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Relevance and implications of positioning analysis for infection-preventive effectiveness of ventilation systems with low-turbulence displacement flow

Abstract: Ventilation technology in German operating rooms is regulated by DIN 1946-4. Since the release of the latest version in 2018, a positioning analysis (worst-case scenario with the largest space requirement) for determining the required protected area in class 1a operating rooms is mandatory. The aim of this investigation was to use typical workflow scenarios to assess existing installations regarding the match of the required and the built size of the protected area. Positioning analyses were carried out together with the on-site staff for various clinical procedures in 2 hospitals to assess the built versus required protected areas. In all cases, the positioning analysis revealed that required protected areas need to be significantly larger than provided by the existing setup. The size of the protected area that is actually required can only be determined by individual positioning analysis. Most existing installations of low turbulence displacement flow systems (TAV) are likely to be too small. The larger protected areas actually require significantly larger rooms in order to maintain proper thermodynamics. Furthermore, significantly higher volumetric flow rates are required. Finally, the current mismatch between actual and necessary protected area would be a possible explanation for the controversial data situation regarding the infection preventive effects of TAV systems.

Keywords: DIN 1946-4:2018, Positioning Analysis, TAV system, Protected Area, Surgical Site Infections

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1 Introduction

Ventilation technology in German operating rooms (OR) has been regulated for many decades by the requirements of DIN 1946-4. [1] In this standard basic specifications for the technical equipment and the necessary operating and performance parameters are defined and described. Since publication of the 04-2008 release a distinction has been made in Germany between room classes Ia, Ib and room class II. The following features apply to the ventilation of the different room classes (RK):

RK Ia: Aseptic operating room with particularly high demands regarding ultraclean air with the installation of a low-turbulence displacement flow ceiling field (TAV system) and the creation of a protected area, where patient, surgical team, sterile instruments / implants and other intraoperatively used medical devices have to be positioned.

RK Ib: Aseptic operating room with high demands regarding ultraclean air with turbulent mixing / dilution flow without creating a protected area usually achieved by installing conventional swirl diffusers or small TAV ceiling panels.

RK II: Rooms or zones that are mechanically ventilated and ventilated without any particular demands regarding ultraclean air. When ventilating and venting these rooms, the primary focus is on comfort criteria and the removal of any pollutants that may be present. With the 09-2018 release of DIN 1946-4 a significant change is now coming into effect for the first time, which will have a lasting impact on the planning process when converting and rebuilding operating rooms. In the course of determining the basics for planning a new OR, a positioning analysis (worst-case scenario with the largest space requirement) is mandatory to determine the required protected area. The aim of this investigation was to use typical workflow scenarios to assess existing installations regarding the match of the required and the built size of the protected area.

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2 Material and Methods

According to DIN 1946-4: 09-2018 positioning analysis is defined as a method for determining the required (horizontal) base area of the protected area, determined from the maximum set-up situations for all procedures planned in this operating room with positioning and placement of the operating table, size and number of operating fields, tables for sterile instruments / materials / (sample -) implants / transplants, medical devices (e.g. C-arm, hybrid OR components), sterile-dressed OR team, etc. Thus, positioning analyses were carried out together with the on-site staff for various clinical procedures (lower leg osteosynthesis, spinal interventions) in 2 hospitals to assess the built versus required protected areas. Therefore, the above described actual “worst-case” configuration applicable to the OR to be planned was determined. This was achieved in close communication between OR nursing staff, OR coordinator, hospital hygienist and hygiene engineer. After determining the worst-case configuration, all relevant components were physically placed in their process-typical position. Then temporarily marks of the resulting limits of the identified protected area were put via tape on the floor and then measured. When determining the dimensions of the protected area, surcharge of approx. 5-10%. Was added in order to take into account the physical constriction of the protection area under a TAV ceiling field. Furthermore, it was taken into account that the selected configuration could also change during the clinical procedure (i.e. side change of the surgeon, insertion and extension of medical equipment, change of implant/instrument systems etc.). Any differences between the existing and actually required protected area were recorded via photo documentation and measured (Fig. 1 and Fig. 2). Then the impact on room size and ventilation system requirements was determined.

3 Results

The positioning analysis for the configuration of lower leg osteosynthesis results in a required protected area of 3.70 m x 4.00 m. If a surcharge of at least 5% is added to the physical constriction of the protected area under a TAV ceiling field, the required protected area is 3.90 m x 4.20 m. This corresponds to a total area of approximately 16.5 m². and total volume flow of approx. 15,000 m³/h. The positioning analysis for the configuration of a lumbar spine procedure level L 3-5, prone position, results in a required protected area of 3.75 m x 3.85 m. If the required surcharge is added the required protected area is 3.95 m x 4.05m. This corresponds to a total area of approximately 15.9 m². The as built situation was only

a TAV ceiling field of 3.2 m by 3,2 m as suggested as exemplary size by DIN 1946-4:09-2018. If you subtract the surcharge of at least 5% the effective protected area only is 3.05 m x 3,05 m.



Figure 1: Setup for lower leg surgery. Blue line protected area as built, yellow-black hatched line protected area as required per positioning analysis



Figure 2: Setup for lower leg surgery. Blue line protected area as built, yellow-black hatched line protected area as required per positioning analysis

In all cases, the positioning analysis revealed that required protected areas need to be significantly larger than provided by the existing as built setup. Typically, an average of approximately 4.00 m x 4.00 m is required to ensure appropriate protected areas for most interventions.

4 Conclusion

In contrast to operating rooms, which are built with a TAV system according to the example size of 3.20 m x 3.20 m mentioned in DIN 1946-4: 09-2018 and a required volume flow of approx. 9.400 m³ / h, significantly higher

ventilation requirements for RK Ia operating rooms need to be met. This will certainly pose many problems for building owners and planners (duct diameters, larger air handling units, larger fans, noise emissions, etc.). Furthermore, energy consumption of these systems must also be considered. If the required air volume increases, this naturally goes hand in hand with higher energy costs. Based on our study required volumetric flow rates are approx. 15,800 m³ / h, equaling approx. 60% more volumetric flow. This entails higher investment cost, but also operating, maintenance and provision cost for the higher energy supply of such systems must be considered and viewed extremely critically from an ecological-economic perspective.

Therefore, it is obvious that the size of the protected area that is actually required can only be determined by individual positioning analysis before planning, designing and installing low turbulence displacement flow systems (TAV) systems. Most existing installations of TAV systems are likely to be too small. The larger protected areas actually require significantly larger rooms in order to maintain proper thermodynamics. Finally, the current mismatch between actual and necessary protected area

would be a possible explanation for the controversial data situation regarding the infection preventive effects of TAV systems. Since it is known that instruments, which are not or not permanently in the protected area during a surgical procedure are exposed to a relevant contamination by airborne bacteria which increases the risk of SSI. [2]

Author Statement

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References

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