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CONTAMINATION CONTROL IN OPERATING THEATRES

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Abstract

Patient safety is a main topic during surgery. One of the main issues inside operating theatres (OR's) is the prevention of airborne particles with bacteria that contaminate the wound area and the instruments. The risks and requirements differ for different types of surgery. To minimize the contaminations and improve the patient safety, controlling the quality of the air inside an OR is essential. Several type of air handling systems are available, suitable for different types of surgery. The most used systems are:

- Turbulent Mixed Airflow systems
- Laminar Airflow systems
- Temperature Controlled Airflow systems

The number of colony forming unit is the environment around the patient has an effect on the surgical site infections. When the environment in the OR is clean, the risk of infection will decrease. What is the best ventilation system in an OR in relation to the requirements of surgery, airborne particles and the use of antibiotic prophylaxis? This paper will provide a comparison of different ventilation systems that will support hospital staff to make decisions about the quality of their Operating Theatres. The three systems will be compared both "at rest" and "in operation".

1. INTRODUCTION

The board of the hospital is responsible for patient safety before, during and after an operation. To guarantee patient safety, the hospital takes precautionary measures to prevent Surgical Site Infections (SSI). Dutch law and regulations are based on the prevention of SSI to minimize the risk of infection.

The following issues influence the patient safety, SSI and result of the operation:

- Personal hygiene
- Behaviour of people
- Discipline
- Clothing and mouth cover
- Cleaning of the OR
- Air quality

The first 5 influences have to do with the people inside the OR and the protocols for their way of working. Only cleaning and the air quality have to do with the room itself without people. Cleaning is related to particle deposition on surfaces and air quality is related to airborne contamination.

When a patient is inside an OR there are several threats of biological contamination. The most common biological contaminations are:

- Infections.
  Infections are pathogen micro-organisms which are caused by poor hygiene of people and materials. To prevent these contaminations discipline is the only option.
- Microbial contamination.
  Micro-organisms will travel via air to the wound area and become a risk when the bacteria enter the body of a patient. Good clothing systems will prevent the release of bacteria inside an OR during surgery.
- Neuro / mycotoxin poisoning.
  The fungal spores will grow rapidly in a condition with the right temperature and humidity. The control of humidity and temperature of the room depends on the scales of the contractor and the use of mouth covers by the personnel.
- Endotoxin poisoning.
  The anaerobe micro-organisms are present in human body openings. Cleaning and sterilisation of instruments will prevent this risk.
- (Bio) chemical poisoning.
  This dead micro-organism can cause a problem when it is airborne and enters the body of the patient. These organisms will be present in air, on instruments and disposables. With discipline and a good air quality dead micro-organism will be removed before they can enter the patient.

To minimize above risks the different governments provide guidelines and standards. These guidelines and standards are different in every country because of differences

in the total process of treatment. The medical process is based on a total set of requirements and protocols. The most common way to prevent SSI is the use of antibiotics before and after the treatment. However, the risk of the use of antibiotics is resistance against these antibiotics. When overusing antibiotics, resistance will become a problem and other ways of treatment have to be found. Prevention of infections will become more important in large parts of the world.

All precautionary actions are based on the 6 influences mentioned in this paper. For the hygiene, discipline, cleaning and behaviour, hospitals will provide protocols to the personnel. The selection of a clothing system is very important. When a hospital selects a clothing system they should look at the cleanrooms as well. In cleanrooms good clothing systems are common practice and bear arms or uncovered hairs are forbidden. There are a number of researches which prove the effectiveness of clothing to prevent particles and bacteria to give off the human body.

The last precautionary action is the design of the OR itself. The OR should be built with suitable materials which can be easily cleaned thoroughly. Next to the construction an effective and clean air supply should be installed to remove any contamination out of the OR as soon as possible and prevent contamination to enter the OR. This paper will give insight in the design of the OR itself by comparing ventilation systems within OR designs.

