Chapter 11

Summary
Nederlandse samenvatting

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11.1 Summary

In this thesis, aerogenic contamination control in operating theatres is addressed in order to increase the understanding of the effect of technical measures to the protective effect in practice. The aim of these technical measures is to increase the protection against entrainment and deposition of potentially microorganisms carrying particles. This is especially of interest for the critical locations in an operating room and instrument preparation room. The questions answered in this thesis are:

1) Is a clean area of 3 x 3 meter, often used in Dutch operating rooms, sufficient to position the patient, sterile instruments and the surgical team?
2) Is the area that is protected by a UDF system influenced by a skirt, different types of operating lamps and the position of the lamp?
3) Is it possible to switch off the ventilation system of operating rooms during prolonged inactivity e.g. during the night and weekend without negative effects on the air quality during normal operational hours?
4) Can a horizontal UDF (UDHF) system in terms of prevention of contamination of the air safely be used during the laying-up process on the instrument table?
5) Does the use of a mobile ultraclean laminar airflow screen reduce the air-borne particle counts in a non-ventilated room to a level safe for the patient?

Is a clean area of 3 x 3 meter, often used in Dutch operating rooms, sufficient to position the patient, sterile instruments and the surgical team?

A size of the protected area of 3 x 3 meters is sufficient for most defined situations, provided a movable operation table is used. For interventions in polytrauma patients however bottlenecks regarding the dimensions of the clean area will probably arise. For this type of surgery, a size of 3.20 × 3.20 meter is proposed. Knowing the required size of the protected area in an operating room is very important during the design phase of the air distribution system in the operating room. Especially if UDF systems are used that generate a cleaner zone in an operating room.

One must realize that outside this protected zone the number of microorganisms carrying particles is higher than inside this zone. However, determining the protected area that a UDF system can realize is measured in the “At rest” condition. This means that all equipment is present and in operation but without the process or the presence of people. As a result, the size of the protected area may deviate during operational circumstances.

In large operating rooms it is more effective to position the plenum eccentrically so additional space is created at the main entrance to the operating room rather than being equally divided around the UDF system. This way there is more usable space for temporary storage of equipment during the procedure.

To improve the UDF air flow a skirt around the canopy with a supply bridge was considered in the design used in the study for this thesis. The supply bridge was positioned 2.05 meter above floor level. For many staff, a height of 2.05 meter is workable for making connections in the slanted part of the supply bridge. It is also concluded that process simulations have great value during the design of an operating room lay-out.

Is the area that is protected by a UDF system influenced by a skirt, different types of operating lamps and the position of the lamp?

The size and quality of the protected zone by the air distribution system is influenced by a skirt and by the type of operating lamps. Using a skirt does not increase the size of the protected zone but it increases the *quality* of the zone protected by the air distribution system. With a skirt the protected zone is 100 times cleaner in the centre than without a skirt. Operating lamps with an open structure have a less negative effect on the quality (degree of protection) of the protected zone. These measures can be used in the design phase or can be used to improve the performance of existing systems.

Is it possible to switch off the ventilation system of operating rooms during prolonged inactivity e.g. during the night and weekend without negative effect on the air quality during normal operational hours?

Switching off ventilation systems during prolonged inactivity can help to save energy. It is concluded that switching off the ventilation system during prolonged inactivity (e.g. during the night and weekend) has no negative effect on the air quality in UDF operating theatres during regular operational hours. After starting up the system, the protected area achieved the required degrees of protection within 20 minutes. The results also show a stable temperature difference within 23 minutes after starting up the system. In practice this time to start up the system is also needed for the preparation for trauma surgery. The time needed for preparing this type of surgery is estimated at 25 minutes. If laying-up instruments is performed in the operating room this start-up time must also be taken into account. It is only safe to start this process if the required degree of protection is reached. Switching off ventilation systems during prolonged inactivity does not only save energy but is also may extend the service life of filters. Both can lead to reduction of operational cost (energy and maintenance).

Can a horizontal UDF (UDHF) in terms of prevention of contamination of the air safely be used during the laying-up process on the instrument table?

The instruments used during surgery are also an important route for contamination of the surgical wound. It is demonstrated by measuring the number of particles and CFU/m^3 that horizontal UDF systems offer at least the same protection against aerogenic contamination as UDF downflow systems during laying-up processes. For laying-up processes the horizontal system offers a more robust solution than the downflow system, provided that a decent work process is used, and the height of the instrument table is adapted to the height of the supply plenum.

Does the use of a mobile ultraclean laminar airflow screen reduce the air-borne particle counts in a nonventilated room to a level safe for the patient?

For surgery with a small surgical wound and a limited number of surgical instruments systems with a smaller protected area may be used. It has been shown that if a mobile air flow screen is used in a poorly ventilated room it protects against contaminations in the setting of intra-vitreal injections. However proper positioning and placing of the surgical drapes is critical. To do so it is important to adjust the setting precisely for each particular site, in order to determine the actual degree of protection present.

