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Laminar flow in orthopaedic operations - *Essential if you can afford it*

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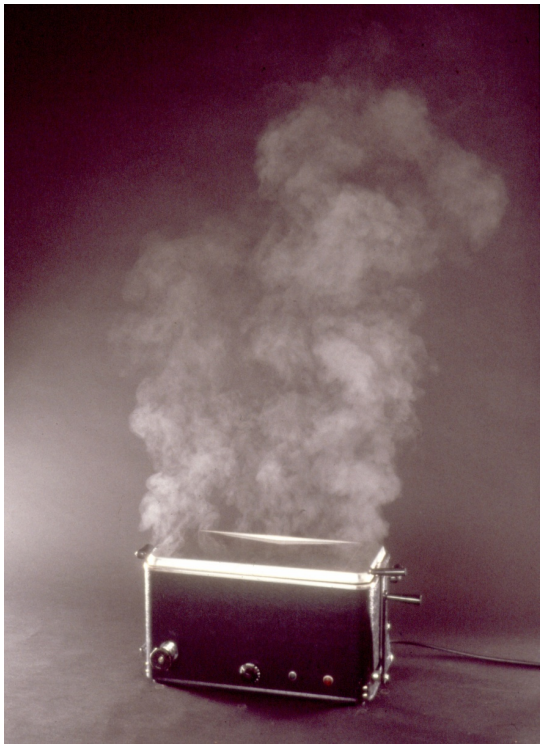
Up until the 1950s in the UK (and elsewhere)

Surgical instruments were usually “sterilised” in boiling waterbaths either in the OR or in a room next to it.

Powerful extract fans would remove the steam.

In doing so, they would create a negative pressure on the OR and air from nearby areas would flow in to replace it.

That air could be contaminated with whatever was colonising/infecting nearby patients



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Early OR ventilation work

Shooter RA *et al*. Postoperative wound infection. Surg Gynec Obstet 1956; 103: 257-62.

Contaminated air was being drawn into a theatre from adjacent areas. When this inward flow was reversed "*This was followed by an immediate reduction in the bacteria in the air and by a striking fall in the incidence of wound infections from 37 out of 427 clean operations to 5 out of 532*".

There are other, similar papers from that era.

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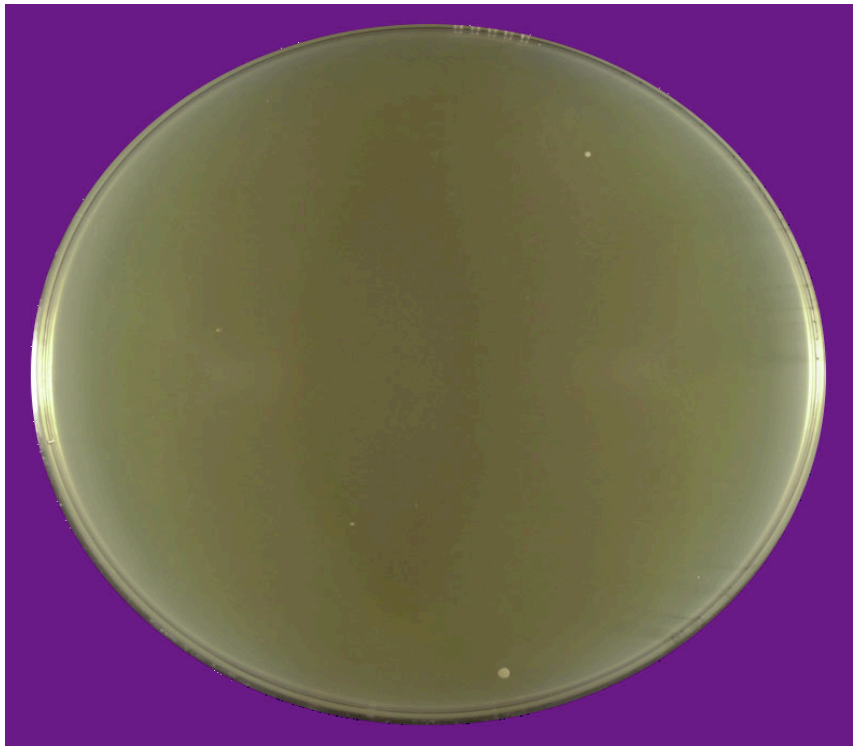
Other sources of airborne contamination



