AORN | GLOBAL SURGICAL CONFERENCE & EXPO

Visualizing Airborne Contamination in the Operating Room

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ADVOCACY Take a Stand

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Faculty Disclosure

Peter Graves	Speakers Bureau Avidicare, Aerobiotix, Ansell Healthcare & Zurex Pharma
Kathy Warye	Consultant to Avidicare AB, Nanosonics, Zurex Pharma, HealthySole, Cepheid Speakers Bureau

Learning Outcomes

- Describe the contribution of airborne contamination to SSI.
- Review risk factors and guidance relevant to limiting airborne contamination.
- Compare the three primary ventilation concepts in terms of impact on airborne contamination.
- Discuss how visualization of airborne contamination can enhance training and compliance with guidance aimed at reducing the risk of airborne contamination.

SSI: Why we should strive for zero

Prosthetic Joint Infection (PJI): On the Rise

- 2.18% of hip and knee arthroplasties become infected.[1] This is an underestimate.
- In one study, cost ranged for a single case of PJI, from $389,307 to $474,004 using a one-way sensitivity analysis.[2]
- Rates of infection are rising due to patient demographics and growing number of comorbidities.[3]
- PJI mortality rate - between 2–7%.[4]
- 5-year survival rate is worse than with many cancers.[5]

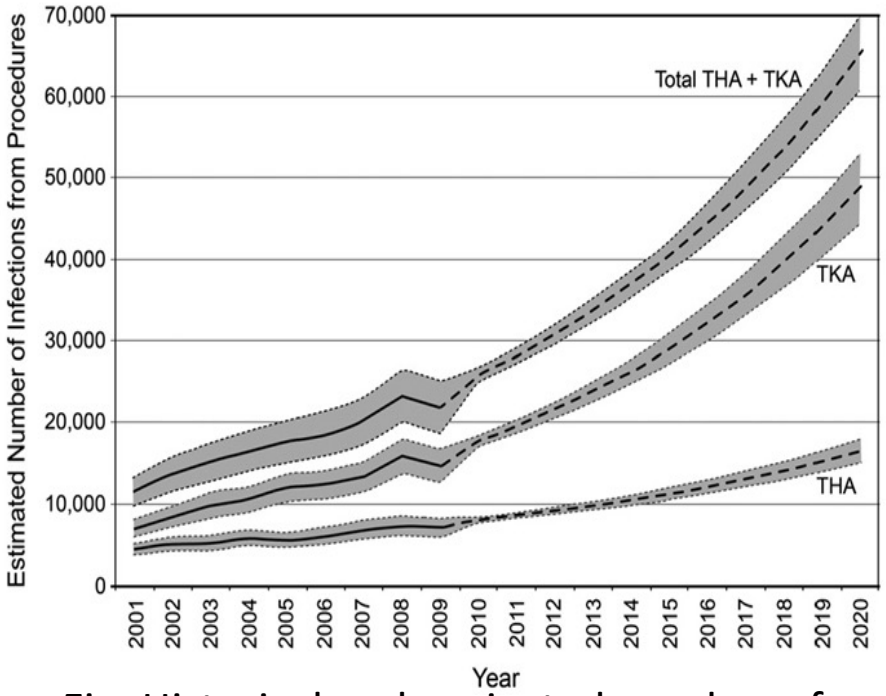
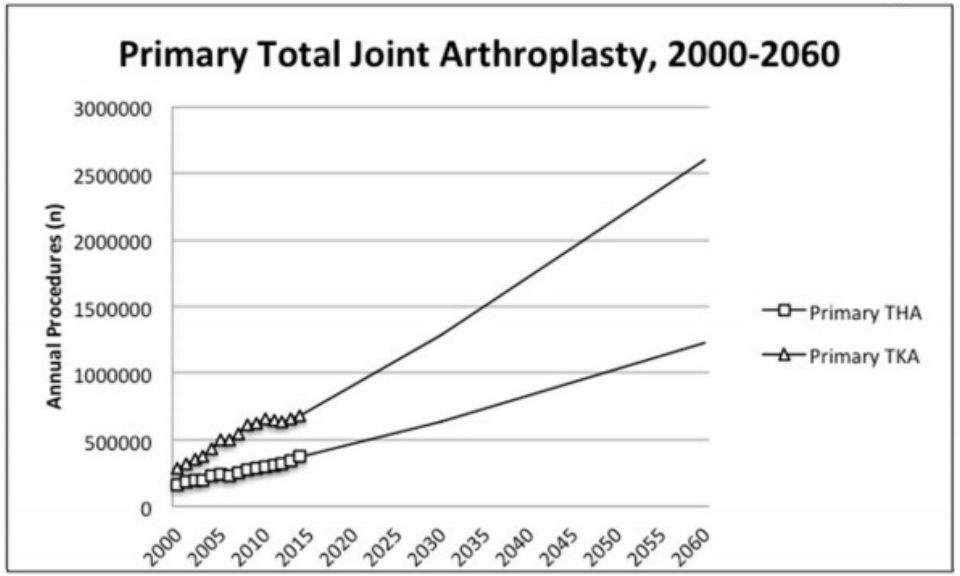


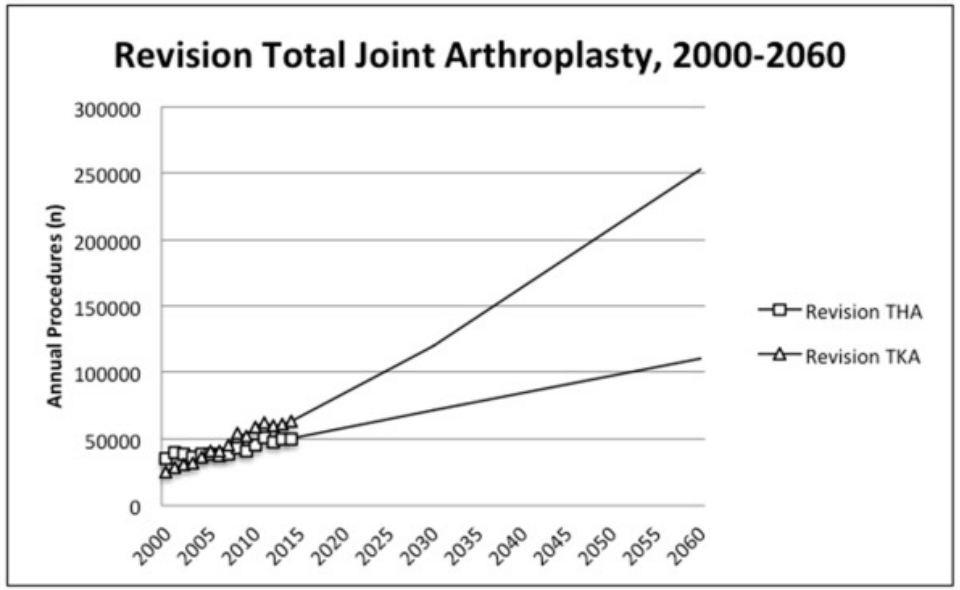
Fig: Historical and projected number of infected THA, TKA, and total (THA + TKA) procedures in the United States. [1]

Exponential growth in PJI projected

Over the next several decades, exponential growth is predicted for total hip and knee arthroplasty (THA/TKA). By 2030:[6]

- Primary THA: 635,000 (171% increase)
- Primary TKA: 1.28M (189% increase)
- Revision THA: 72,000 (142% increase)
- Revision TKA: 120,000 (190% increase)



