The Locomotive

Proper Air Flow In Surgery

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Introduction
Equipment breakdowns during surgery can directly affect the health of patients and force the shutdown of a hospital's entire surgical suite. Without reliable surgical capabilities, a hospital's emergency room may shut down, causing elective surgeries to be postponed or performed at other hospitals. In-house patients may have to be transferred to competing hospitals. And the media attention brought on by the closing of a hospital's surgical suite and lingering concerns about reliability issues also can lose future business to other hospitals.

Proper Air Flow and Quality
Proper HVAC air flow can help protect patients from infection and reduce the risks of costly litigation and business interruption. Hospital engineers today should be concerned about more than the surgical team complaining about the temperature. Air quality is essential to the health of patients and the financial well-being of the entire hospital.

This article addresses one particular necessity of the surgical suite — HVAC air flow. Without the proper air flow environment, hazards can be created. By reducing these hazards, operating room contamination is reduced, patient infections due to reduced contamination are reduced and loss of dollars (business interruption) because of surgery suite problems are reduced. This discussion does not address medical malpractice issues relating to doctor/patient treatment plans or surgical techniques.
Surgical Suite Environment
For purposes of this article, the surgical suite environment includes pre-operational rooms, recovery rooms, clean storage rooms for surgical instruments, restricted transitional areas outside of the operating rooms and the operating rooms themselves. Other special areas where invasive procedures take place, such as obstetrical suites, also are included in this environment.

Mechanical and Infection Hazards
Air supply to the surgical environment is a necessary part of infection control. Air flow into the surgical suite and removal of air through the exhaust vents serve to dilute airborne microorganism concentration. The removal of airborne microorganisms in surgery is even more strict compared to the usual epidemiological precautions because incision has taken place on the patient, exposing open tissue to contaminants.

Reducing Airborne Infection
The dilution of airborne microorganism concentration is not achieved simply by providing air changes in the surgical suite.

Three factors relating to air changes that provide a positive reduction in airborne induced infections are: proper air quality, proper air volume changes and proper air flow direction.

Proper Air Quality
Filtration Proper air filtration for the surgical suite ultimately requires at least a 90 percent final filter in accordance with ASHRAE Standard 52-76. Many surgical suites incorporate the use of high-efficiency particulate filters (HEPA). But this may be overkill. Most airborne microorganisms are in the 0.5m to 5.0m diameter range.

HEPA filters efficiently remove particles up to 0.3m and provide virtually bacteria free air to surgery. However, 90 percent filters are equally effective if maintained properly. These final filters should be located as close to the air destination (operating room) as possible. HEPA or 90 percent final filtering may not be the only filtering necessary. If odors are present, there may be a need for activated charcoal or electronic filters. The amount of pre-filtering depends upon the intake environment of the air handler.

Humidity Operating room humidity is the most important comfort factor recognized by surgeons. 1996 NFPA 99, Appendix A, recommends a relative humidity of at least 50 percent. A relative humidity of 50 percent helps to dissipate electrostatic charges, which can be hazardous in an oxygen-rich environment. This humidity level also controls airborne bacteria.

Humidity lower than 35 percent may cause drying of mucous membranes and hypothermia of patients during lengthy procedures. Additionally, 1996 NFPA 99, paragraph 5-4.1.1 states "floating particulate increases in conditions of low relative humidity, and the fact that the incidence of would infections may be minimized following procedures performed..."
in those operating rooms in which the relative humidity is maintained at the level of 50 to 55 percent” are advantages.

Humidity much above 55 percent causes undue sweating by surgeons and operating personnel. Unfortunately, when surgeons become uncomfortable, operating room personnel have been known to open windows or leave doors open. This, obviously, places the patient at a higher risk of infection.

Temperature Along with humidity, temperature plays an important role in comfort, but has not been indicated to be a direct factor in infection control. Rather, a comfortable environment in the operating room can reduce hazards created by misusing or abusing the operating room environment.

It is recommended the surgical suite temperature be maintained in a range of 68 degrees F to 75 degrees F, with controls for selecting any desired temperature within this range. In practice, for small rooms filled with personnel and heat emitting equipment, achieving the low end of this range can be difficult and may require dedicated chiller units.

Proper Air Volume Changes
Air volume to and from the surgical suite is recommended to be 25 air volume changes per hour. Studies have shown 25 air volume changes per hour to be effective in diluting airborne microorganisms in operating rooms with human activity.

It is not essential that 100 percent of the air supplied to the surgical suite be outside air. According to ASHRAE and NFPA 99, 80 percent of the surgery air volume can be re-circulated with no more microbial contamination than 100 percent outdoor air filtered in the same manner. This fact can save the hospital money by reducing heating or cooling costs because of the re-circulation of the air.

Also important in air volume to the surgical suite is maintaining a positive pressure in the operating room. An anesthetizing location should have a slightly higher pressure than adjoining rooms and corridors so that infiltration of contaminated air will be eliminated. The positive pressurization of the operating room can be accomplished by supplying more air to the location than exhausting from it.

Proper Air Flow Direction
It is important to note that airborne bacteria in an operating room may not be eliminated even by providing "bacteria free" air from the air handlers. High ambient airborne particle concentrations may be generated if the air flow in the surgery suite is turbulent rather than unidirectional. Turbulence can stir up previously settled particles on horizontal surfaces. Causes of turbulence in the operating room includes the improper positioning of supply diffusers and exhaust grills, opening of doors, blocking of exhaust grills by equipment, circulation of operating room personnel, etc.

In order to create a unidirectional air flow in surgery with minimal turbulence, NFPA 99 recommends that ventilating air is to be supplied from the ceiling or high on the walls in each room. The supplied air should then be exhausted from several inlets located near the floor on opposite walls. It is very important that these exhaust grills not be blocked by freestanding medical equipment.

With this type of supply and exhaust installation, equally low infection rates have occurred in operating rooms compared to the concept "Charnley Chamber," the ultimate in clean operating rooms. This NFPA 99 recommended design assumes the strictest of personal aseptic precautions were followed by surgical personnel in order to achieve the equally low infection rates.
Summary
The more hospital engineers and surgeons understand the safety issues involving surgical HVAC, the better they can focus their efforts to reduce infection rates of surgery patients and also to lessen the financial burden of business interruption.

It should no longer be an issue for hospital engineers to simply keep the surgeon from complaining that it is too hot in surgery. There are very specific reasons for maintaining proper air flow, direction, humidity and temperature in surgery. These factors not only benefit the patient, but reduce the risk of litigation brought against the hospital by patients who develop infections.

Surgery is a vital service provided to the community and important to a hospital’s financial well-being. Without a well maintained surgical air handler and surgical HVAC system, the entire surgical suite can be shut down, effectively closing down other hospital departments as well.

About the Author
William G. Gurry is the national health care industry consultant for Hartford Steam Boiler’s Commercial Loss Control group. He joined Hartford Steam Boiler in 1994 after five years in hospital engineering and about fifteen years in power plant design, research and operation. He received a B.S.M.E. from California Maritime Academy and currently is working on his M.B.A. in health care administration from Golden Gate University. He is a member of the American Society for Health Care Engineering.