1,000 litres of air sampled in an empty room

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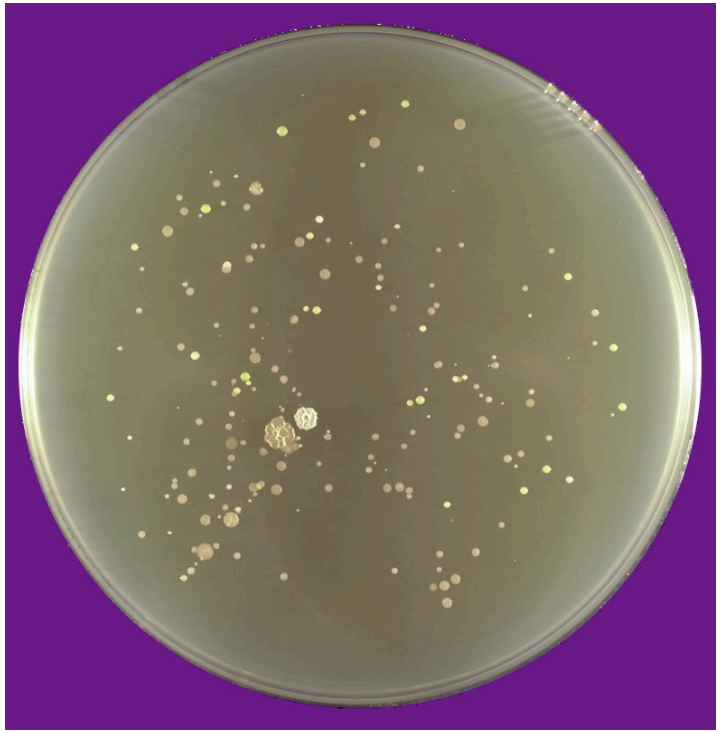
Other sources of airborne contamination



1,000 litres of air in the same room with someone walking by the sampler

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The function of conventional OR ventilation

Aerobiologically, the things that generate most airborne contamination in an operating theatre are the staff.

The most common unit of contamination (colony forming unit – “cfu”) is a microcolony on an airborne skin scale. That microcolony will contain between 1 and 1,000 bacteria. (*Microbial numbers are a critical factor in initiation of infection*).

A significant purpose of operating theatre ventilation is to prevent airborne bacteria from settling-out in "the wound".

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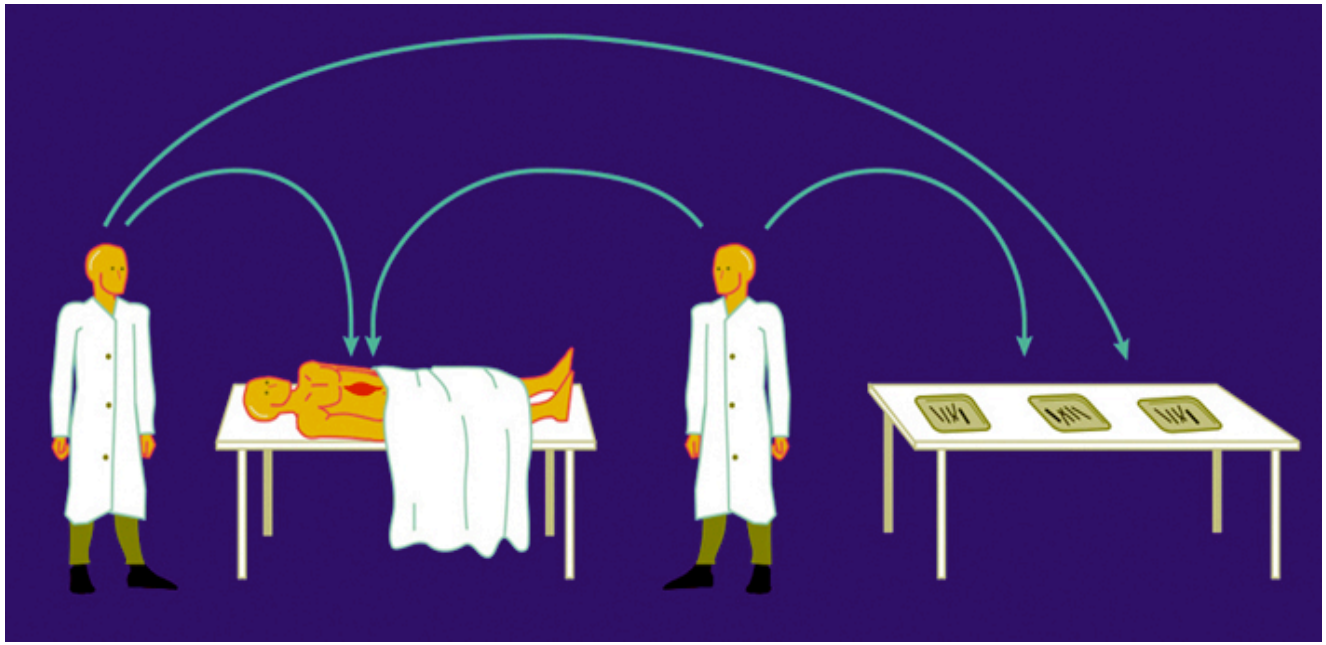
Pathways of airborne theatre wound contamination