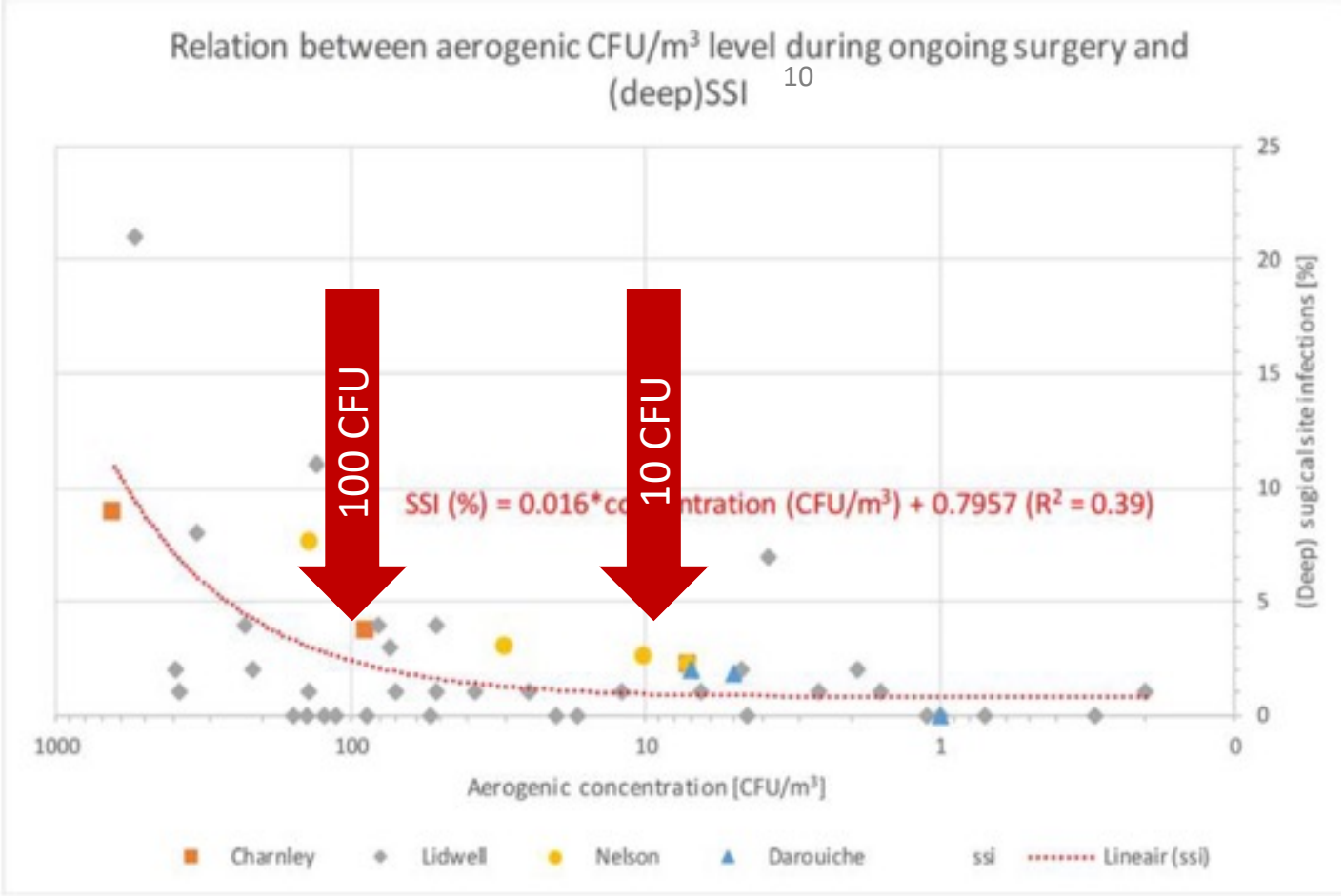


Airborne contamination risk

Correlation of airborne bioburden and SSI

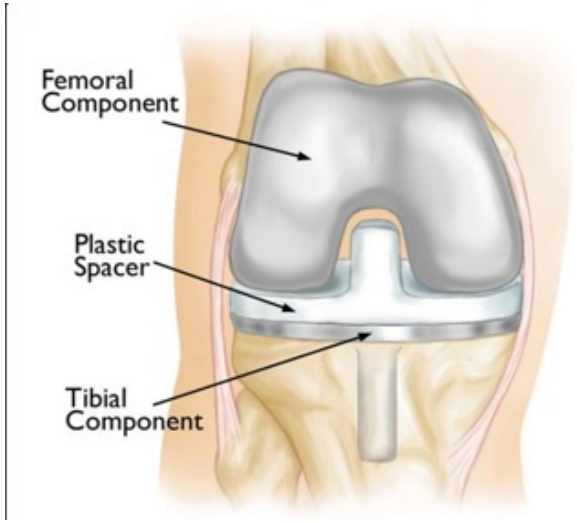
The major exogenous source of SSI is transmission by air.

- Large, multi-center study - majority of bacteria in the surgical wound likely reached it by the airborne route.[7]
- 98% of bacteria in wounds, in the conventionally ventilated room, came directly or indirectly from the air.[8]
- Airborne transmission accounts for 20%–24% of post operative wound infections.[9]



SSI risk factors with an airborne component

- Number of personnel in the OR
  - Humans disperse over 10M skin squames per day
  - Over 1M contain bacteria
- Movement of personnel and equipment
- Door openings and closings
- Length of procedure
- Type of procedure
- Presence of an implant
- Exposure of sterile implants, instruments and devices



Orthopedic Implant Infection: Consequences

- Hip or Knee aspiration
- If positive for infection – irrigation and debridement
- Removal of hardware may be necessary
- Insertion of antibiotic spacers
- Revisions at future date
- Long term IV antibiotics in community or rehab
- Future worry about the joint
- *In other words* –
- DEVASTATING FOR THE PATIENT AND SURGEON

Surgical Guidance: People, traffic and door openings

- Numerous studies have been conducted correlating door openings, number and movement of staff and equipment to significantly elevated particle counts.[11-14]

- AORN and CDC recommend limiting the number of personnel in the room, movement and opening of doors.

What the evidence tells us

- Efforts to limit the number of personnel and movements of the team have been of limited success. [15]

- A study of door openings/closings during joint surgery found: [16]
  - Even with a sign on the door discouraging entry, average of 40 door openings occurred each hour.
  - Each time a door opened it took 20 seconds to fully close.
  - In a large percentage of cases doors were open as much as 15-20 minutes of every hour.

Why it Matters

- **Factors that Influence Bacterial Counts:**
- Type of surgery
- Site of procedure
- Number of staff
- Frequency of OR door opening
- Surgical stage
- ** The stage of surgical procedure had the highest correlation with the number of bacteria.

Number of Staff	Mean Bacterial Count (cfu/m³)
Mean of 6.2	
2	43.0 ± 46.3
3	57.6 ± 31.4
4	78.1 ± 41.1
5	75.0 ± 41.2
6	73.2 ± 43.7
7	76.4 ± 47.1
8	101.7 ± 52.9
9	109.7 ± 55.5
10 or more	95–129

# Door opening	Mean Bacterial Count (cfu/m³)
<5	73.6 ± 46.8
6-10	80.7 ± 45.1
>10	87.1 ± 49.4

- Fu Shaw, L., et al., *Factors influencing microbial colonies in the air of operating rooms.* BMC infectious diseases, 2018. 18(1): p. 4-8.
- Parvizi, J., et al., *Environment of care: Is it time to reassess microbial contamination of the operating room air as a risk factor for surgical site infection in total joint arthroplasty?* American Journal of Infection Control, 2017. **45**(11): p. 1267-1272.
- Teter, J., et al., *Assessment of operating room airflow using air particle counts and direct observation of door openings.* American Journal of Infection Control, 2017. **45**(5): p. 477-482.

Airborne Contaminates

- Aerosol Generating Procedures
  - COVID-19
- Surgical smoke (plume)
  - Smoke evacuation systems
  - PPE
  - Air filtration systems

OSHA estimates that 500,000 workers are exposed to laser and electrosurgical smoke each year, including surgeons, nurses, anesthesiologists and surgical technologists.

Alp, et al. Surgical smoke and infection control, J of Hosp Infect. 2006

Polling Question #1

- Have you undertaken an initiative to reduce door openings/closings?

  1-Yes

  2-No

- If yes, how would you rate the long-term success of that effort?

  1 - Low
  2 - Moderate
  3 - High

Polling Question #2

- If yes, how would you rate the long-term success of that effort?

  1 - Low
  2 - Moderate
  3 - High

Time To Look Up

Focusing on patient and staff safety

- Capturing the aerosols at its source
- Continue to use smoke evacuation
- Continue to use air filtration systems
- Dramatically limit door opening
- Limit movement within the OR

Even with these efforts, we still have not been able to get to zero infections!

It is time that we look at our ventilation systems

- Is the technology of yester-year capable of meeting the needs of tomorrow?