2. GENERAL ASUMPTIONS

To determine the effectiveness of the ventilation systems, all systems will be compared in two situations with two different methods of measurements in the “at rest” situation. The measurements will take place based on particles and based on bacteria. Both methods are used for classification of OR’s in Europe.

The OR’s which will be used for the measurements are approximately 50 m^2 and have a height of 3 metres. At all measurements temperature and humidity will be approximately 21 ˚C / 55 %. In all OR’s the air supply will have a HEPA filter with a minimum quality of H13.

All air volumes are dedicated for the ventilation system. A ventilation system will function with a certain amount of air. Every system has a different air volume for an optimal performance.

“At rest” situation

In the “At rest” situation the OR is equipped with all fixed medical equipment. Lamps and pendula are mounted and all fixed items against the walls will be in place. The lamps will be in position as shown in figure 1[1]. The pendula’s will be in position of the most common operation.
Next to the fixed equipment will be medical equipment with a heat load present in the OR. The surgery tower and anaesthesia equipment will be present and switched on.

table.

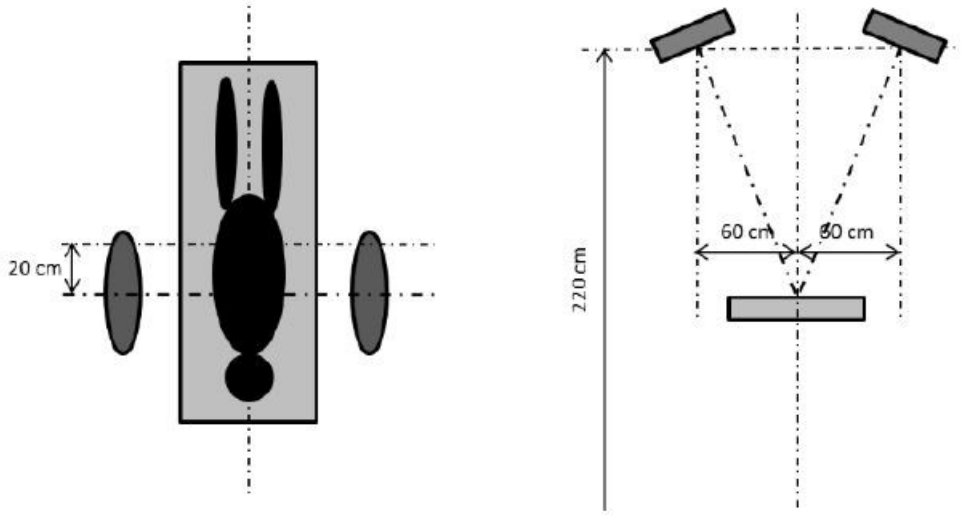

Figure 1 Lamp position "At Rest"

