Carondelet Neurological Institute in Tucson, Arizona. This facility makes innovative use of a track mounted CT scanner shared by two operatories, housed in its own "garage." Included are photos, 3D models, and some practical recommendations regarding square footage impacts/needs.

Intraoperative Suite Science
Providence Together (2010)
P. Macheske & L. Matejowsky

This diagram of am IMRI intraoperative surgery at the Brain Institute at Providence St. Vincent Medical Center in Portland, Oregon details the interaction of imaging, surgical, and typical room components.

Design Considerations for New Technology Surgeries

Space Needs

The first and perhaps most obvious impact of these surgery types is surgery size. Demands for space increase to:

Accommodate larger teams with additional diagnostic, imaging, and surgical experts

Accommodate additional equipment around "typical" surgery equipment

Provide image equipment control (sometimes with dedicated technicians) and storage areas outside of the OR itself

Provide dedicated equipment support areas, some with their own temperature and air demands

Allow mobility of equipment, as cost and use often require equipment to be shared between rooms

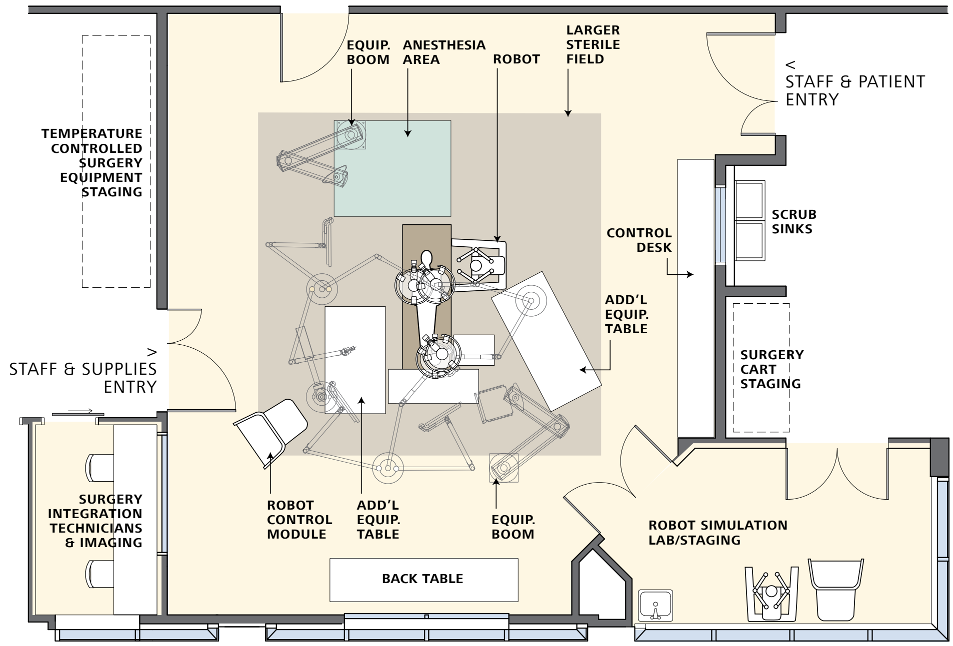
Provide flexibility in equipment location, and allow for unspecified future possibilities

Equipment & System Interactions

Along with increased space demands, all the "stuff" in the surgery area interacts, creating a geometric puzzle. Increasing space does not solve the puzzle, as the real need is "togetherness," or efficient adjacencies and minimum distances between patient, doctor, nurse, equipment, controls, and monitors. Placing equipment on "booms" clears the ground and table level, but complicates interactions at the ceiling and with air diffusers. Lighting demands are complicated by different specialties using the same space; the swings of the light booms and arms interact with other equipment, and each moving piece can block light from or conflict with another.

Radiation and Magnetic Affects

The equipment in Interventional/Hybrid Surgeries can emit radiation. At Providence Sacred Heart, the walls of the Hybrid OR required lead lining to limit radiation exposure from the Artis Zeego to the surgeons and others in the operating suite. In Intraoperative surgeries, the impact comes from the very strong magnetic fields created by the equipment. For an IMRI installation in an intraoperative OR, magnetic fields are created in the sterile surgical suite, requiring clear visual zoning and identification of relative areas of magnetic interference, as well as use of non-ferrous surgical tools.



Robotic Surgery Suite (above)
A typical robotic or interventional surgery suite can be more than twice the size of a general surgery suite and requires attention to systems, fields, power, sensitivity, and ways to educate staff.

Upgraded Power Requirements

More reliance on critical equipment powering surgery and imaging during surgery is increasing demands on the quantity, quality and redundancy of power. (Imagine a blackout while a robot arm is "operating?") Much of this equipment must be connected to a UPS (uninterruptible power supply). Increased sensitivity in creating the "live" digital images increases power quality demands (for example, limiting minute voltage fluctuations). More equipment, and more lighting drives increased power demands and cooling impacts.