Seeing is believing

Why pressure, direction and velocity are important to reducing airborne bioburden

- **Positive pressure**: To avoid flow of air and airborne pathogens from nonsterile adjacent areas into the OR. (Door openings defeat positive pressure).
- **Direction:** Consistent unidirectional flow to sweep air downward to exhaust vents.
- **Velocity**: Air must be driven at speed that ensures 1) unidirectionality, 2) high enough to overcome obstacles and heat convection from staff and 3) minimize turbulence.

These characteristics minimize the presence of pathogens in the surgical field.

Ventilation Concepts

KEYWORDS

- **CFU/m³** – Colony Forming Unit, measured in cubic meters of air
- **ACH** – air changes per hour
- **m/s** – meters per second (velocity)
- **CFD** – Computational Fluid Dynamics modeling - simulates velocity, pressure and temperature

THREE VENTILATION SYSTEMS

- **TMA** - Turbulent Mixed Air Flow
- **UDE/LAF** – Unidirectional/Laminar Air Flow (protected zone)

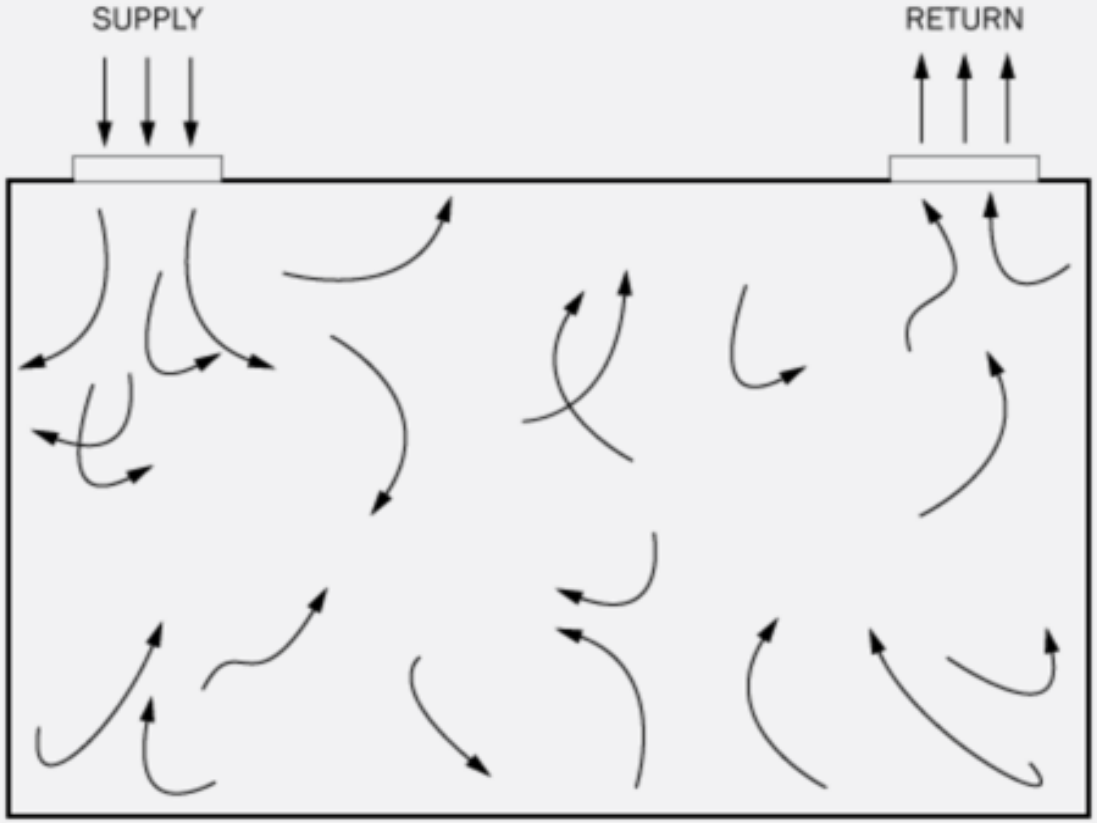
Dates to the 1960s

- **TcAF** – Temperature-controlled Air Flow (whole room protection)

Developed 2012, new to US Market

Conventional Ventilation: Turbulent Mixed Airflow

- Dilution principle: Filtered air streamed into space, provokes *turbulent* mixing of clean and contaminated air.
- Key parameter: Number of ACH
- Air moves in unpredictable manner as dictated by pressure and temperature differences. Air molecules, constantly colliding, creating contamination as particles are transported around the room before leaving via the return grille.[7]

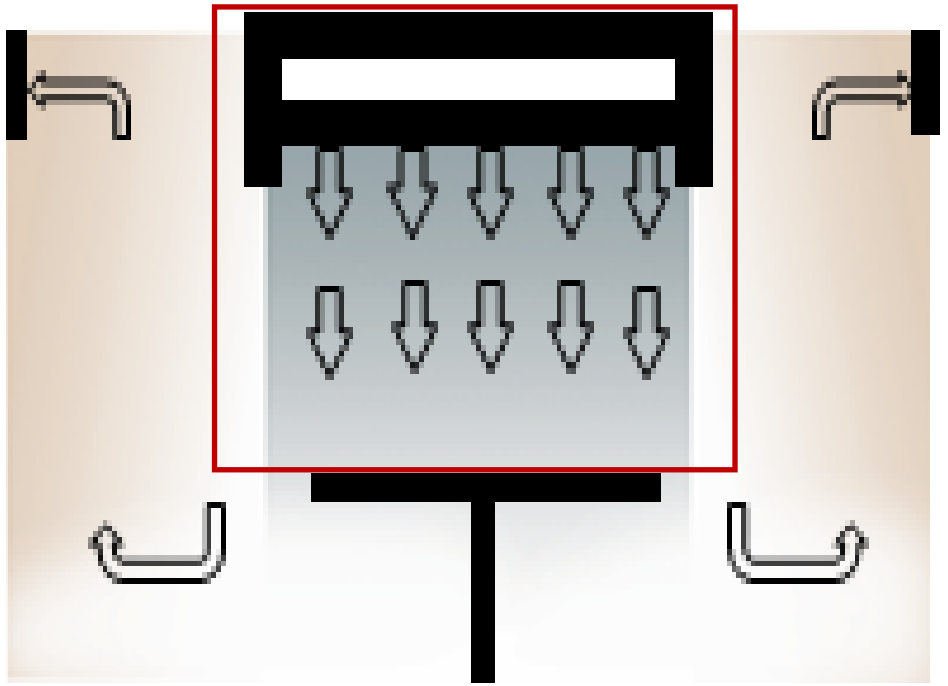


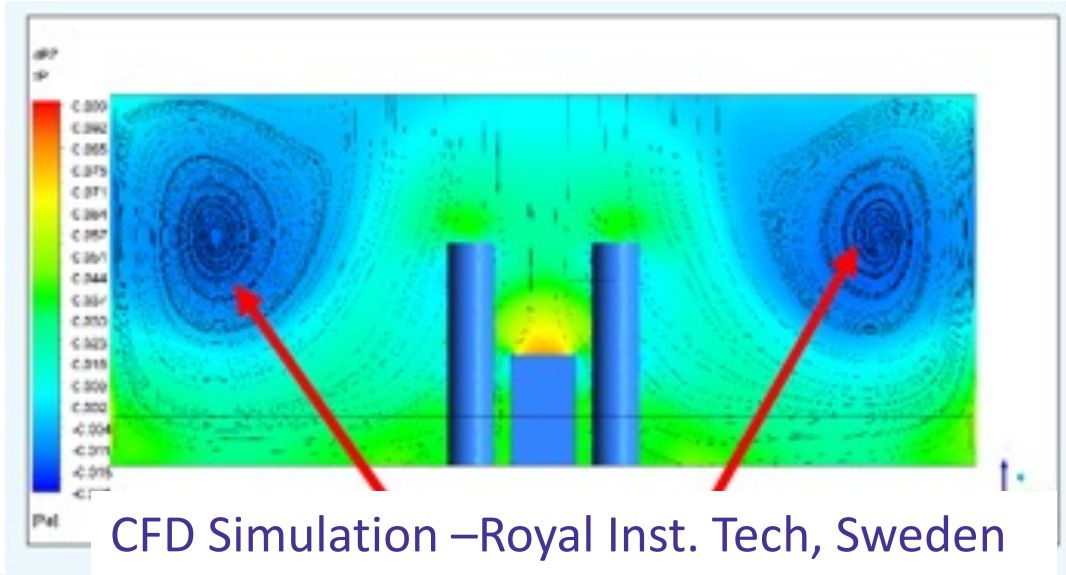
Turbulent Flow, ArchToolBox [17]

- Inefficient - scales linearly, to halve CFU-level, requires 2X airflow.

