A perspective on OR laminar air flow

This perspective elaborates on recent study findings published in the November 2008 *Annals of Surgery,* which conclude there may be little benefit from vertical laminar air flow (LAF) for preventing surgical site infections (SSIs) in orthopedic and general surgical procedures. The investigation by Christian Brandt, MD, and colleagues from Germany warrants comment both on the validity of the conclusions and on the contrast between the OR design described in the study and current improved OR design in the US.

**Study design issues and conclusions**

The study involved a survey of 55 hospitals in Germany that examined the possible role of OR heating, ventilation, and air conditioning (HVAC) system designs on SSI rates following procedures on approximately 100,000 patients.

At first glance, this investigation appears to lessen even further the weak recommendation in the Centers for Disease Control and Prevention 1999 SSI guideline, which states: “Consider performing orthopedic implant operations in operating rooms supplied with ultraclean air.” Nevertheless, the study raises more questions than it offers definitive answers. Importantly, the authors acknowledge this was not a randomized, controlled, blinded study, the most rigorous study design.

There is the “suggestion” of slightly higher rates of SSI for many procedures performed in the ORs with implied traditional, high velocity vertical LAF. However, statistical significance was limited to only a few categories of procedures, and a myriad of other variables might be involved in frequency of SSIs at these hospitals.

**Other explanations?**

An editorial by Lipsett accompanying the study accepts its conclusions but rightly seeks other explanations, such as identification of other confounding factors (ie, obesity, smoking, glucose control, and temperature control). Epidemiologists have pointed out that the sample size needed for a randomized, multicenter trial examining the impact of HVAC design on SSI infection rates is cost prohibitive and unlikely to ever be conducted. The Brandt et al investigation, while substantial in the number of patients followed, lacks details of other practices, such as design of HVAC in ORs in participating facilities, skin preparation, timing of preoperative antibiotic prophylaxis, and other perioperative care processes.

Therefore, we believe this paper does not provide sufficient environmental design data to provide definitive answers. Equally important, we wish to clarify that the systems described in this paper are not the same as new designs currently required in the US by the 2006 *Guidelines for Design and Construction of Health Care Facilities* from the Facility Guidelines Institute (FGI) published by the American Institute of Architects (sidebar).

These requirements not only optimize OR conditions but also consider ambient temperature, patient normothermia, and overall impact on healing.

**Examination of OR HVAC design**

The OR designs noted for the ventilation systems in the Brandt et al study (conventional turbulent ventilation with HEPA filter or high velocity, vertical LAF with HEPA filter) are described in generic terms, precluding more detailed assessments at each facility such as air changes per hour, pressurization, temperature, and humidity.
Because these more complete details on HVAC design are not available, it is not necessarily an apples-to-apples comparison between the 2 systems.

For the vast majority of procedures, there was no statistically significant association between vertical LAF and higher rates of SSI. More importantly, traditional high velocity LAF (90 to 400 feet per minute, or fpm) has been typical and used in many hospitals for decades in the US, UK, and Europe.

Farhad Memarzedeh, PhD, and colleagues at the US National Institutes of Health (NIH) undertook a modeling study using computational fluid dynamics (CFD) analysis because they were aware of other studies that indicated no benefit, such as those by Marotte et al, Fitzgerald, and Salvati et al, or that paradoxically showed an increased SSI rate for knee arthroplasty, such as the Salvati et al report.

The NIH findings first published in 2002 found a low velocity (25 to 35 fpm), vertically directed, unidirectional downward airflow over the OR table with return air (exhaust) ducts at various heights around the OR achieved optimal removal of airborne particulates. Based on the NIH study, this modified HVAC design of vertical, unidirectional, low velocity airflow was adopted in the FGI 2006 Guidelines.

A key finding from the NIH study is identification of a thermal plume or “heat bounce” up from the incision on the patient’s skin that moves particles up and away from the incision. In addition, the lower velocity of airflow in the NIH study did not cool the patient substantially.

Is there a relation between normothermia and HVAC design?

Prior investigations of traditional vertical high velocity LAF, including the Salvati study, suggest that perioperative personnel create disruptions of airflow over the operative site and may increase the risk of complications. Another factor that might explain this contradiction relates to patient normothermia. High velocity flow over the operative site may create hypothermia and counteract the normal protective effect of the “heat bounce” of particles just above the incision.

Normothermia and warmer OR temperatures have been increasingly recognized as important to wound healing and reduced SSI. An example is the 2008 report by Kurz. Though the effect of the NIH design on reduced SSI rates has not been measured, this design optimizes air quality while maintaining patient normothermia. A critical component of the newer design is use of nonaspirating diffusers with unidirectional air flow, which aid in maintaining normothermia along with additional local warming devices.

Importantly, the HVAC systems in the Brandt et al study differ from the FGI 2006 Guidelines. The authors even highlight that LAF “could result in lower intraoperative wound temperatures.”

We posit that one explanation of the paradox of increased rates of SSI for some procedures in the study is hypothermia of the patients—and even the surgical wound bed. Both ambient and patient body temperature are likely lessened with traditional high velocity LAF, which may predispose patients to SSI, as reported by Kurz et al in 1996. Perioperative personnel are unlikely to sense colder ambient room temperature because they wear multiple layers and are closer to OR lights. In fact, experts such as Kurz are now recommending that the ambient temperature in the OR be elevated at induction of anesthesia and remain elevated during the procedure.

The Brandt et al study acknowledges that LAF systems reduce the bacterial burden in OR air. However, the paper then disputes the connection between bacterial airborne counts and SSI rates, and implies, particularly in the last paragraph, that current guidelines are essentially unsupported. Given the lack of additional details we described above, we disagree that the current FGI 2006 Guidelines need re-examination.

Guidelines revision for 2010

The FGI 2006 Guidelines are under revision for 2010. The revision should be completed in spring 2009, with publication in early 2010. In the revised guidelines, the requirements for design of HVAC in ORs may be refined or applied more broadly but will continue to recommend this newer NIH design. Despite Brandt et al’s new study, we feel the guidelines optimize patient safety and should be used when facilities are planning for new or renovated surgical suites.
Perioperative professionals and infection preventionists need to collaborate with architects and engineers in this planning and in particular pay close attention to HVAC design, especially in view of this new study.

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References


Guidelines for OR HVAC systems

The 2006 *Guidelines for Design and Construction of Health Care Facilities* specify the following design parameters for OR HVAC systems:

- Air is supplied unidirectionally by nonaspirating ceiling diffusers with [low] face velocity between 25 to 35 feet/minute (0.13 to 0.18 meters/second), located in the center of the OR so that it covers at least the area footprint of the OR table plus a reasonable margin around it (eg, 21 inches on short sides; 12 inches on long sides).

- At a minimum, return air (exhaust) is near the floor level but can also include returns high on the walls in addition to those near the floor.
• The OR is kept in positive pressure.
• Strive for between 20 and 25 air changes/hour (ACH).
• The system is designed to be maintained between 68° F and 73° F with 30% to 60% relative humidity.

For more information, go to www.fgi-guidelines.org.