Probably around 70% of airborne microbes that end-up in a surgical wound are transferred there via surgical instruments.

Keeping the instruments clean is at least as important as keeping the wound clean.

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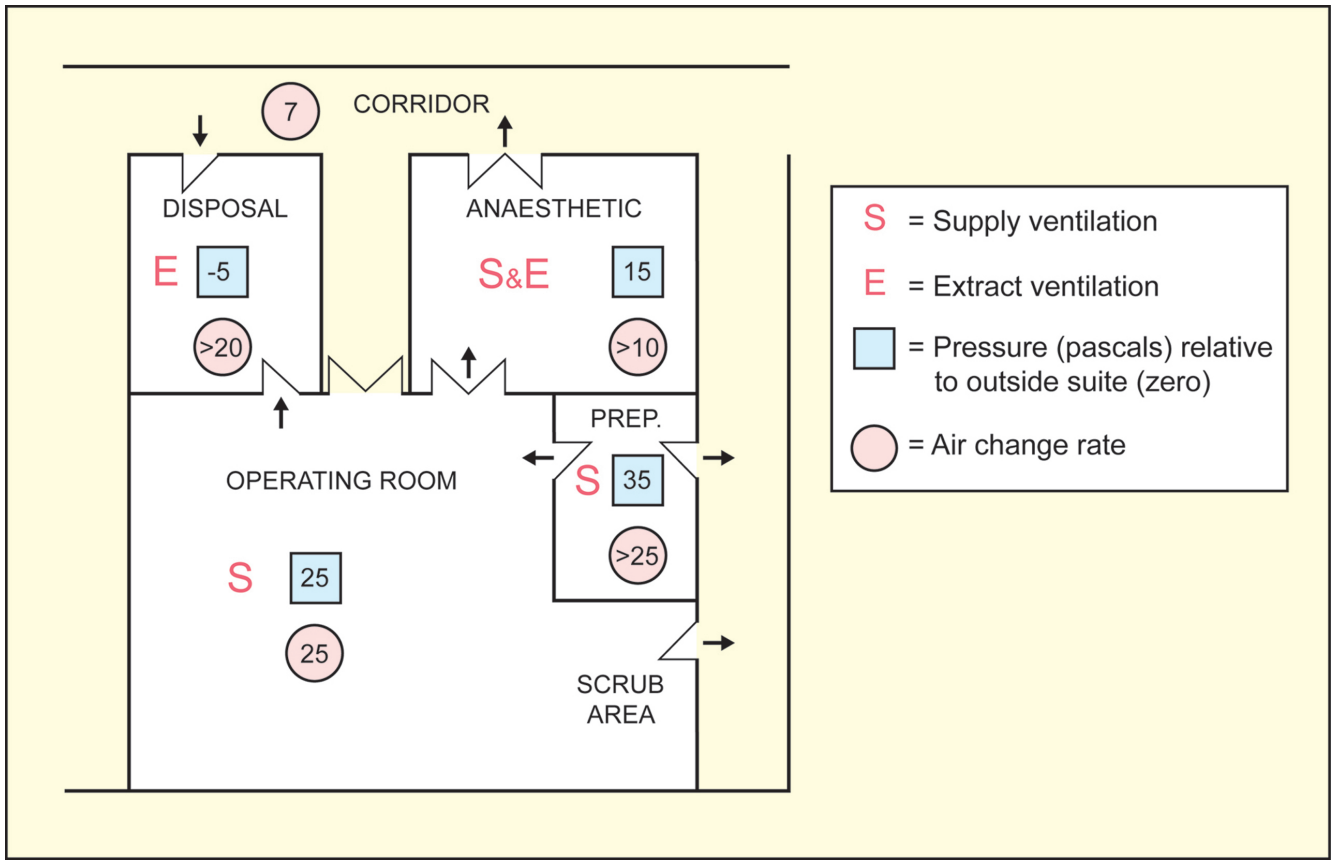
Conventional OR ventilation