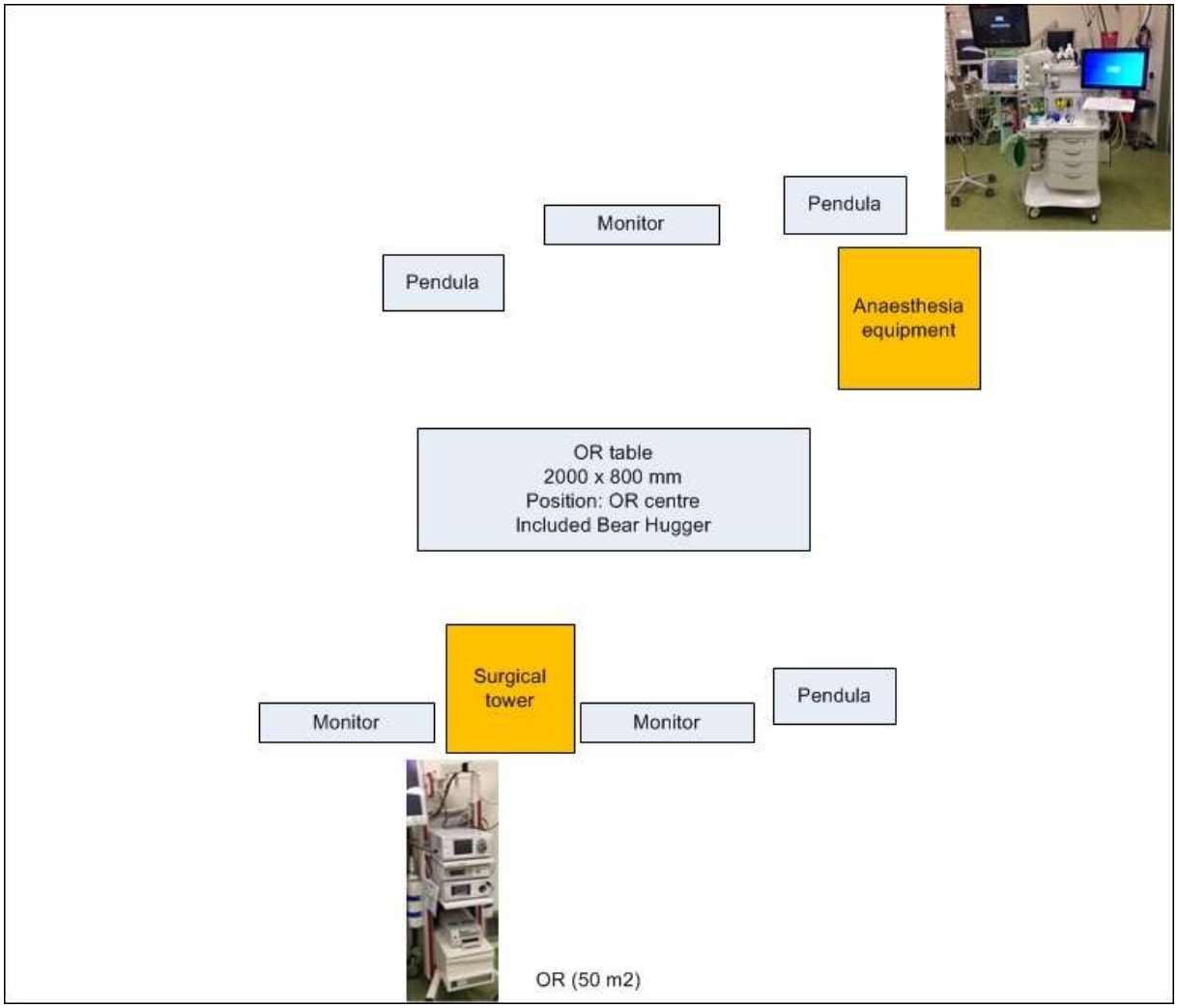

Figure 2 OR "At Rest"

"In operation" situation

In the "In operation" situation the OR will be in use for a real operation. The operation need to have a duration of minimal 45 minutes. During the operation a minimum of 3 samples need to be taken next to the wound area and on the instrument table.

