Evaluation of measures to decrease intra-operative bacterial contamination in orthopaedic implant surgery.

Knobben BA, van Horn JR, van der Mei HC, Busscher HJ.

Bibliography prepared by Precision Air Products Co. Updated 1/9/2006.
Ventilation performance in the operating theatre against airborne infection: numerical study on an ultra-clean system

Chow TT, Yang XY. Division of Building Science and Technology, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong SAR, China.

A laminar airflow study was performed in a standard operating theatre in Hong Kong, the design of which followed the requirements of the UK Health Technical Memorandum. The study of the ultra-clean ventilation system investigated the effectiveness of the laminar flow in: (i) preventing bioaerosols released by the surgical staff from causing postoperative infection of the patient; and (ii) protecting the surgical team against infection by bacteria from the wound site. Seven cases of computer simulation are presented and the sensitivity of individual cases is discussed. Air velocity at the supply diffuser has been identified as one of the most important factors in governing the dispersion of airborne infectious particles. Higher velocity within the laminar regime is advantageous in minimizing the heat-dissipation effect, and to ensure an adequate washing effect against particulate settlement. (Emphasis by Precision Air Products.) Inappropriate positioning of the medical lamps can be detrimental. Omission of a partial wall may increase the infection risk of the surgical team due to the ingress of room air at the supply diffuser periphery. (Emphasis by Precision Air Products.) This paper stresses that a successful outcome in preventing airborne infection depends as much on resolving human factors as on overcoming technical obstacles.


Ultraclean air for prevention of postoperative infection after posterior spinal fusion with instrumentation: a comparison between surgeries performed with and without a vertical exponential filtered air-flow system.

Gruenberg MF, Campaner GL, Sola CA, Ortolan EG.

STUDY DESIGN: This study retrospectively compared infection rates between adult patients after posterior spinal instrumentation procedures performed in a conventional versus an ultraclean air operating room. OBJECTIVE: To evaluate if the use of ultraclean air technology could decrease the infection rate after posterior spinal arthrodesis with instrumentation. SUMMARY OF BACKGROUND DATA: Postoperative wound infection after posterior arthrodesis remains a feared complication in spinal surgery. Although this frequent complication results in a significant problem, the employment of ultraclean air technology, as it is commonly used for arthroplasty, has not been reported as a possible alternative to reduce the infection rate after complex spine surgery. METHODS: One hundred seventy-nine patients having posterior spinal fusion with instrumentation were divided into 2 groups: group I included 139 patients operated in a conventional operating room, and group II included 40 patients operated in a vertical laminar flow operating room. Patient selection was performed favoring ultraclean air technology for elective cases in which high infection risk was considered. A statistical analysis of the infection rate and its associated risk factors between both groups was assessed. RESULTS: We observed 18 wound infections in group I and 0 in group II. Comparison of infection rates using the chi-squared test showed a statistically significant difference (P <0.017). CONCLUSION: The use of ultraclean air technology reduced the
infection rate after complex spinal procedures and appears to be an interesting alternative that still needs to be prospectively studied with a randomized protocol.

4: AORN J 67 (4): 841-851

**Ultraclean Laminar Airflow ORs**

Friberg B, Umea University, Umea, Sweden

To minimize postoperative infections, ultraclean laminar airflow (LAF) units equipped with high-efficiency particulate air filters developed for electronic and aerospace technology have been adapted for ORs. Traditionally, the airflow was either vertical or horizontal and, to function properly, encompassed extra side walls inside the OR. Recently, new airstream technology has provided zoned downflow units that provide an exponential airflow (ie, resembling an upside-down trumpet mouth). The exponential airflow allows for omission of extra side walls, making them more versatile in clinical use. Each different type of LAF requires knowledge of airstream patterns and how OR team members need to dress and work to prevent contamination of the sterile air and the aseptic areas. This article discusses different LAF systems and related demands on OR clothing and behavior.


**Role of the environment of the operating suite in surgical wound infection.**

Ayliffe GA. Department of Medical Microbiology, University of Birmingham, United Kingdom.