Unidirectional/Laminar Air Flow (LAF)

- Air should flow in a straight, unidirectional path with steady velocity and parallel streamlines.
- Creates a limited *clean zone* around surgical field.
- Unidirectional flow easily *disrupted by objects in pathway.*
- Challenged by *vortices in the periphery*.
- Comparative study of ventilation concepts: Mean values of airborne CFUs outside protected zone - *55-fold higher* than values inside.[18]

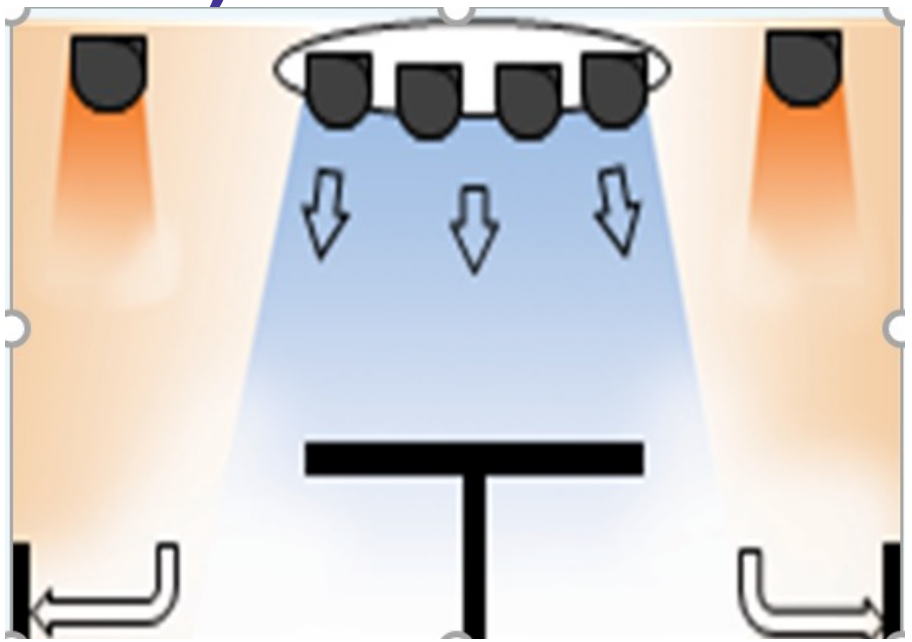


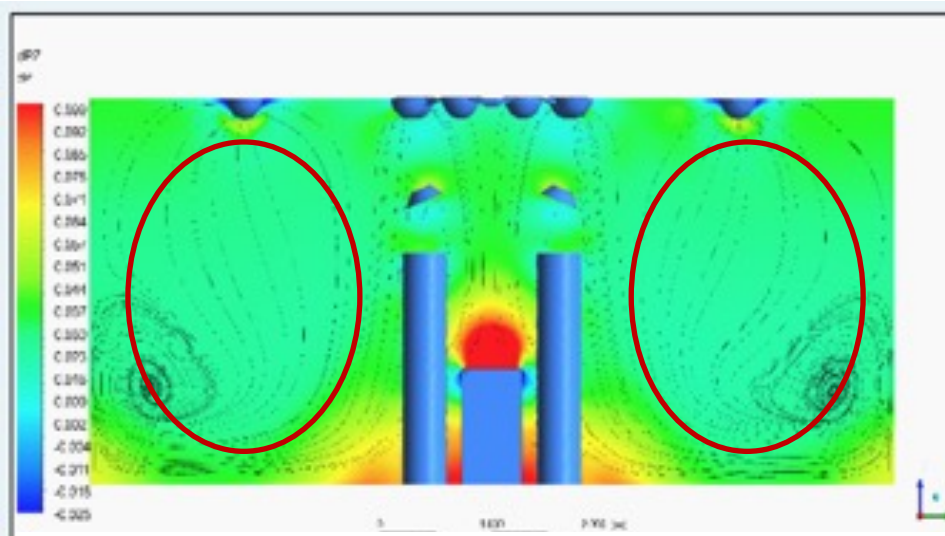


CFD Simulation –Royal Inst. Tech, Sweden

Temperature-controlled Air Flow (TcAF) [19,20]

- HEPA filtered air dispersed from air showers at 1.5°C cooler than ambient room temperature.
- Temperature differential creates a gravity-driven down-flow, consistent throughout the space.
- Fall speed of the air (>0.25 m/s), counteracts heat convention from staff and lamps, obstacles in pathway.
- Air supplied in the periphery prevents stagnation zones.
- Temperature /humidity: Set at any level to ensure patient safety, staff comfort.

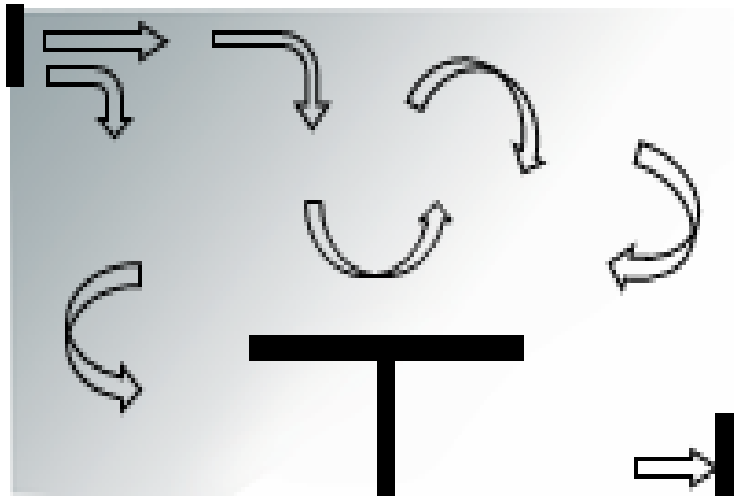




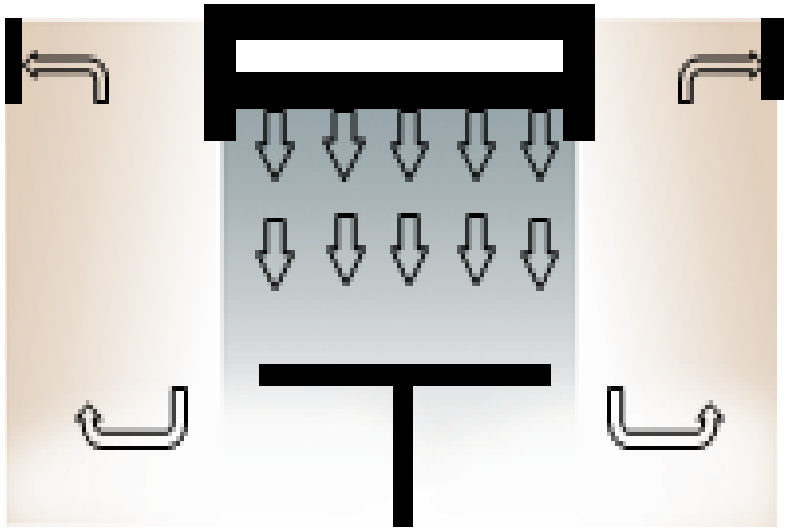
CFD Simulation –Royal Inst. Tech, Sweden

