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Should Laminar Airflow Systems Still Be Used in Total Joint Arthroplasty?

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Abstract

The number of joint replacements is increasing annually. One of the most serious complications with total joint arthroplasties is infection. Periprosthetic joint infections (PJIs) are difficult to treat, have a high impact on patients' lives, and are a serious economic burden. Prevention of PJIs is important. Use of laminar airflow (LAF) systems has been considered a possible preventive measure; however, from the perspective of the current literature, it is possible that this assumption should be reconsidered. This minireview provides an overview of important aspects within the representative literature about the use of LAF systems and why they should be reconsidered as standard technology in the operating room.

The number of joint replacements is increasing annually[1]. Because of the higher life expectancy of patients, the threshold for operating on vulnerable patients with chronic diseases and predisposing variables (e.g., obesity and malnutrition) is becoming lower[2-6]. These variables are associated with higher numbers of complications and mortality[4-7].

One of the most serious complications with total joint arthroplasties (TJAs) is infection[8,9]. A periprosthetic joint infection (PJI) is a biomaterial-associated infection that involves biofilm formation on the prosthesis, making it difficult to treat[8,10-12].

PJIs are challenging not only for orthopaedic surgeons, but also for the patients and their families in terms of the physical and psychological impacts that are associated with this condition[9]. It affects their quality of life and their ability to return to their daily routine[9].

Another important aspect of a PJI is its serious economic impact, with the costs of treatment estimated to be 3 to 4 times the cost of a primary TJA[9,13]. Most PJIs are surgical site infections (SSIs). Prevention of these kinds of infections is important[14]. Many preventive measures regarding TJAs can be seen in daily practice. Some of these have been used for a long time, with the assumption that they are effective; 1 example is laminar airflow (LAF) in operating rooms (ORs)[2,15]. Clean air in ORs is supposed to be achieved with this technology, minimizing contamination of the surgical field with airborne microbes[2,16,17].

LAF is described as 1 massive body of air within a designated space that moves in the same direction at the same speed along parallel flow lines[16,17]. LAF systems use a continuous airflow of ultraclean filtered air containing <10 colony-forming units (CFU)/m^3 of bacteria[16,17]. The air is recirculated under positive pressure into the OR16,17; therefore, surgically generated contaminants are continuously removed[16,17].

There are 2 kinds of LAF systems: horizontal and vertical[17]. In the horizontal systems, high-efficiency particulate air filters are installed in an entire OR or on a portion of an OR wall. These horizontal LAF systems are easier to install than the vertical systems, especially in existing ORs. However, correct positioning of the members of

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the operating team is required for the LAF to obtain its intended effectiveness[17].

The vertical version of LAF systems involves ceiling filters that direct air vertically downward into the OR[17]. This type of system is less dependent on the positioning of the members of the operating team. However, a possible entrainment of flow can occur with movement of the people within the periphery, possibly causing disruption of the LAF. Because of the airflow disruption, contamination inward toward the operative site can be introduced[17].

Both types of systems create a unidirectional flow of air that is free of eddies and turbulence[17]. Thus, any material shed by the surgeon and the assistant(s) during surgery is directed outward and away from the wound site, which hypothetically prevents any bacteria from these materials from landing on the wound and causing an infection[17].

The theoretical background and the use of LAF continue to be highly debated. This review provides an overview of important aspects from the literature about the use of LAF systems and why they should be reconsidered as the standard technology in the OR.

Different Outcomes in Recent Literature

Orthopaedic surgical practices have evolved over the past 15 years. For example, there is a different approach in surgical preparation that no longer requires skin shaving, use of alcohol with skin preparation, and antibiotic prophylaxis given 15 to 30 minutes preoperatively[18,19]. There are many simple infection-preventive measures that can be implemented in daily practice, such as leaving telephones, laptops, and tablets out of the OR; limiting traffic and door movements in the OR; not using drains in TJAs; protecting the patient from hypothermia; and reducing the number of allogenic blood transfusions[8,14].

Determining the effect of just 1 of the infection-preventive measures in current practice is a daunting prospect[20]. Concerning the use of LAF, the organization of randomized clinical trials (RCTs) would also be difficult[20] because of the expected lack of control of confounding factors and the large number of patients that would be needed to achieve sufficient statistical data[21]. However, there appears to be adequate evidence in the literature from which to draw conclusions for future guidelines about air management in the OR.

The assumption that LAF systems reduce the risk of SSIs was based on outdated literature about surgeries that were performed between 1971 and 1990[15,17]. Techniques within medicine have improved since then. This includes OR air-filtration methods in conventional ventilation systems, which obscure the differences between LAF and conventional ventilation systems[15,20]. This might be one of the reasons why current studies show no substantial differences in infection rates with the use of LAF and conventional ventilation systems[2,20,22]. One of these studies is a very recent meta-analysis that shows no benefit from the use of LAF systems compared with conventional turbulent ventilation systems in the OR for reducing the risk of SSIs in patients with total hip and knee arthroplasties. The authors advised that the LAF equipment should not be installed in newly built ORs[20]. This supports the most recent guidelines of the World Health Organization (WHO) about the prevention of SSIs, suggesting that LAF ventilation systems should not be used in an effort to reduce the risk of SSIs in patients undergoing total arthroplasties[14].

Increased Risk of Infections

The fact that LAF systems may not be superior to conventional ventilation systems may not be the most important issue. According to a meta-analysis by Gastmeier et al., LAF systems seem to increase the risk of SSIs[21]. The authors, however, presented several limitations of their study because surveillance and registry databases were not originally designed to be subjected to this kind of analysis. Also, the studies included in the meta-analysis used different definitions for PJIs, which is an important limitation for interpreting the outcomes[21]. Although we might question the results of this analysis, their assumption about LAF systems and higher risk of SSIs are supported in other articles as well. There is a well-done meta-analysis by Bischoff et al. that states that the probability of developing deep SSIs after a total hip arthroplasty is higher when LAF systems are used than when conventional systems are used[20]. Although this effect was not shown to be statistically significant, evidence does appear to indicate a possible correlation between LAF and SSIs[20].

Economic Aspects

Costs are an important aspect when making a decision about ventilation systems in the OR. The economic aspects of LAF versus conventional ventilation systems are described within the current literature. A review about the cost-effectiveness of strategies for reducing the risk of infection following total hip arthroplasty states that the use of LAF indicates higher costs and worse health outcomes[23]. In comparison with conventional systems, LAF systems showed higher investment costs and operating expenses, including a 24% increase in building costs and a 34% increase in annual operating costs when LAF rather than a conventional system was used in Italy[24]. LAF systems appear to be an economic burden when compared with conventional ventilation systems.

Discussion

Although the available literature seems to show an increased risk of SSIs following TJA when LAF systems are used, the quality of evidence seems too weak to draw firm conclusions. Additional research is necessary to determine whether LAF leads to more SSIs. However, it is questionable whether a proven higher infection risk

would be a decisive reason for changing current practices and guidelines. Of course, this would contribute to attitudes about changing current practices and guidelines, and it could be an argument for the discontinuation of surgery in existing ORs that are equipped with LAF. If the infection risk with LAF and conventional ventilation systems is determined to be equal after quality studies have been performed, this evidence, combined with the economic aspects of LAF versus conventional ventilation systems, might be sufficient to oppose building LAF systems in new ORs.

With the recent guidelines of the WHO concerning the prevention of SSIs, the most current available evidence, and the economic aspects, it seems that LAF systems might be eliminated in the future, and conventional ventilation systems will become the gold standard.

Note:

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