Surgical Suite: Creating the Optimal Environment

By: Dan Pollock, system specialist for advanced airside system controls

Back when Hippocrates first uttered the oath that modern-day doctors still swear by, none could have imagined the complex industry that healthcare would become. And certainly no one back then could have imagined that the buildings where healthcare is practiced could have such an impact on patients' health outcomes. But this is indeed the case.

Multiple studies point to a strong relationship between patient health outcomes and indoor air quality.

The Link between Patient Health, Caregiver Well-Being, and Hospital Environments

A visit to a hospital these days can be risky for patients, families and staff. Hospital-acquired infections are among the leading causes of death in the United States, killing more Americans than AIDS, breast cancer, or automobile accidents, according to the Institute of Medicine (IOM).

A scan of the medical literature, funded by the Robert Wood Johnson Foundation and led by the Center for Health Design, found hundreds of articles in peer-reviewed scientific journals demonstrating the effects of the hospital environment on patients and staff. More than 120 of those studies link infection to the physical structure of the hospital, and several specifically link air quality and infection rates.

In one of the cases cited in the Center for Health Design's study six patients and a nurse were infected with methicillin-resistant staphylococcus aureus, which was traced to a ventilation system, according to Kumari et al. In another case in the same study, the source of the infection was the exhaust ducting of the adjacent isolation room ventilation system.

"Healthcare facilities are environments of controlled hazards," states the HVAC Design Manual for Hospitals and Clinics of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). The hazards include molds, bacteria, viruses, and other pathogens introduced into the environment not only by the sick patients who are there to be treated, but also by naturally occurring condensation. The challenge is to control them to a level that is deemed safe for the facility's occupants, patients and caregivers. Controlling the airflow, temperature and humidity in the hospital environment can help maintain excellent indoor air quality (IAQ) and can help control the growth of molds, bacteria, viruses and other pathogens.

IAQ is Critical for Better Patient Care

Indoor air quality for infection control and comfort can have a significant effect on patient care and health outcomes. Maintaining healthy air quality is critical to achieving healthcare setting accreditation, including Joint Commission on Accreditation of Healthcare Organizations (JCAHO) standards.

High quality heating, ventilation and air conditioning (HVAC) systems are integral to an effective infection control strategy. They also ensure comfort levels to facilitate patient healing and staff productivity.

IAQ is important to successful patient outcomes, and should be considered part of health care delivery. There are numerous published rules and guidelines for ventilation rates, filtration efficiencies, and pressure control set out in building codes and state departments of health. This is why it's important for HVAC engineers and

health care professionals to work together when establishing the IAQ requirements or guidelines for a healthcare setting.

Building Infection-Fighting Qualities Right into the Surgery Suite

The survival of microorganisms, which can lead to infection, can be influenced by several factors: ventilation, temperature and humidity, according to ASHRAE's position paper entitled, Airborne Infectious Diseases, released June 2009. Your surgery suite's environment can benefit from building systems equipped with sensors and controls that can be calibrated to discourage the survival of pathogens:

Ventilation – Recent studies indicate that up to one-third of all hospital-spread infections are airborne. Airborne contaminates include inorganic particles, airborne mold and bacteria. In poorly ventilated hospitals there is a higher risk of airborne infectious particles.

What you can do: Ideally, at the design stage, the ventilation system should be developed to meet the specific and strict IAQ needs of operating rooms as well as other specialized hospital spaces. Existing systems can also be upgraded to improve ventilation, filtration frequency of air exchanges, positive and negative air pressure, and exhaust systems. To meet optimal IAQ levels, air changes must occur at high frequencies with low airflow velocity. Highly effective air handlers, with low leakage rates, meet high filtration and static pressure standards essential to infection control. The ventilation system should also be flexible to change the room environment as necessary to isolate or contain the potential spread of airborne infection.

Temperature control goes beyond patient and staff comfort, to health outcomes. For example, lowering the surgery patient's body temperature can be beneficial to slow bleeding in the patient on the operating table, but lowering it to less than 36°C, can lead to surgical site infections (SSIs). Low body temperature may increase patients' susceptibility to SSIs by causing vasoconstriction and impaired immunity (Brooks, 2003).

What you can do: Clearly, precise sensors and controls are important to maintaining a healthy environment and patient health. Heating and cooling solutions for hospitals should be designed to ensure the healthiest and most comfortable temperatures for each setting, from surgical suites to patient rooms and visitor waiting spaces.

Moisture control is also important to preventing the spread of pathogens, according to the U.S. Environmental Protection Agency. Excessive humidity can promote the spread of microbes and also require re-sterilizing equipment.

What you can do: Moisture technology, such as desiccant dehumidifiers, is helping to meet the stringent humidity requirements in healthcare settings. An energy-efficient humidity control solution for healthcare facilities, using a desiccant rotor or other "drying" component can be extremely effective in controlling humidity. In addition, humidity and dew point sensors are needed to help control the space conditions because the needed supply air dew point and supply air temperature are often not equal. For example, in an operating room where there is an 8F degree difference between the temperature required and the supply air temperature, if the space is controlled just by a thermostat the air delivered will be 8F dew points too high to meet the relative humidity requirements. So, not only is a humidity sensor required, it must also be accurate. The sensor should be accurate within at least two percent of actual value to be able to properly control the relative humidity/dew point in the operating room.

