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Testing the effectiveness of operating room ventilation with regard to removal of airborne bacteria

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ABSTRACT

In this research the ability of the ventilation system in an operating room to keep the operating table and the instrument tables free from airborne bacteria has been evaluated in an experimental mock-up for different ventilation systems under various static circumstances. To accomplish this, the VDI 2167 particle test has been used as a basis. In this test particles are released on the floor and smoke concentrations are measured on the operating table.

The VDI 2167 method was able to distinguish the different systems, but did not provide for a complete evaluation. The thermal balance in the room plays a major role in whether a laminar downflow system works and the VDI method does not incorporate this into the tests in an adequate manner. Moreover, the influence of surgical lighting is not included in the test method in an effective way.

1. Introduction

Airborne bacteria in operating rooms can cause infections deep in the wound. The most critical areas in an operating room are the operating wound and the instrument tables. A better ventilation system reduces the concentration of bacteria, and therefore the chance of deposition of bacteria in the wound [1]. There are two types of systems in use; laminar and mixing systems. With mixing systems, the concentration of contaminants is diluted. A higher ventilation or recirculation rate automatically gives a lower contaminant concentration. Laminar systems on the other hand are supposed to deliver clean air to critical areas before it mixes with contaminated surrounding air.

Laminar downflow systems are seen as the successor of mixing systems, but research that correlates postoperative wound infections and the type of ventilation system in use has not shown consistently that laminar airflow systems lead to fewer infections than mixing systems [2–6]. From this it can be concluded that either the airborne route does not play a significant role in the occurrence of wound infections or laminar flow systems do not perform in practice the way they should.

The performance of ventilation systems was evaluated by various different people over the past years, with different outcomes. One method to measure the performance is either to use Petri dishes to sample deposition of bacteria during an operation, or to use a bacterial air sampler to measure the concentration of airborne bacteria [7–9]. This is a very direct way to evaluate risk, but because factors such as quality of clothing and procedures influence the result, this method is unsuited for comparison between systems in different hospitals.

Alternatively the transport of bacteria can be simulated using either a fixed particle source or a tracer gas when the operating theatre is not in use. The advantage is that the source strength in these cases is fixed, so that any change in measured concentration is due to changes of the performance of the ventilation system. This method has been used by authors in Refs. [10–12]. A standardised method is described in VDI 2167 [13] and was later incorporated in DIN1946-4 [14]. A fixed source allows measurement of the performance of the ventilation system directly. If measuring is impossible or impractical, it is also possible to do a simulation instead. [15–18]

The VDI 2167 describes a way to test whether particles from the environment are able to penetrate the clean area and settle in the operating area. To perform an assessment according to VDI 2167, heated puppets have to be placed in the room. Smoke sources are placed on the floor around the clean area. By measuring the smoke concentration on the operating table the performance of the ventilation system can be measured. Because lamp position, puppets, equipment, particle source position and particle measurements have all been standardised, it is possible to compare results from tests in different rooms.

The main question in this paper is whether the VDI 2167 is able to differentiate between different types of ventilation systems. It

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