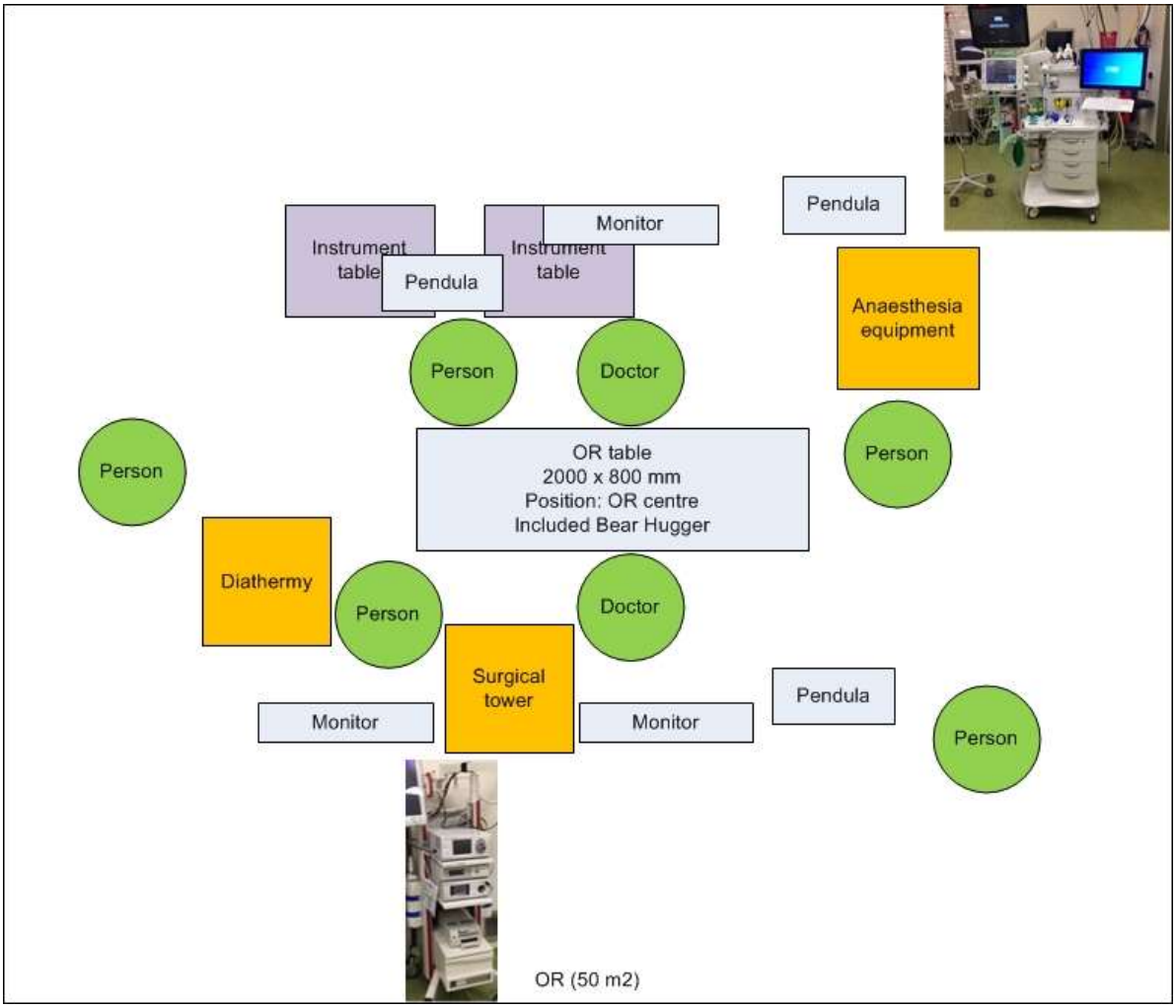

Figure 3 OR "In operation"

3. VENTILATION SYSTEMS

Turbulent Mixed Airflow system (TMAF)

A turbulent mixing ventilation system is based on the dilution of the amount of contamination in the room. The system will function with an air volume of 5000 m^3/h. The air will be inserted in the whole OR with a speed > 0,5 m/s.