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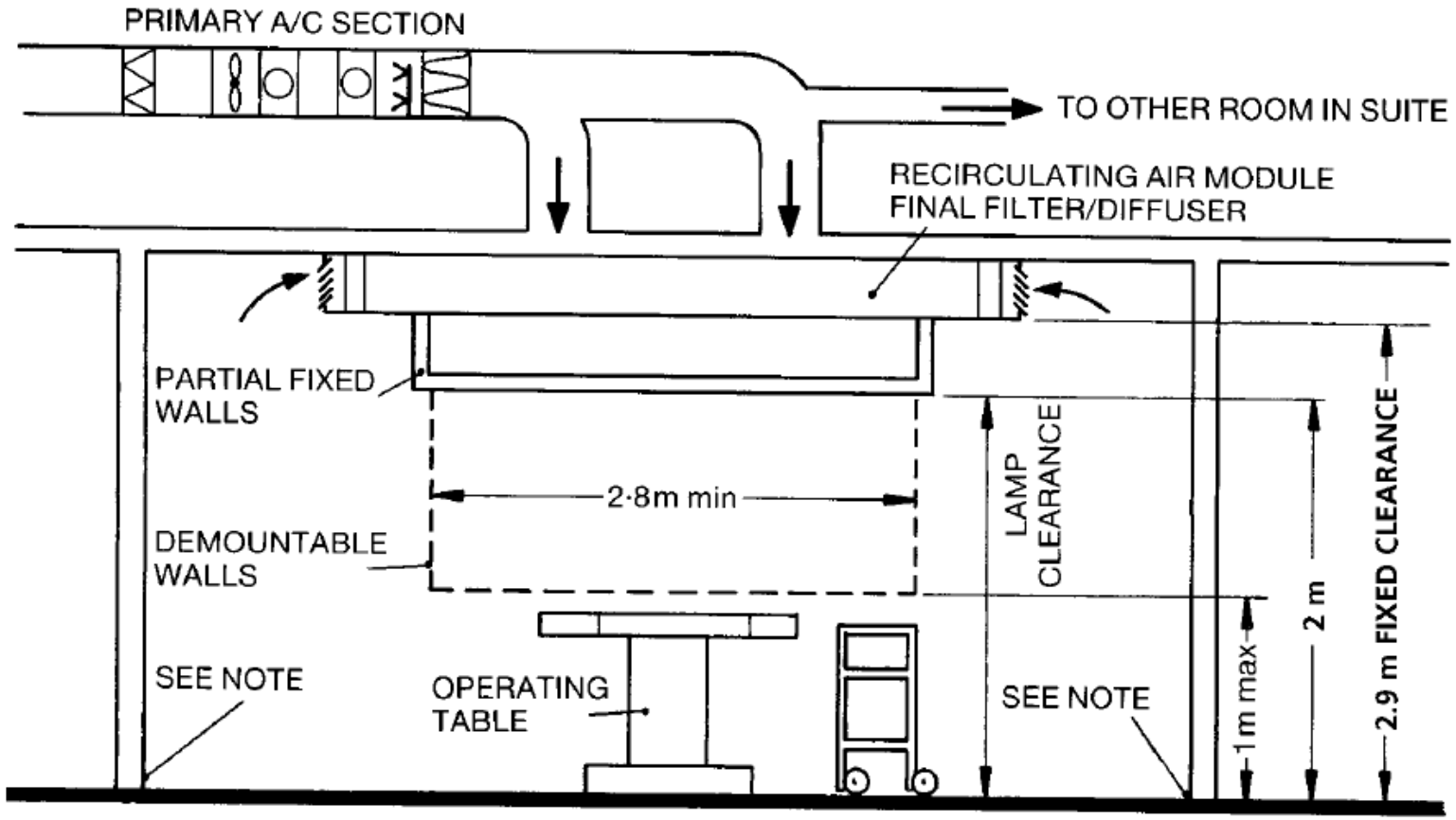
Laminar flow ventilation