Overall conclusion and discussion

It is stated that UDF systems have the ability to protect an area against aerogenic contaminants in an effective way. The effectiveness of a system against entrainment of microorganisms carrying particles from outside the protected area and the ability to remove potential microorganisms carrying particles generated in this zone is however affected by many variables, figure 11.1.

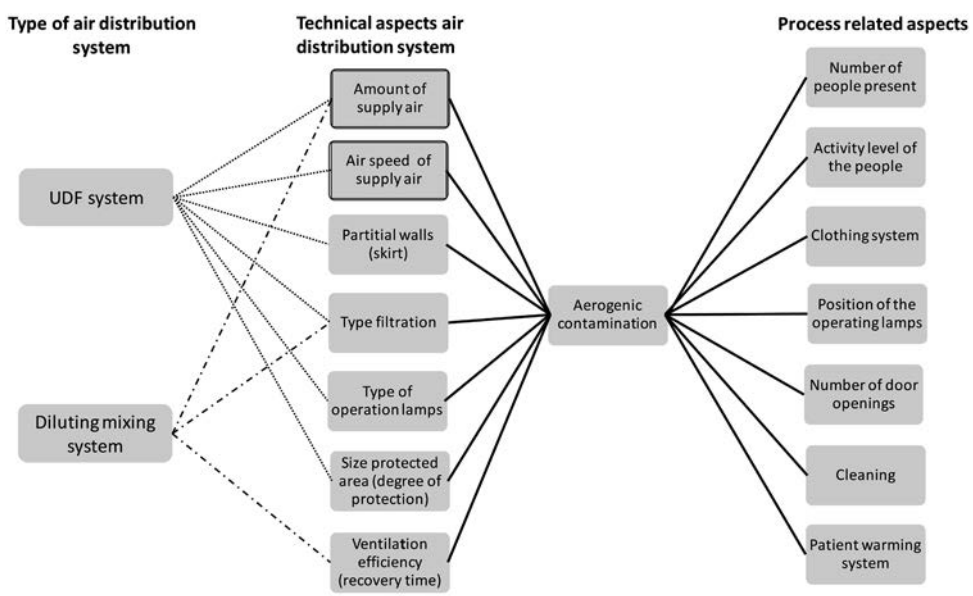

Figure 11.1. *Aspects that determine the aerogenic contamination in an operating room.*

If different types of air distribution systems are compared, at least the technical and process-related aspects as shown in the figure 11.1 must be taken into account. A good comparison between the properties of air distribution systems is only possible for systems with the same amount of supplied air. Only in this way is the performance of the distribution system being compared and not the air volume. Most studies based on retrospective analyses of routine surveillance data have a major weakness. The embarrassment with these studies is that UDF or laminar flow system and diluting mixing system are not unambiguously defined. Most common approach in these studies is that the type of system used in the operating rooms, UDF or diluting mixing system, is obtained by a questionnaire. If a diffuser, canopy or plenum is used the system is often classified as UDF system without knowing whether this system performs as a UDF system based on performance tests.

It is also concluded that measuring the performance of a system based on a challenge by an artificial source of particles is a good indication for the effectiveness of a system during ongoing surgical procedures (recovery test, entrainment or segregation test). Systems that are designed based on a specific maximum source strength (number of people and clothing system) like diluting mixing systems, are more sensitive to disruption of the process than systems creating a protected zone. A disruption may be an increase of the number of people or calamities. The performance of these systems can best be demonstrated by CFU measurements during ongoing surgical procedures. This because during use there are regular deviations from the design conditions (e.g. number of persons in the operating room and discipline). This method may also be used if the protected zone is too small to contain the surgical wound, the surgical team and sterile instruments or if the UDF airflow is severely interrupted by obstacles such as support arms, monitors, working lamps with a closed structure or other ceiling mounted systems. These CFU measurements not only show the technical performance of the system, but also the effect of the processes on the aerogenic contamination.

Future direction

Since much remains unclear in the route of infection of surgical wounds and implants, further research should focus on the source of wound contaminants, and infection-causative bacteria. More investigations are needed about the proportion of bacteria that contaminate directly via the air, or indirectly via hands and instruments. More information about the role and importance of per- and early postoperative endogenous infection is needed to get a better insight of the relative role of the bacterial air quality in the operating room and eventual prophylactic measures in bacteria carrying patients.

There is a lack of studies concerning the investment and operational costs of different systems. In such studies, a better comparison basis must be maintained (figure 11.1), whereby a distinction must be made between a new build situation and renovation. The hypothesis is that UDF systems with the same amount of outdoor air (ODA) and the same amount of secondary air (SEC) have comparable investment and operating costs as mixing systems. If these proposed studies are carried out, this can contribute positively to the discussion regarding different types of air distribution systems.