Most surgical wound infections are acquired in the operating room from the patient's own microbial flora. The remainder are acquired mainly from the staff in the operating room during surgery. The inanimate environment (e.g., walls, floors, and surgical instruments) has little relevance to the spread of infection. Because the air is an important route of spread in joint prosthesis operations, the routine use of an ultraclean air system and exhaust-ventilated clothing is frequently recommended. (Emphasis by Precision Air Products.) The value of such a system in other types of clean surgery is doubtful, but other measures, such as the following, may provide similar results at less cost: reduction of the number of persons in the operating room; a policy of not opening doors during operations; the use of comfortable, washable, bacteria-impermeable clothing by the operating-room staff; and concentration of the airflow over the operation site rather than over the whole operating room.


**Clean air at operation and subsequent sepsis in the joint.**

Lidwell OM.

When Charnley and others began to do substantial numbers of arthroplasties, they met a high incidence of subsequent failure from sepsis. There was at that time a revival of interest in the possibility that surgical sepsis originated from airborne bacteria, and engineering developments had provided the means for attaining much cleaner atmospheres. Over a period of ten years, Charnley reduced airborne contamination by more than 100-fold, and his sepsis rate fell, without using antibiotics, by tenfold. He had, however, made other procedural changes, and there were those who reported equally good results without using the ventilation and clothing systems he had...
devised, although usually they had given prophylactic antibiotics. The results of recent randomized studies have confirmed that considerable reduction in the sepsis rate can be obtained by operating in ultraclean air but that similarly low rates can be achieved with normal ventilation when prophylactic antibiotics are given. In addition, the two methods are effective independently, and used together sepsis rates in the joint after total arthroplasty have been reduced to a few per 1000. (Emphasis by Precision Air Products.)


The effect of previous surgery, operating room environment, and preventive antibiotics on postoperative infection following total hip arthroplasty.

Nelson JP, Glassburn AR Jr, Talbott RD, McElhinney JP.

In 711 consecutive total hip arthroplasty operations, approximately 80% of patients were followed one to 7 years. Per priman operations outnumbered hips having had previous operations 511 to 200. The incidence of infection was higher in the hips having had previous operations (1.6 vs 3.5%). The overall incidence of deep infection was 16/711, or 23%. Analysis of the influences of operating room environment and preventative antibiotics revealed that there was a marked decrease in the attack rate of deep infection (7.6 vs 0.6%) when the Clean Room, personnel-isolator system, and preventative antibiotics were used. (Emphasis by Precision Air Products.) Reduced intraoperative wound bacterial contamination is accompanied by a reduced incidence of sepsis.

8: J Hosp Infect. 2002 Jun;51(2):79-84.

Environmental controls in operating theatres

Dharan S, Pittet D. Infection Control Programme, Department of Internal Medicine, University of Geneva Hospitals, Switzerland.

Surgical-site infection is the leading complication of surgery. Normal skin flora of patients or healthcare workers causes more than half all infections following clean surgery, but the importance of airborne bacteria in this setting remains controversial. Modern operating theatres have conventional plenum ventilation with filtered air where particles >/=5 micron are removed. For orthopaedic and other implant surgery, laminar-flow systems are used with high-efficiency particulate air (HEPA) filters where particles >/=0.3 microm are removed. The use of ultra-clean air has been shown to reduce infection rates significantly in orthopaedic implant surgery. Few countries have set bacterial threshold limits for conventionally ventilated operating rooms, although most recommend 20 air changes per hour to obtain 50-150 colony forming units/m(3) of air. There are no standardized methods for bacterial air sampling or its frequency. With the use of HEPA filters in operating theatre ventilation, there is a tendency to apply cleanroom technology standards used in industry for hospitals. These are based on measuring the presence of particles of varying sizes and numbers, and are better suited than bacterial sampling. Environmental bacterial sampling in operating theatres should be limited to investigation of epidemics, validation of protocols, or changes made in materials which could influence the microbial content.