Equipment Sensitivity

Much of this new imaging equipment is extremely sensitive to changes in environmental conditions, especially temperature and vibration. Equipment also has very tight allowances and geometries, for connections, distance off the floor, etc. At Providence Sacred Heart, for example, because the new chiller required above the operating room would induce low frequency vibrations into the building structure, nitrogen-filled bellow springs were installed to limit vibration transfer from the new chiller to the Zeego itself.

Follow-On Education Demand

Part of the puzzle for hospitals adding technological and surgical capabilities is to educate staff and specialists and transition practice patterns. This creates demand for simulation and education space to, for example, learn use of a new robot and how it impacts procedures. This training (sometimes working with cadavers) is best performed at the location of the equipment itself, and creates specific space and adjacency requirements. A/V equipment as a training tool—as well as for communication during surgery—is both an opportunity and an additional complication.

[CONTINUED ON PAGE 6]

Design Considerations for New Technology Surgeries

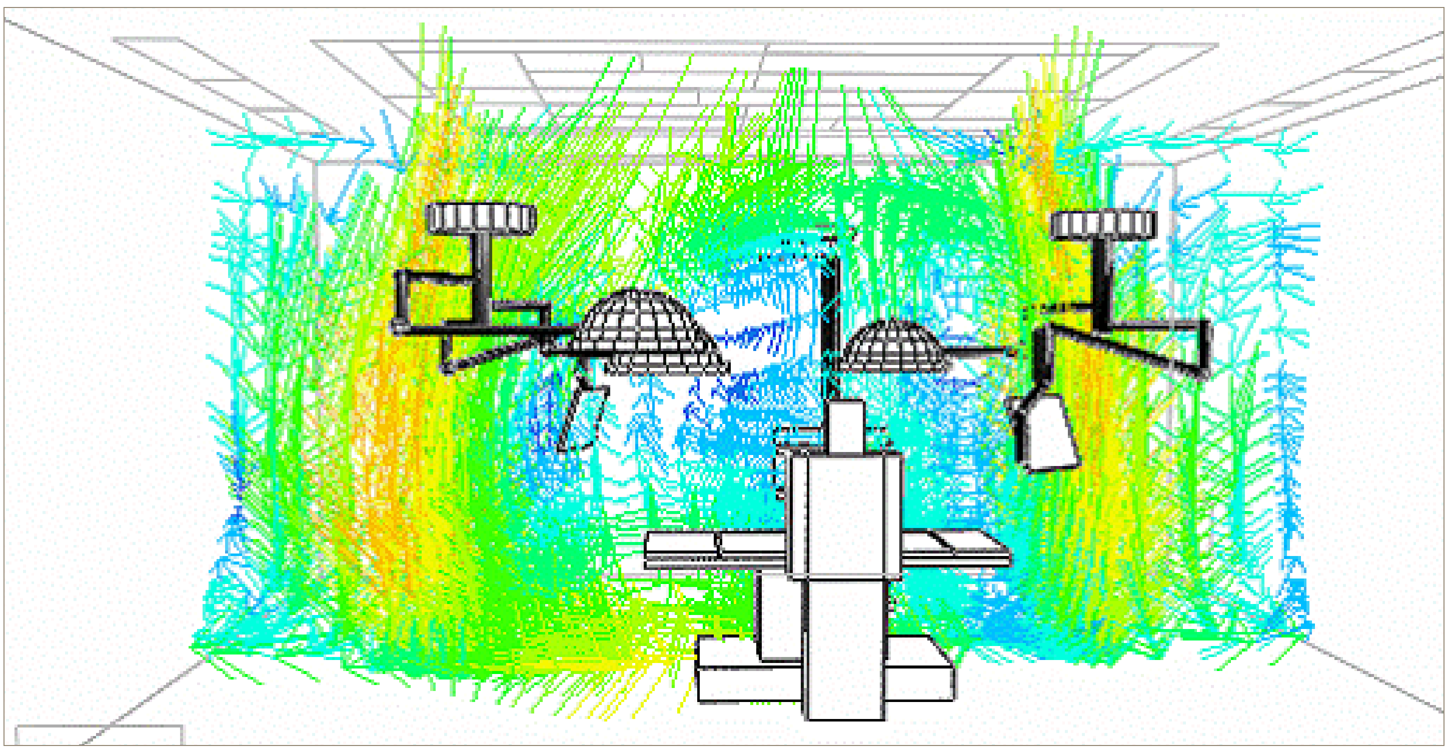
Air Flow & Temperature Demands

Air temperature and temperature change parameters can dramatically affect mechanical and other system design. At the Sacred Heart Hybrid, the cardiac surgeries demanded a wide and fast-changing range of temperature. Glycol was required in the chilled water loop and the air handler required extra space to access, maintain, and clean the deeper row cooling coil. Return air ducts carry very cold air, raising the risk of condensation, requiring insulation, and taking up yet more volume.