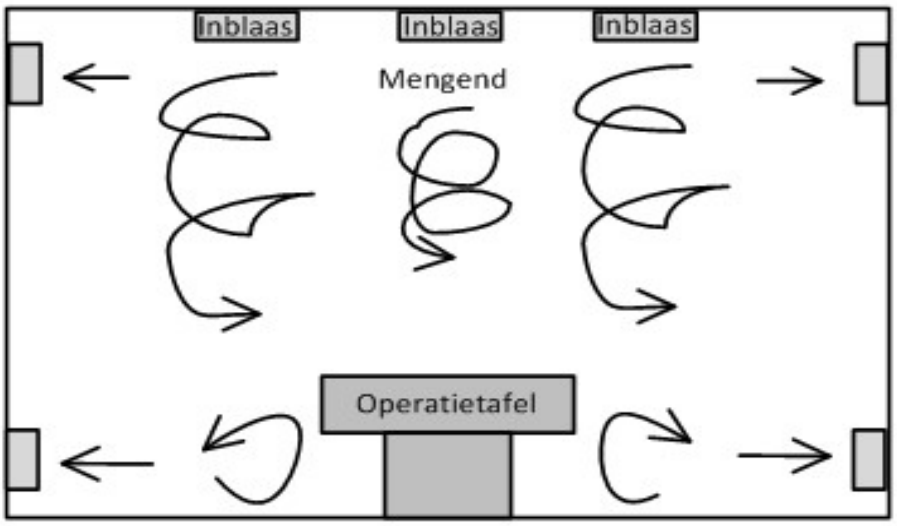

Figure 4 Turbulent Mixed Airflow system

Laminar Airflow Systems (LAF)

With a laminar airflow system air will be inserted in the room with a plenum in the centre of the room. The size of the plenum will depend of the kind of surgery. In these measurements the size of the plenum is 3200 x 3200 mm. The plenum is placed in the centre of the OR with an air volume of 11.000 m^3/h. In the periphery there will be no air supply available. The air speed will be 0,3 m/s. The air flow is divided in two different zones with different temperatures. There will be a difference of 2 K in temperature between the 2 zones.

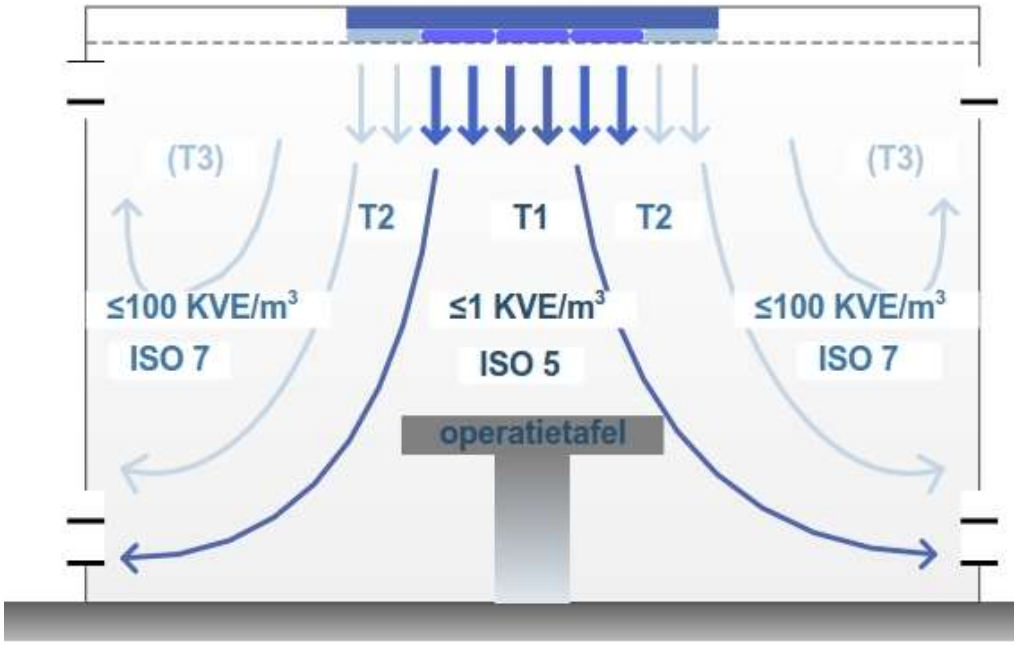

Figure 5 Laminar Airflow system

Temperature Controlled Airflow Systems (TCAF)

The temperature controlled airflow system is based on gravity. In the room a central plenum with 8 airshowers (Opragon 8) is positioned. Around this plenum 12 external airshowers are positioned. The total amount of air is 6.800 m^3/h. The air speed will be > 0,25 m/s at the table. The temperature difference between the central plenum and the room temperature will be -2 K.

