REDUCTION OF PATIENT RADIATION DOSE, EXCELLENT IMAGE QUALITY AND GOOD AIR CLEANLINESS IN A HYBRID CARDIAC CATHETERIZATION LABORATORY: A PARADOX?

Ludo VEREECKEN[1*],MSc, Kim HAGSTRÖM[2], DSc, Frédéric VAN HEUVERSWYN[1], MD, Pascal DE WAEGEMAEKER[1], MSc, Pekka KANERVA[2], LicSc, Ismo GRÖNVALL[2], BSc, Sander RAMIOUL[3], BSc

[1]Ghent University Hospital, Ghent, Belgium, [2]Halton Oy, Helsinki, Finland ([3]Leuven, Belgium)

INTRODUCTION

Historically there was a clear separation between cardiac surgery and interventional cardiology. For surgical procedures one needs a full operation theatre and for interventional procedures an excellent X-ray imaging system at low radiation dose is necessary. Nowadays borders are fading and more and more hybrid procedures are being performed. For that purpose a single room is needed combining optimal image quality, reduction of patient radiation dose and ultra clean air.
The practical standard for ultra clean air in the operation theatre has been the laminar flow principle. This technology works as designed only when there is no or very low disturbance of the air streamlines, which is not the case in most interventions [1,2].

Typical set-up for a complex cardiac procedure

MATERIALS & METHODS

In this work a new technology (Halton Vita OR Space solution, Halton, Helsinki, Finland)[3,4] is presented. A smart controlled-dilution flow provides the ultraclean conditions into the whole operating room. For this purpose the complete deployment for a TAVI (Transcatheter Aortic Valve Implantation) procedure including personnel, devices and a state-of-the-art new monoplane imaging system was modelled in the new room. For this complex procedure, where a cardiologist, a cardiovascular surgeon, an anesthesiologist , an anesthesiology nurse , an instrumentation nurse and a circulating nurse work together, a set of 3D-CFD – simulations (three-dimensional Computational Fluid Dynamics) were executed. A steady state analysis with shear stress transport model (Ansys Inc., Canonsburg, PA, USA) was used.

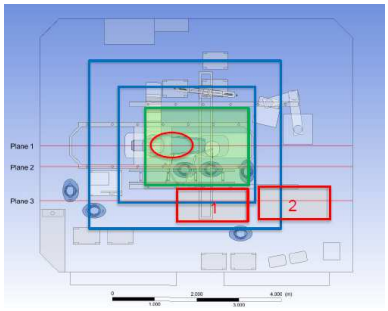
Air cleanliness at rest and in operation conditions

- Two basic requirements
  - No infection due to pollution during the intervention
  - No infection due to cross contamination
- At Rest conditions*
  - General room cleanliness level ISO 5 (EN ISO 14644)
  - Recovery Time (100:1) < 10 minutes
- In Operation conditions*
  - < 10 CFU /m³ (CFU, colony forming unit – active sampling)

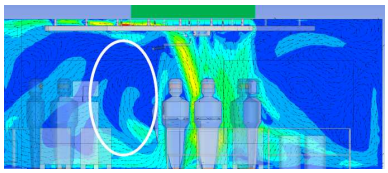
* CEN TC156 WG18, Hospital Ventilation Working Draft

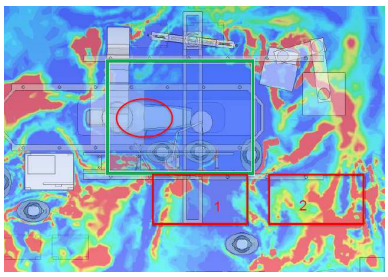
RESULTS

A comparison between a classical laminar flow field (green rectangle) and a ring of nozzles was made. Three critical zones (wound area) and instrumentation table 1 and 2 were studied.

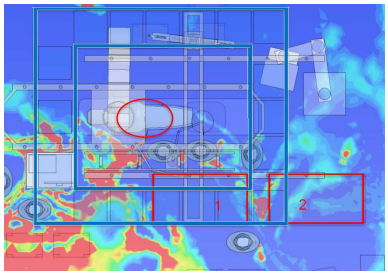


The C-arm is blocking the laminar airflow causing air to stagnate and even turbulence underneath the obstacle. Contaminations are not pushed away, so there is no cleaning effect of the LAF. Moreover critical areas outside the central area are not protected.



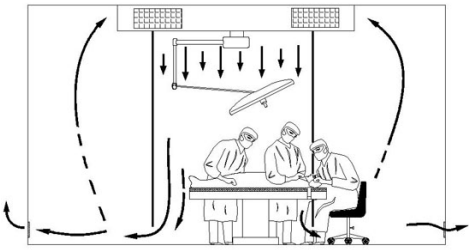


In the presented solution all critical areas are covered and pass the air cleanliness tests.

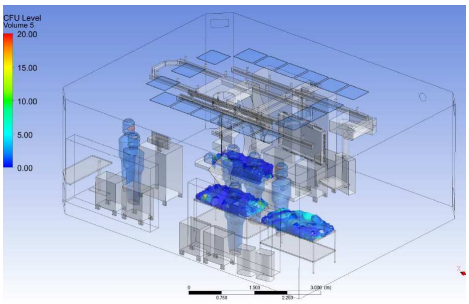


CONCLUSIONS

All challenges of patient safety must be examined when designing and building a state-of-the art operating room.
One should rethink the applicability of LAF in a hybrid catheterization lab (or modern OR) with large obstacles and need for clean conditions in different areas of the room.



If Charnley's principle is not fulfilled, CFD calculation is necessary.
The Halton Vita OR Space solution gives good air quality even in complex OR (ceiling-mounted devices, multiple critical zones).



This paper presents the results of a comprehensive simulation of the solution in operation conditions. The simulation confirmed that even for very complex procedures, the studied solution is capable of producing ultra clean (<10 CFU/m³) conditions according to CEN TC156 WG18 standard draft EN 16244-2. Moreover this has been accomplished at a maximum 40 dBA ventilation system sound level.

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UZ GENT

UNIVERSITEIT GENT

CONTACT

T+32 (0)9 332 53 30
M+32(0)476 02 69 52
ludo.vereecken@uzgent.be
www.uzgent.be

linkedin.com/in/ludo vereecken