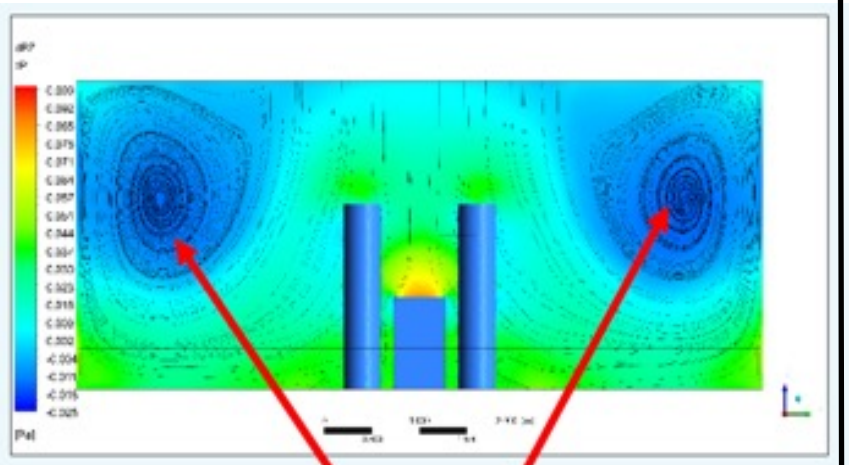
How Ventilation Concepts Compare

TMA

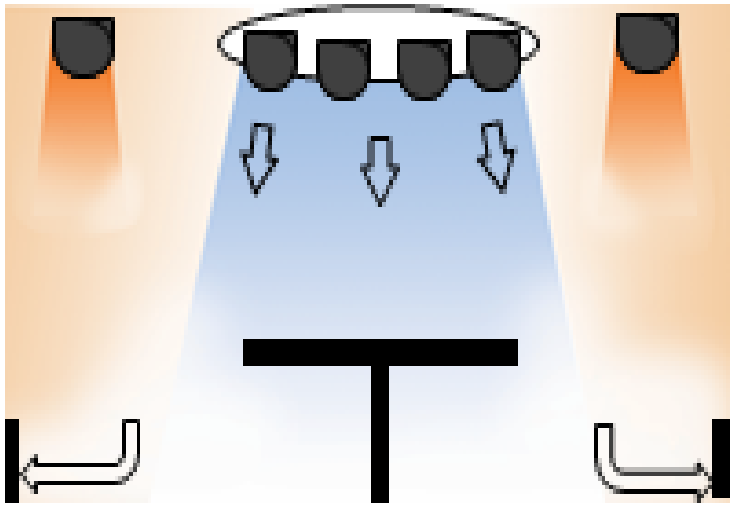


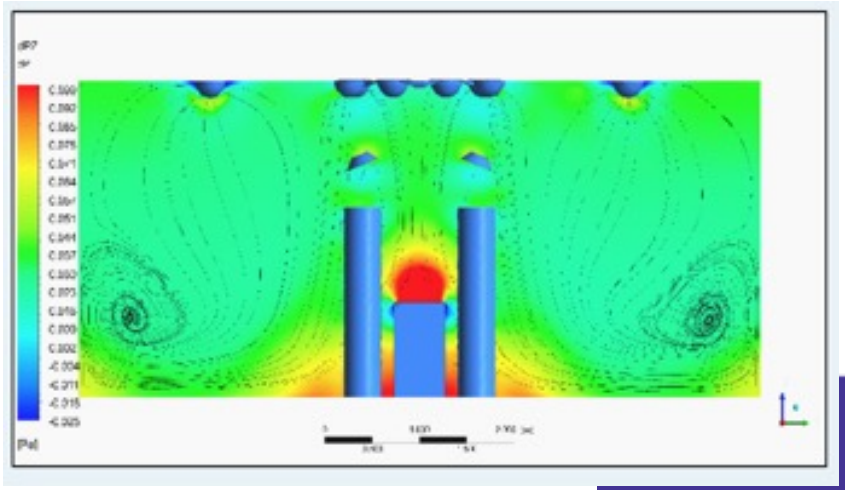
UDI/LAF Protected Zone





TcAF: Whole Room Protection



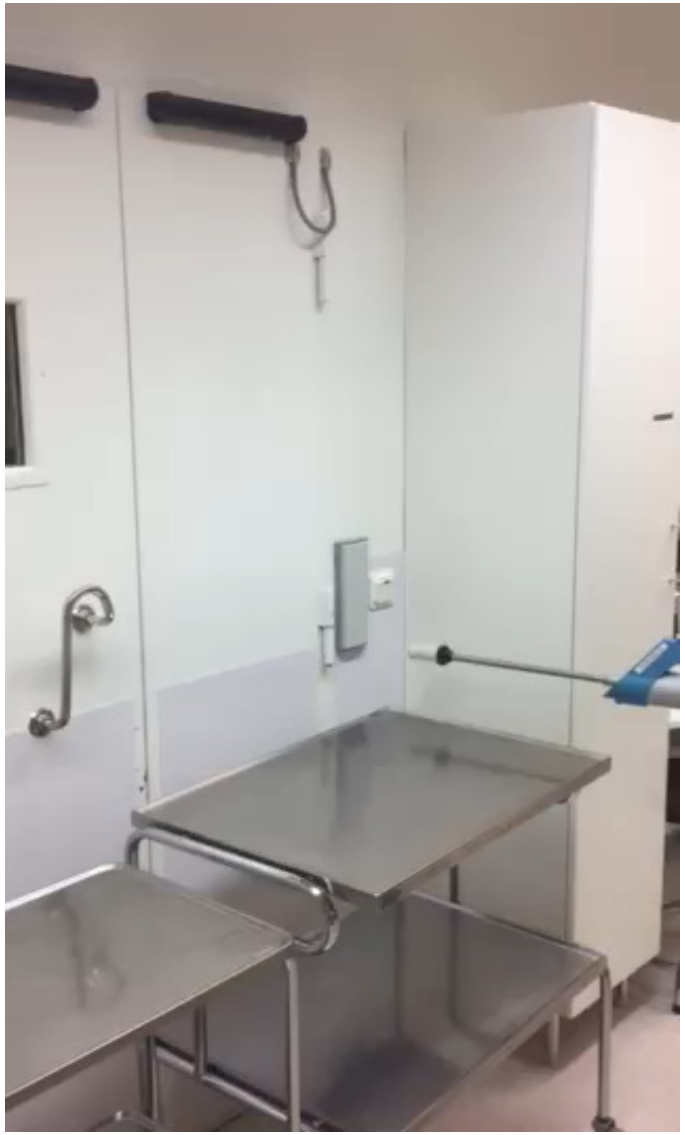


Polling Question #3

Which ventilation system do you have in your ORs?

1 - TMA
2 - UDI/LAF
3 - Both
4 - Don’t know

LAF: Challenged by obstacles, unable to protect periphery



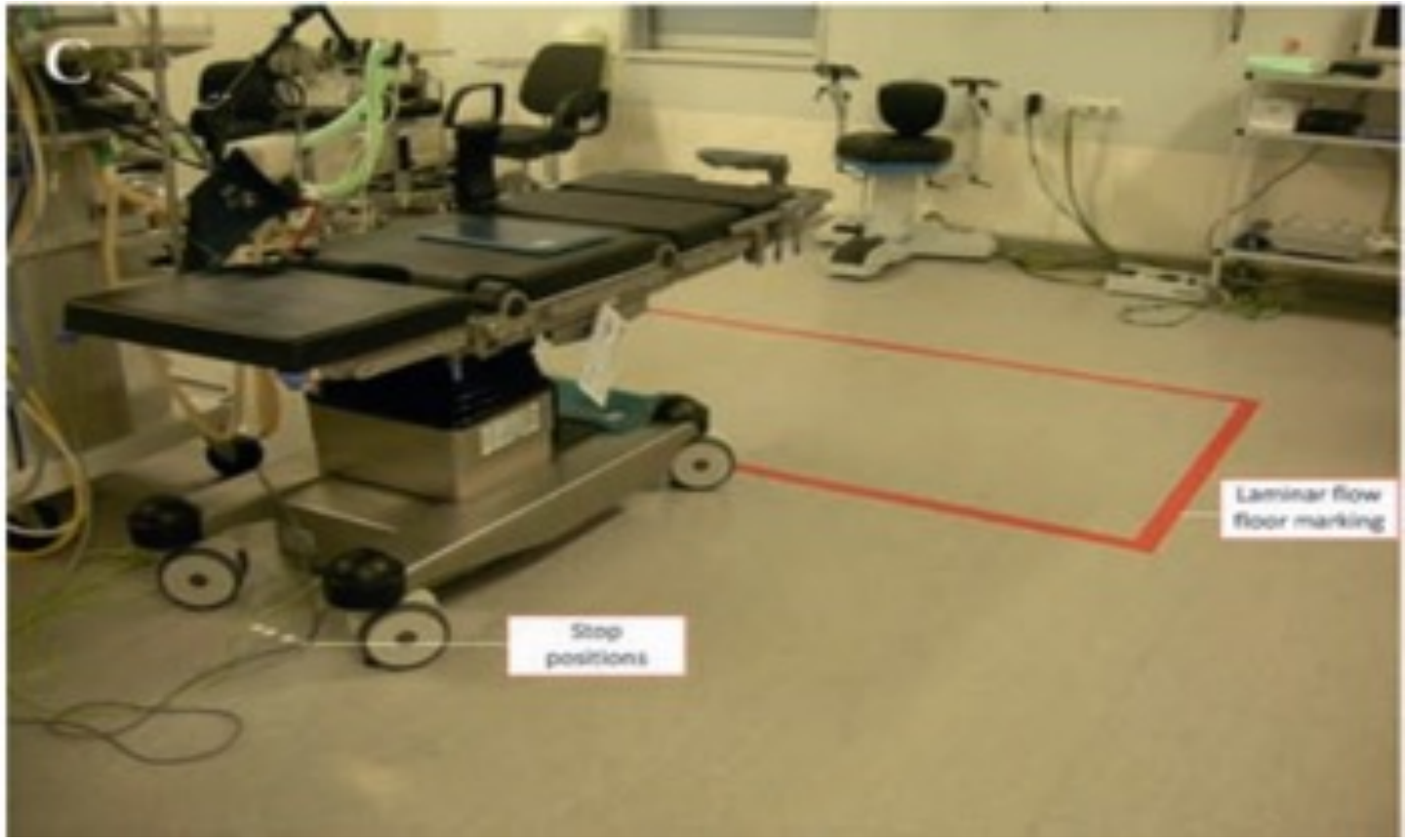
TcAF: Navigates obstacles, maintains downward airflow throughout the room, including the periphery

