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DOI 10.1007/s12273-013-0145-4

Ultra clean ventilation system performance relating to airborne infections in operating theatres using CFD modelling

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Abstract

Preventing airborne infections during a surgical procedure is of paramount importance for effective and economical delivery of care, as well as for health and well-being of patients. Ultra clean ventilation (UCV) systems are commonly used in operating theatres, in particular for orthopaedic surgery because of the higher risk of infection from exposed deep wounds. This research, investigates the airflow pattern of a UCV based operating theatre using computational fluid dynamics (CFD). The effects of the opening and closing of doors in two pressurisation scenarios (0 and 20 Pa) with the surrounding spaces at various inlet and door inflow velocities are investigated. The UCV system operates effectively in the positive pressure (20 Pa) scenario but fails when there is no pressure difference between the operating theatre and surrounding areas. The implications of the research findings are discussed in the context of design guidance and the operation of the airflow system.

Keywords

operating theatre,
airborne infection,
ventilation,
CFD

Article History

Received: 29 March 2013
Revised: 1 May 2013
Accepted: 27 May 2013

1 Introduction

The hospital environment is host to a wide variety of micro-organisms coupled with a large array of transfer modes to the patient. These micro-organisms can be dangerous to patients with wounds, undergoing a surgical procedure or are immunosuppressed. About ten percent of all patients catch an infectious disease while staying in a hospital (Plowman et al. 1997). The modes of transfer include surgical equipment, medical equipment, physical contact, foodstuff, beverages and airborne routes. Airborne bacteria can be distributed by the ventilation system or by air infiltration into sensitive areas, such as intensive care units or operating theatres. Patients in these areas are often in a weakened state with low defence systems and infection can, in some circumstances, cause fatal complications. A more detailed discussion of airborne routes can be found in (Whyte et al. 1992) and non-airborne routes in (Whyte et al. 1991).

All surgical procedures carry a risk of infection. This infection can develop at the wound site and may not be detected for weeks, months or even years after the operation. Certain types of surgery, such as prosthetic implantation, amplify this risk due to the deep wound and the insertion of the prosthetic device.

In addition to the health risk, infections place a large financial burden on the health care service. The following example illustrates the magnitude of these costs (Tinker and Roberts 1998). Each year approximately 50 000 primary hip replacements are performed in the UK. If a post-operative infection occurs, then the complete procedure must be repeated at an estimated cost of £32,000 (MacDonald 1995). With a conservative annual infection rate of 1%, the additional costs per annum is about £16 million. However, many hospitals have reported higher failure rates and hence larger additional costs. There are no national figures available for the UK or the USA and it is possible that infection rates could be significantly higher (MacDonald 1995). Therefore, the reduction of infections in surgical operations would have a positive effect on patient health, department running costs and operation waiting lists.

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