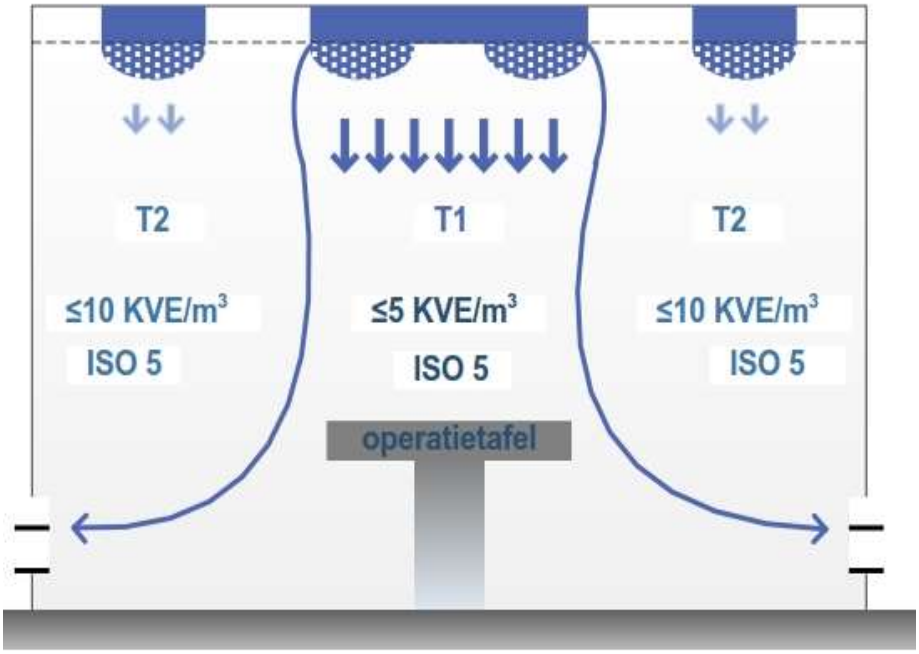

Figure 6 Temperature Controlled Airflow system

4. MEASUREMENT RESULTS

The measurements of the OR ventilation systems are done to find out the most effective ventilation system to remove contamination outside the OR. All other aspects of the ventilation system and the functioning of the OR are not taken into account and will not be part of the comparison of the systems.

Bacterial measurements "At Rest"

Bacterial measurements "At rest" give no information about the function of a ventilation system inside an OR. These measurements will provide information about the cleanliness of an OR. When bacteria are found on the surface of an OR the cleaning of an OR should be done properly. When airborne bacteria are found the filtering system is not functioning well and need to be checked.

These measurements have been done in 3 OR's in 2 different hospitals. The information was needed before the classification of the OR's started. The hospital wants to be sure of the right cleaning procedure. The filters were tested before and - proved to be functioning according to specifications.

Ventilation system	Result cfu/m^3	
	Centre	Periphery
TMA system	0	0
LAF system	0	0
TCAF system	0	0

Table 1 measurements cfu/m^3 "at rest"

Because the information given had no indication of the effectiveness of the ventilation system, the results will not be used for the comparison of the systems.

Particle measurements "At rest"

Particle measurements "at rest" is a method which is used in the Netherlands for classification of an OR. The OR is tested with a controlled amount of particles in the periphery. Depending on the type of system, the measurement points are defined. The contamination has a minimum of 10^7 particles > 0,5 µm.

Measurements at a TMA system are done in the centre of the OR and near the border of operating area. At the position of the yellow stars the contamination is released and the red stars are the measurement points.