Turbulent Mixed Air Flow, uncontrolled circulation

Why the periphery is important

- *Effects of operating room floor marking on positioning of surgical devices* [21]

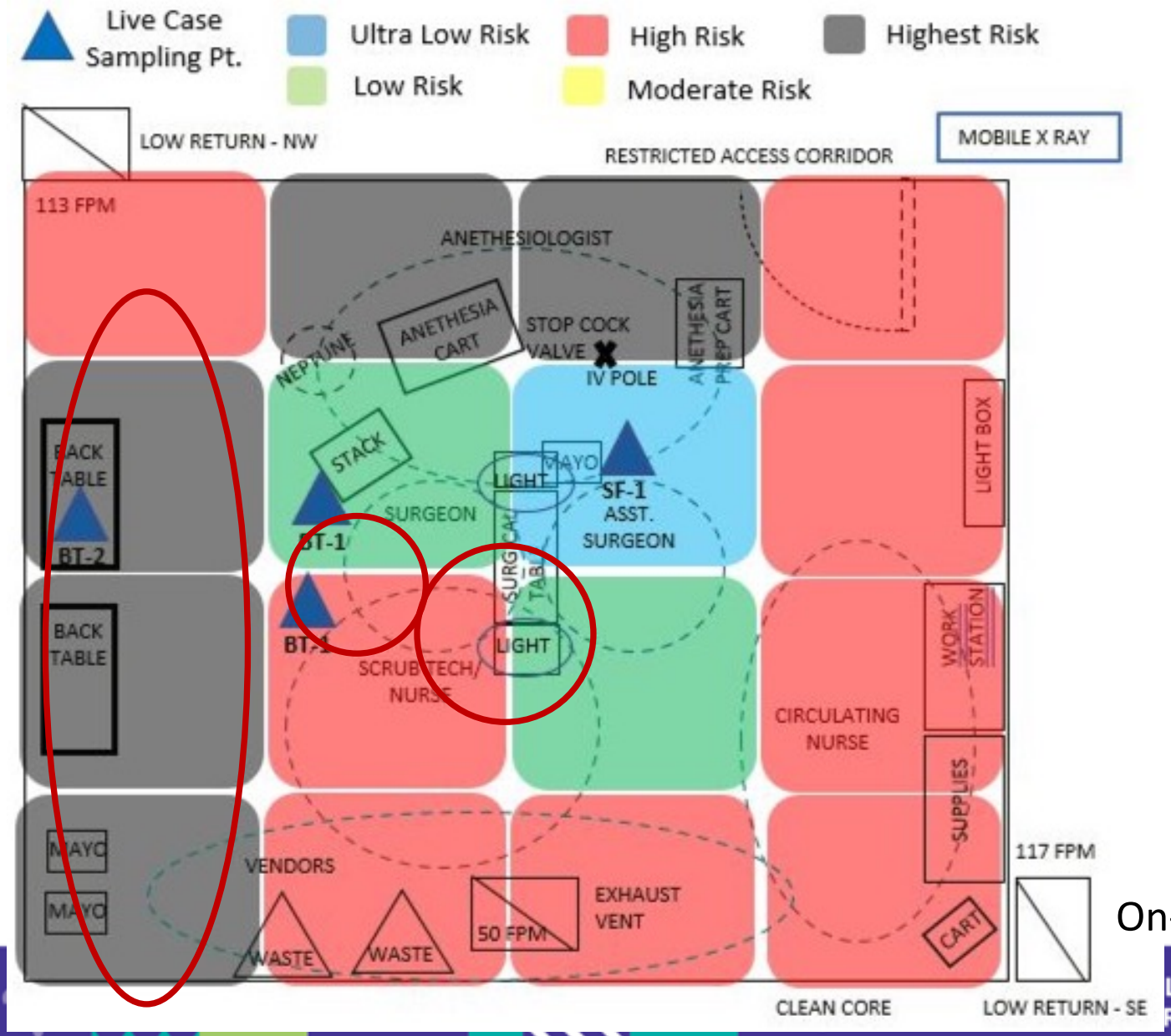
- Prior to marking: devices in clean zone in only 6.1% of surgeries
- After marking: devices in clean zone in 36-52% of surgeries
- Risk for implant infection



CFU heat map: Live case w/ conventional ventilation

Measurements taken in 3 locations:

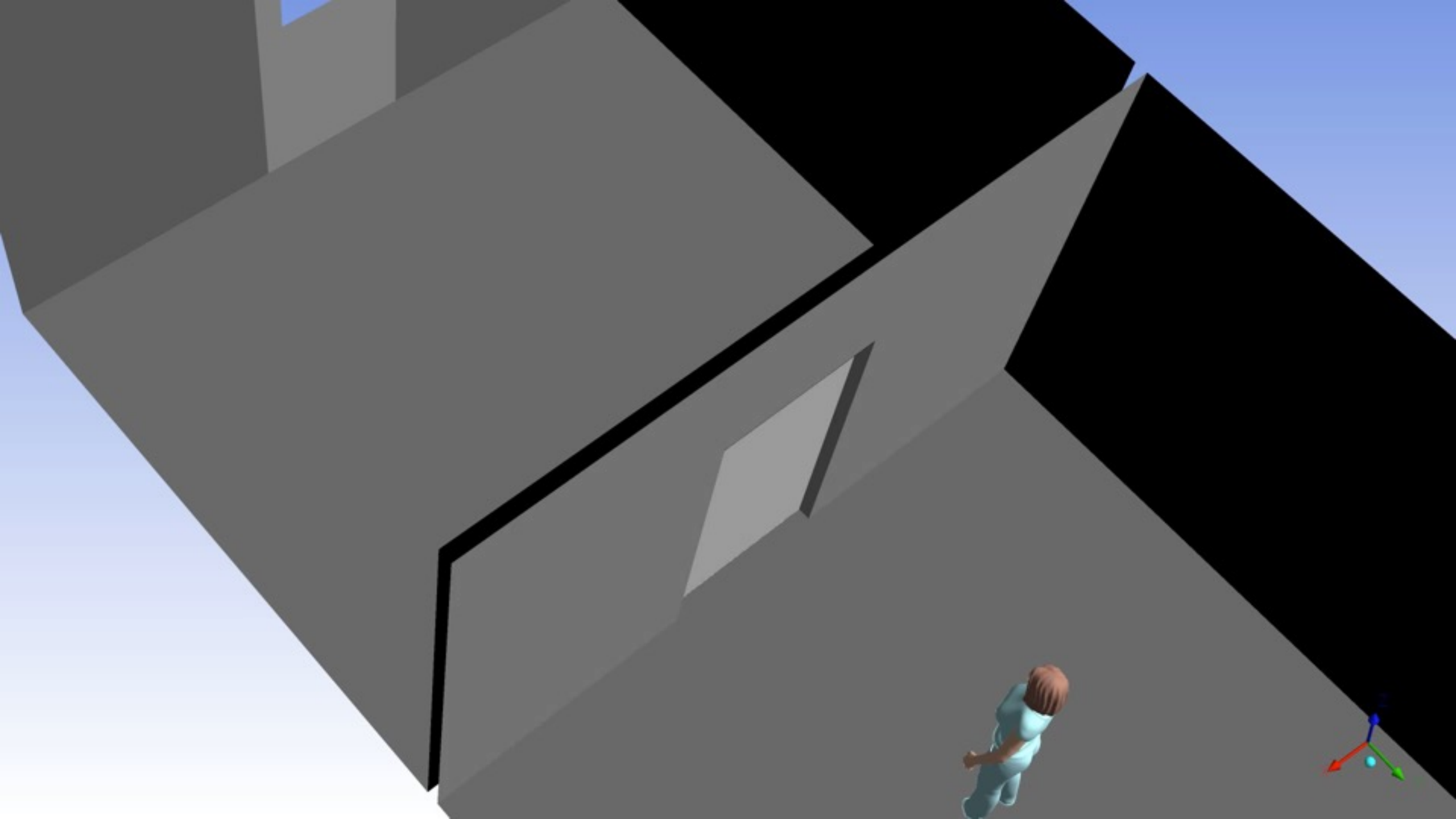
- Wound/surgical field
- Instrument tables
- Periphery (case carts/back tables)