Small changes in performance criteria (e.g. how fast does the temperature need to change from 45 to 90 degrees?), and specialized requirements for temperatures at specific areas (e.g. at the sterile field or the table vs. along the perimeter wall) can have large impacts on equipment size and air flow. Commissioning becomes even more important, as there are more complex system interactions and greater demands on HVAC controls.

ASHRAE standard 170, adopted by the 2010 AIA Guidelines for Design and Construction of Hospital and Healthcare Facilities, requires a minimum amount of diffuser area over an operating table along with velocity requirements. This forces more precedence for the diffuser in the already cramped ceiling space above the surgical table, and impacts the location flexibility for all the equipment—and people in the room—that affect the laminar air flow, as well as the location of the diffusers relative to the sterile field. Multiple warm bodies around the table add more complexity. We expect computational fluid dynamics—the analysis of these air flows—to become more common.

Surgeries, Air Flow and the Sterile Field (below)
A graphic demonstration and analysis of the complexity—and variability—of air flows in surgery. (From the University of Massachusetts Memorial Hospital in Worcester.)



Additional Expertise & Interaction in Design

Fundamentally, these new operatories are more equipment-centric, and we've found the participation of engineers and technicians from multiple equipment manufacturers critical for mapping impacts and charting alternatives. Their tools include data, expertise, and often 3D and animated visualization of equipment placement and use.

The architect, engineer, and contractor team may need to interact more with medical and surgical staff–with increased equipment technology and multiple overlapping impacts, efficient solutions require "real-time" interaction of multiple health care, equipment, and design/construction experts. Participation on the hospital side needs to include the various surgical, imaging, and administrative functions, as well as Environmental Services and Central Sterile services, responsible for and or overlapping in use of the facility.

We've found it powerful and educational to have the design team watch the specific surgery that will be performed, specifically to see how the room is used, the physical and space interactions of all the people in the surgery room, and the interaction of equipment, supplies, cables, cords, monitors, and more. As BIMs (Building Information Models) become richer, with more data and content, we expect to use them for "live" analysis of these interactions, with 3D modeling of not only the room and the equipment, but the medical staff, the patient, and even supplies. Mock-ups are key at various stages, from conceptual "fome-core" models to full size diagramming to contractor-built samples.

The Sunny & Cloudy Future

To stretch a metaphor, we see sun in the future—technology and capability growth that will improve outcomes, further reduce hospital stays, moderate costs, and increase flexibility in delivery. We also see clouds, in that there are so many technology, practice, and social developments that the horizon is hard to see. Of course this is not new, or likely to change, but we decided to give forecasating a try. This winter we assembled a small group of A/E/C industry "wonks," architects and engineers passionate about healthcare design, and asked: ***what might design of healthcare surgeries be in ten years?***

Below is a table representing some themes of our discussion, with columns analyzing:

Specific trends in medical technology development or equipment design

Associated impacts on healthcare delivery

Resulting changes in facilities design and construction

TREND >	IMPACT >	RESULTING FACILITY CHANGES
Increase minimally invasive and non-invasive techniques.	> Promising expectations include: Single port laparoscopy and NOTES (Natural Orifice Transluminal Endoscopic Surgery)	> Growth in hybrid surgeries, with significant imaging demands (power, space, associated HVAC and structure) along with surgery capability, including traditional surgery support.
Increase computing power and information storage capability. **Decrease cost pushing information centric healthcare.**	> Digital information use, processing and display.	> Power (quantity and quality) demands increase. > Electrical/Data coordination moves to more primary than "support" role. > Coordination of "display" equipment with medical equipment.
Increase robotics. **Include free moving robots within the body.**	> Less invasive surgeries = less risk of infection. > Remotely facilitated surgeries.	> Reduced air temperature variation and flow demands, reduced HVAC requirements. > Increased demands for clean power, reduced information degradation? > New-generation data connections at both the treatment and remote doctor site. > "Remote" or mobile facilities to "take the operaing room to the patient."
Robots serve different support functions in hospitals, such as: **Patient interaction and communication;** **Pharmacy dispensing/delivery;** **Maintenance/cleaning**	> Interaction between humans and machines. > More co-location of human and machine activity.	> Increased space planning demands and zoning.
Increase biotechnology and bioengineering capabilities.	> Genetic based treatments and fewer traditional surgeries. > Transplant activity with genetically engineered organs.	> Reduced hard core surgery facility needs. > Increased hard core surgery facility needs.
New lighting technologies, such as: **LED** **High-intensity metal halide**	> Better lighting at surgery areas.	> Less heat gain from lights, less HVAC impact.
Increase voice activation software/hardware.	> Voice-activated robotics; equipment use.	> Increased acoustical sensitivity and resulting analysis. > More accommodation for robots. > Fewer staff in operatories and less space needs.

Healthcare Design Insights, produced by Mahlum, furthers evidence-based design, offering practical tools and ideas to healthcare administrators, facility managers, and developers. We welcome your feedback and ideas for future issues!

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Projects featured in this issue:
Pages 2, 3, 4
Providence Sacred Heart Medical Center, Spokane, Washington
Architect: Mahlum