Pressure - Strict pressure control is also necessary to prevent migration of airborne contaminants.

What you can do: Operating rooms must be kept at positive pressure relative to other areas to diminish movement of infectious contaminants into the room. Airborne infection isolation rooms must be kept at negative pressure to limit movement of infectious agents, such as tuberculosis, from the patient to other areas of the building. Protective environment rooms must be kept at positive pressure to protect immuno-compromised patients from infectious agents elsewhere in the building (Center for Energy and Environment). HVAC systems should be designed, and maintained, to meet these various critical pressure needs of these healthcare spaces.

Monitoring IAQ – Indoor air quality that is consistently maintained is critical to a healthy surgical environment.

What you can do: Routine monitoring of air quality, including bacteria, viruses, particulate, pressure and moisture enables the hospital to meet or exceed regulatory standards, and correct any problems that may lead to high contamination risks. A particle counter can confirm the efficiency of filtration systems. The size of the filter, the seal on the housing, and spacers installed for fit may all contribute to assuring that airflow passes through the filter media (Streifel, 2005).

The Importance of Maintaining Proper Temperature in the Surgical Suite

A hospital's physical environment is linked to the health of patients and caregivers, and it can have a direct impact on the satisfaction of both. The modern surgical suite is a prime example of how the environment directly affects both patient health and caregiver satisfaction.

Comparatively, over time, the temperature in operating rooms has been driven to lower levels for a number of very practical reasons:

- Cooler temperatures slow down the metabolic rates of exposed organs and minimize bleeding during surgery. Less blood loss and a slowed metabolism places less stress on the patient, which can improve patient health outcomes. But again, operating room temperatures should not be allowed to go too low. Temperature sensors and controls are crucial to maintaining the optimum temperature for patients and caregivers.

- The increased desire by surgical teams to minimize exposure to air borne contaminants and the transfer of bodily fluids has led to more complete gowning of the surgical team. This extra gowning traps more heat and results in the need for lower temperatures in the surgery suite to minimize perspiration. Doctors and nurses do not want to sweat during critical procedures.

- In orthopedic procedures, which require the use of cements and glues to set joints, the drying rate of the adhesives is crucial to improved patient outcomes. If the operating room temperature is too warm, the adhesives set too quickly. Colder temperatures allow adequate time for proper setting of the joints.

The need to control the temperature and humidity of surgical suites is clear – patients and caregivers need a cool, dry surgical environment to support them in the sometimes tension-fraught atmosphere of the operating room.

Another of the important attributes of a healthy hospital and surgical environment is air circulation. This can be achieved and maintained by designing work areas of sufficient size to accommodate air circulation around modern operating room equipment such as robotic surgical tools. In addition, special air handling units with desiccant wheels or other components can help manage condensate and control humidity.

Air-Cleaning Systems May Offer the Solution to Building Odor Problems

There are a number of air cleaning systems available in the building systems markets that are effective in removing contaminants and neutralizing odors. Some combine multiple technologies to address all types of indoor air contaminants such as particles, gases and bioaerosols.

High-efficiency particle filtration, ultraviolet germicidal irradiation (UVGI) and photo catalysis (PCO) can be used together to improve IAQ in spaces with low-level odors and areas with a threat of, or concern about, the airborne spread of disease.

- High-efficiency particle filtration systems can remove a high percentage of fine and ultrafine particles.

- Ultraviolet germicidal irradiation (UVGI) or high-intensity "C" band ultraviolet light damages the DNA of microorganisms – including fungi, bacteria and viruses – to prevent them from reproducing.

- Photo catalysis – Also known as photo catalytic oxidation (PCO) utilizes ultraviolet radiation to create highly reactive hydroxyl radicals that aggressively oxidize odor-causing chemicals and decompose airborne microbiological contaminants that they contact.

Air-handling systems with these technologies are available either as factory-engineered and -installed components of your air cleaning equipment; or they are also available as portable, standalone units.

When you consider that the estimated annual cost of hospital-acquired infections in the United States is $5 billion, according to the U.S. Centers for Disease Control, the opportunity to realize significant savings by investing in healthier building designs is compelling too.

Even older, existing hospital structures can improve indoor air quality, deliver a more comfortable environment and drive cost savings by retrofitting with new energy-saving technologies and advanced sensors and controls. In addition, new healthcare buildings in the design and early building stages can deliver healthier environments and cost savings through proven design qualities, proper equipment installation and correct control and maintenance.

Better-designed operating rooms and hospitals mean better health outcomes for patients. Healthcare institutions and providers have the data and analysis to support the case for better healthcare buildings. The healthcare building design and construction industry has the know-how. Better healthcare buildings make good sense for patients, caregivers, communities and businesses.

ABOUT THE AUTHOR

Dan Pollock is the Trane system specialist for advanced airside system controls. He has a deep knowledge of building and HVAC system controls needed to control all aspects of indoor air quality and the related system energy. He developed some of the control strategies used in the ASHRAE HQ near net zero HQ renovation. He has been a featured speaker on advanced desiccants and HVAC systems to the American Society for Healthcare Engineering, ASHRAE and other industry meetings. He earned his bachelor of arts in mechanical engineering and a master's of business administration from the University of Wisconsin.

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