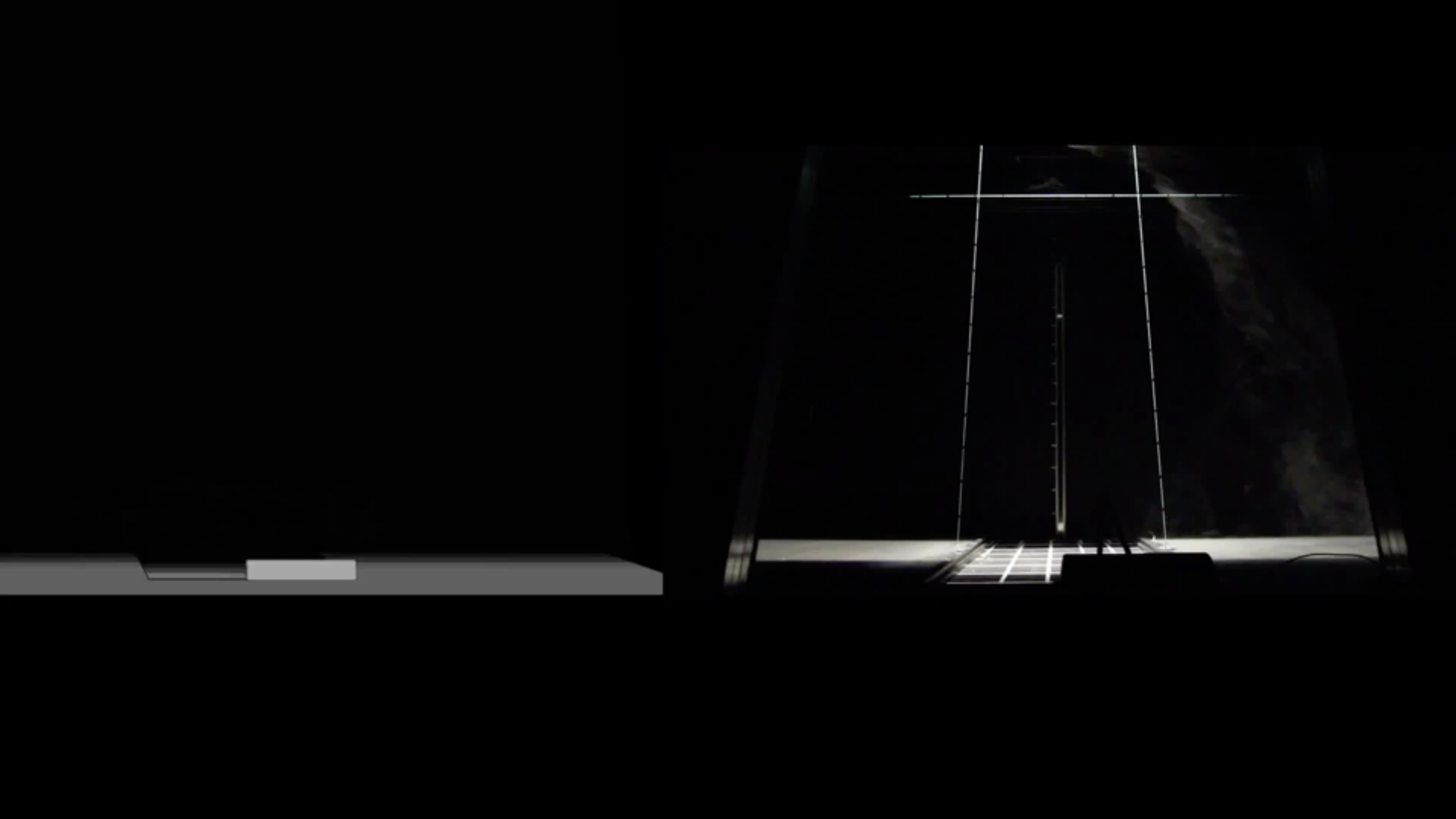


Polling Question #4

When was the last time you assessed airborne microbial contamination in your ORs?

1 - Last 12 months
2 - Last 5 years
3 - After an outbreak
4 - Never



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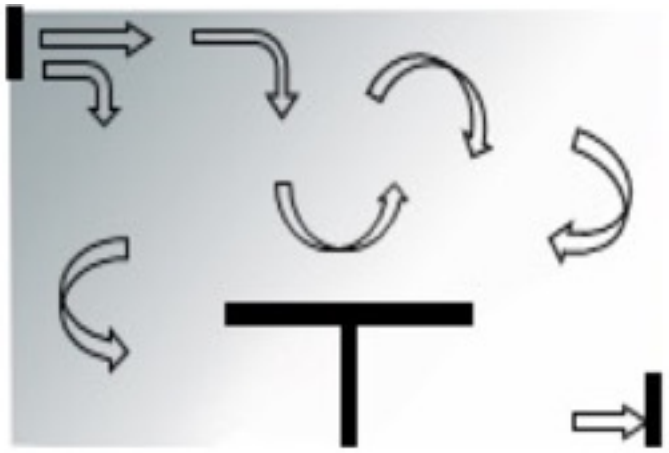
VISUALIZATION INTERACTION COLLABORATION

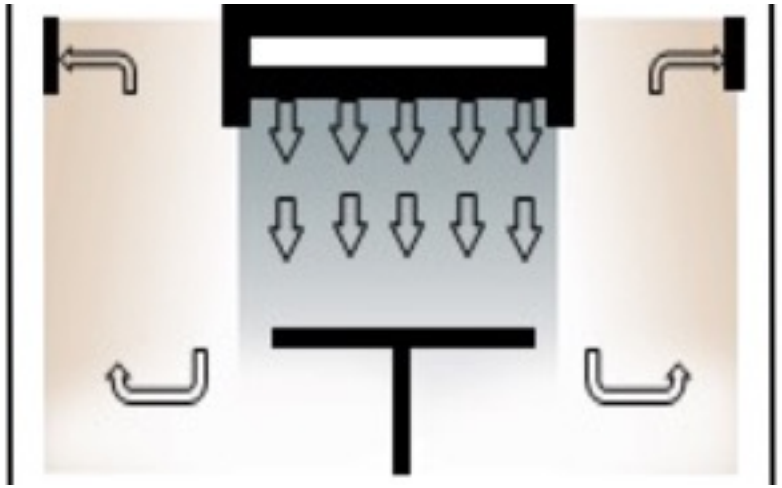
Visualization as a tool for training and behavior modification