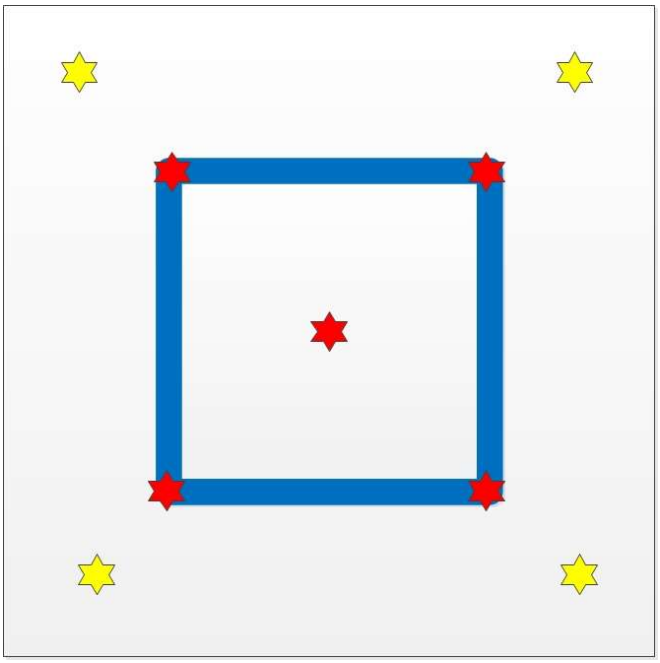

Figure 7 Measurement positions TMA system

Measurements at the LAF system will be done at the corners of the plenum area inside the OR and in the centre of the OR. At the position of the yellow stars the contamination is released and the red stars are the measurement points.

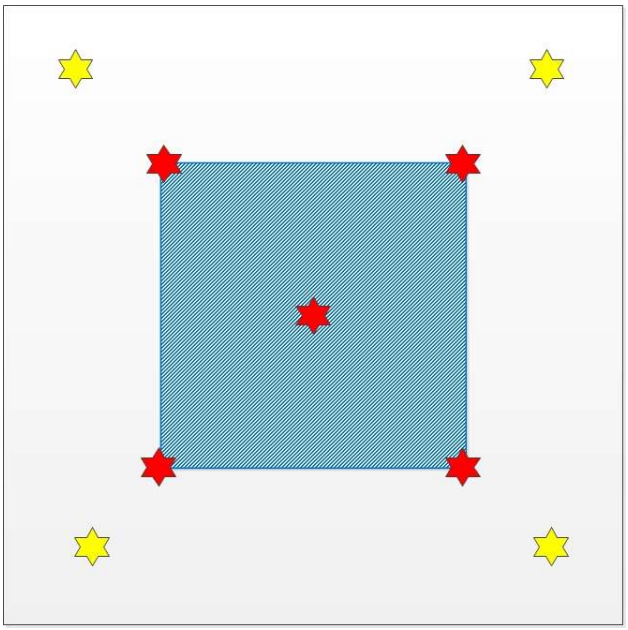

Figure 8 Measurement positions LAF system

Measurements at the TACF system will be done at the border of the plenum box inside the OR and in the centre of the OR. At the position of the yellow stars the contamination is released and the red stars are the measurement points.

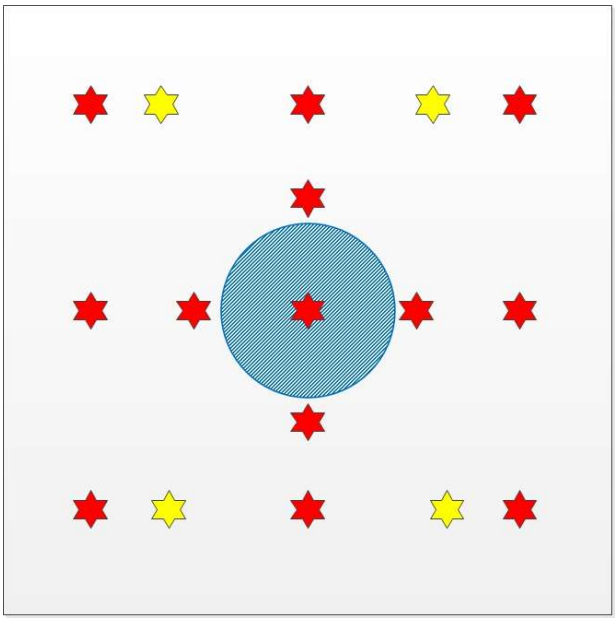

Figure 9 Measurement positions TCAF system

To compare the results of the measurements all average values are calculated and placed in the result table. The measurement tools are all calibrated and have the same accuracy. The values give an indication of the average level of particles inside the OR at different positions.