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Conventional vs. laminar flow

Conventional ventilation

- prevents contamination from outside entering the OR
- dilutes contamination generated in the OR

Laminar flow ventilation

- prevents contamination from outside entering the OR
- Prevents contamination from the OR periphery entering the ultraclean area
- rapidly and efficiently removes contamination generated around the wound and exposed instruments

Microbiological standards for working ORs

- Conventional – less than 180 colony forming units per cubic metre of air
- Laminar flow – less than 10 colony forming units per cubic metre of air

(*and remember that a colony forming unit can be up to 1,000 bacteria in a microcolony*)

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Why is nothing simple?

- In the 1970s, work by Lidwell (UK), using specific studies in selected hospitals, showed a significantly **lower** infection rate of hip & knee replacements in laminar flow compared to conventional
- In the 2000s, work by Gastmeier (Germany) and Hooper (New Zealand), using national surveillance data, showed a significantly **higher** infection rate of hip & knee replacements in laminar flow compared to conventional

Question: Why does doing surgery in far cleaner air result in a higher infection rate?

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Possible explanations - 1

- **Theatre discipline**: If surgeons think that laminar flow ventilation does all the infection prevention work for them, is there less stringent attention to infection prevention?
  - This includes protecting instruments if exposed in a preparation room before being brought in to the OR.

- **"Space suits"**: It is common practice for surgeons in laminar flow ORs to use body enclosures. These are variable in design and function; some are designed for specific exhaust of air from the space suit, others are more for personal protection. Could it be that these are inadvertently directing contaminated air from the lower arm/wrist into the wound?

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Possible explanations - 2

Maintenance of patient body temperature ("normothermia"): There is an established link between perisurgical hypothermia and infection. The high level flow of air in a laminar flow canopy will reduce patient body temperature far more than the airflows at the same temperature in conventional ventilation. For me, this is the most likely explanation of the Gastmeier/Hooper observations.

- That Gastmeier also noted higher infection rates in appendectomy, cholecystectomy, colon surgery and herniorrhaphy in laminar flow compared to conventional ventilation also favours this explanation.
  - These are not procedures where air quality is highly critical (normally done in conventionally ventilated ORs) but where patient body temperature is probably far more important.
- It is possible to modify perioperative patient care and patient warming devices to maintain normothermia in laminar flow surgery

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Adaptability of laminar flow systems

Laminar flow systems have a conventional air supply passed through additional fans in the laminar flow canopy to produce the downward air velocity needed.

Laminar flow systems usually have two settings:

1. On full – this produces laminar flow ventilation
2. A reduced (“set back”) setting that produces a lower ventilation rate equivalent to conventional OR ventilation.

➢ *It is possible to use laminar flow theatres as either laminar flow or conventional ventilation*.

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The case for laminar flow

Operating rooms are expensive; laminar flow are more expensive than conventional.

The system that you install in 2015 will probably be the one that will still be with you in 2045.

There is currently uncertainty about whether laminar flow is better or worse than conventional ventilation.

- **If you install laminar flow, it can be used for either laminar flow or conventional ventilation.**
- **If you install conventional, it can only be used as conventional ventilation**.

The best way to make your system “future proof” (i.e. adaptable for developments in our future knowledge) is to install laminar flow ventilation for those procedures that may benefit from it (essentially orthopaedic large prosthetic surgery) if you can afford it.