Visualization as a tool for training and behavior modification

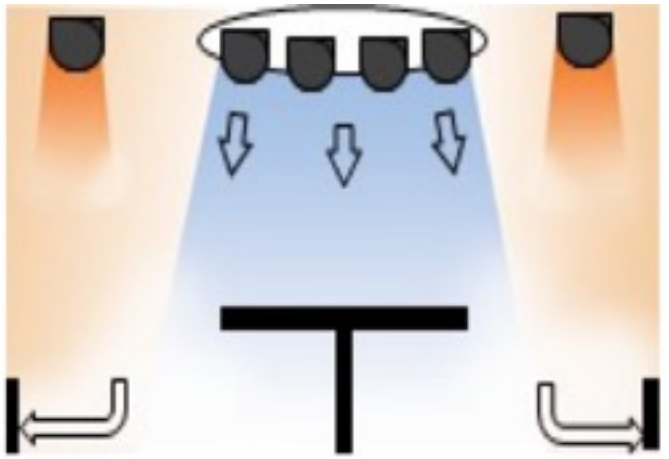
- Know your ventilation system and how it does/does not protect patients from microbial contamination
- Ensure exhaust vents are not obstructed by room equipment



Turbulent Mixed Airflow



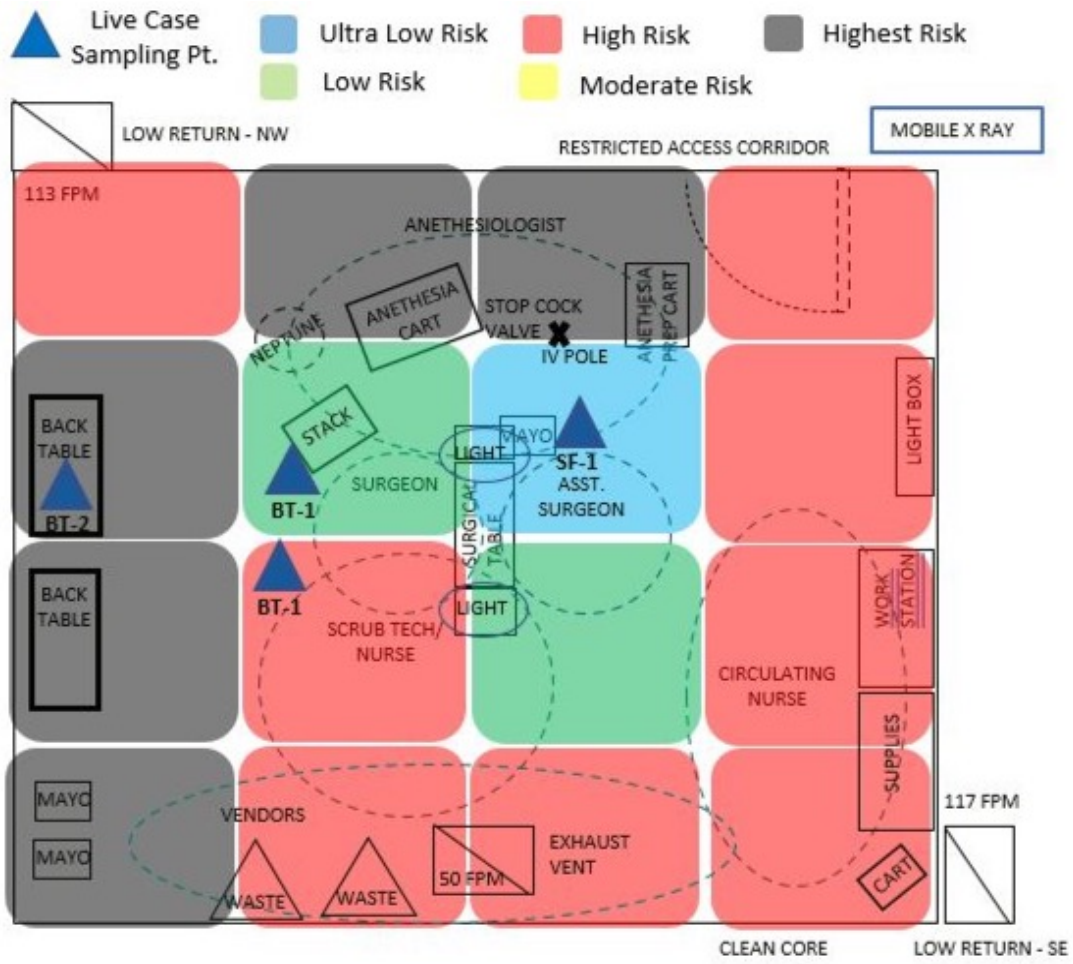
Laminar Airflow



Temperature-controlled Airflow

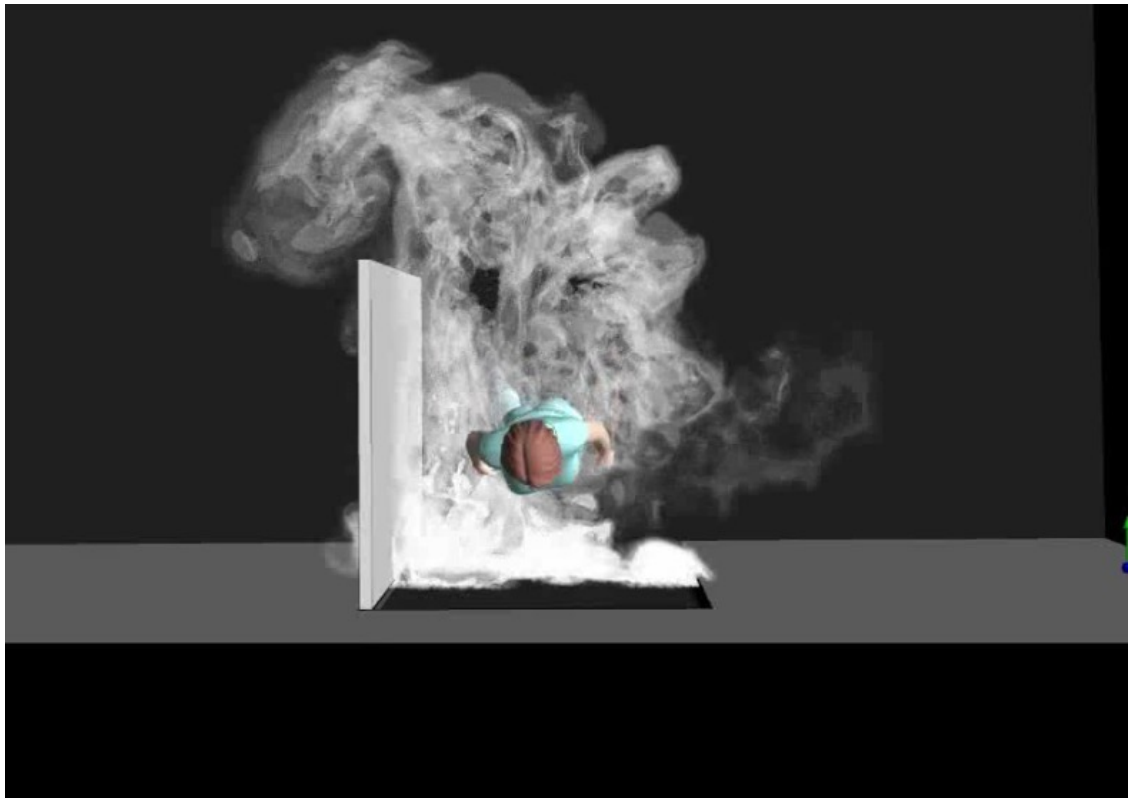
Visualization as a tool for training and behavior modification

- Measure airborne contamination in your OR (either air samplers or settle plates -- see USP 797 for methodology).
  - Map clean/hot spots
- Ensure that sterile items - instruments and implants – are positioned in clean zone
- Ensure system is properly calibrated
- Ensure preventative maintenance is being performed – check records



Visualization as a tool for training and behavior modification

- Reinforce impact of door openings via videos
  - Identify opportunities to prevent door openings
  - Stock sufficient supplies in the operating room
  - Schedule breaks/relief personnel
- Limit unnecessary personnel



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QUESTIONS

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Thank You!

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