Ventilation system	Result particles	
	Centre	Periphery
TMA system	381,503	318,503
LAF system	0	117,748
TCAF system	0	163

Table 2 measurements particles "at rest"

Particle measurements "In operation"

Particle measurements "In operation" are difficult to carry out because of the operation process. Measurement positions will conflict with personnel and equipment in the OR during operation. There are indicative measurements done in an OR with a LAF system. During several measurements particles are measured on available positions during the process.

During the measurements there are several moments that the number of particles increase above the level of the ISO classification. During the operation 20% of the time the number of particles is above the level of ISO 6 classification. The exceedance of air quality is present during diathermy, extreme movements of people in the OR and when the number of people above the wound area increase. During the preparation and completion of the operation the number of particles increase above the level as well. These exceedances are part of the 20% as well.

Bacterial measurements "In Operations"

Bacterial measurements "In operations" is a method which is used in Sweden for classification of an OR. During operations a minimum of 3 measurements have to be done. The operation need to have duration of 45 minutes or longer and a minimum of 3 measurements have to be done.

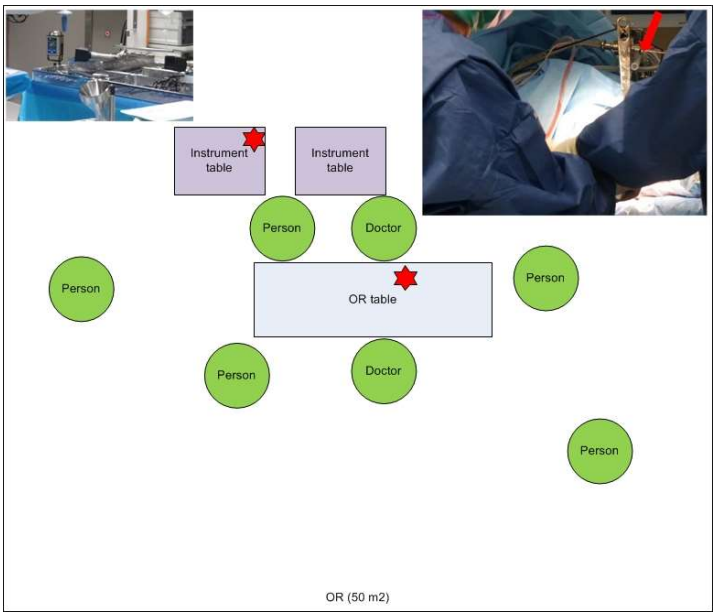

Figure 10 Measurement positions[2]

Measurements at a TMA system are not done. Because of a delay in the research there is no data available for this system.

The other systems are measured according to the Swedish standard. To compare the results of the measurements all average values are calculated and placed in the result table. The measurement tools are all calibrated and have the same accuracy. The values give an indication of the average level of bacteria inside the OR at different positions.

Ventilation system	Result cfu/m^3	
	Wound area	Instrument table
LAF system	0	4
TCAF system	0	< 1

Table 3 measurements cfu/m^3 "at operation"

5. CONCLUSION

All measurements show that an effective ventilation system will create a cleaner environment inside the OR. The effectiveness of every system is different and will influence the results of an operation. The amount of air and the distribution of air inside an OR gives different results. Increasing the amount of air has a positive impact on the results. However the distribution of air can have positive influences on the results as well. Measurements show that the LAF system and TACF system will create the cleanest environment inside the OR. Both systems are based on cleanroom technology.

To create a clean environment the distribution of HEPA filtered air in the whole OR gives better results. During all measurements the influences of pendula, medical equipment, door movements and clothing system were visible. During the measurements no research had been done on different clothing systems and different medical equipment.

Altogether, the result of an operation is based on several influences in the OR. The most important influences are behaviour, hygiene and discipline of the people inside the OR. People are the main source of contamination during operations. Next to these influences a good distribution of HEPA filtered air in the whole OR will create a clean and safe environment for the most complex and sensitive operations.

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