Effect of ultraclean air in operating rooms on deep sepsis in the joint after total hip or knee replacement: a randomised study.
Lidwell OM, Lowbury EJ, Whyte W, Blowers R, Stanley SJ, Lowe D.

In a multicentre study of sepsis after total hip or knee replacement the operations performed by each surgeon were allocated at random between control and ultraclean-air operating rooms. Records were obtained from over 8000 such operations. In the patients whose prostheses were inserted in an operating room ventilated by an ultraclean-air system the incidence of joint sepsis confirmed at reoperation within the next one to four years was about half that of patients who had had the operation in a conventionally ventilated room at the same hospital. When whole-body exhaust-ventilated suits had been worn by the operating team in a theatre ventilated by an ultraclean-air system the incidence of sepsis was about a quarter of that found after operations performed with conventional ventilation. (Emphasis by Precision Air Products.) When all groups in the trial were considered together the analysis showed deep sepsis after 63 out of 4133 operations in the control group (1.5%) and after 23 out of 3922 operations in the ultraclean-air groups (0.6%) (ratio 2.6, 95% confidence limits 1.6-4.2; p less than 0.001). The design of the study did not include a strictly controlled test of the effect of prophylactic antibiotics, but their use was associated with a lower incidence of sepsis than in patients who had received no antibiotic prophylaxis at their operations (0.6% (34/5831) v 2.3% (52/2221); ratio 4.0).


Ultraclean air and antibiotics for prevention of postoperative infection. A multicenter study of 8,052 joint replacement operations.


To determine the value of ultraclean air in operating rooms, 8,052 operations for total hip- or knee-joint replacement were followed up for 1-4 years. For operations done in ultraclean air, bacterial contamination of the wound, deep joint sepsis, and major wound sepsis were substantially less than for operations done in conventionally ventilated rooms (Emphasis by Precision Air Products.) Sepsis was also less frequent when prophylactic antibiotics had been given. The two precautions acted independently so that the incidence of sepsis after operation in ultraclean air and with antibiotics was much less than that when either was used alone. Wound sepsis was associated with an enhanced risk of joint sepsis. Staphylococcus aureus was the commonest joint pathogen, but infections with other organisms, often considered to be of low pathogenicity, were almost as numerous. Most S. aureus infections were traced to sources in the operating room.


Laminar airflow versus conventional air operating systems: a seven-year patient follow-up.

Ritter MA, Stringer EA.

A 7-year follow-up was conducted on 183 total hip replacements and evaluated for infection. Eighty-seven operations were done in a horizontal laminar airflow operating room and 89 were done in a conventional operating room without laminar airflow. In the laminar airflow group, there were 2 infections (2.2%) and 6 (6.7%) in the conventional operating room. Excluding those patients who had undergone previous operations, there were 3 infections out of 76 (4%) in the conventional operating room group. One infection out of 68 (1%) occurred in
the laminar airflow group. There were no statistical differences in the infection rates. These data are interpreted to suggest that daily uncontrollable variables which may produce infections are minimized by the use of laminar air-flow operating rooms (Emphasis by Precision Air Products.)

CDC GUIDELINE FOR PREVENTION OF SURGICAL SITE INFECTION, 1999

Alicia J. Mangram, MD; Teresa C. Horan, MPH, CIC; Michele L. Pearson, MD; Leah Christine Silver, BS; William R. Jarvis, MD;

Most of the studies examining the efficacy of ultraclean air involve only orthopedic operations. Charnley and Eftaknan studied vertical laminar airflow systems and exhaust-ventilated clothing and found that their use decreased the SSI rate from 9% to 1%. Prophylaxis on the rate of deep SSIs. The SSI rate following operations in which ultraclean air alone was used decreased from 3.4% to 1.6%, whereas the rate for those who received only antimicrobial prophylaxis decreased from 3.4% to 0.8%. When both interventions were used in combination, the SSI rate decreased from 3.4% to 0.7%.

Introduce all air at the ceiling, and exhaust near the floor.

Consider performing orthopedic implant operations in operating rooms supplied with ultraclean air.