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Operating theatre ventilation: *Keeping instruments sterile*

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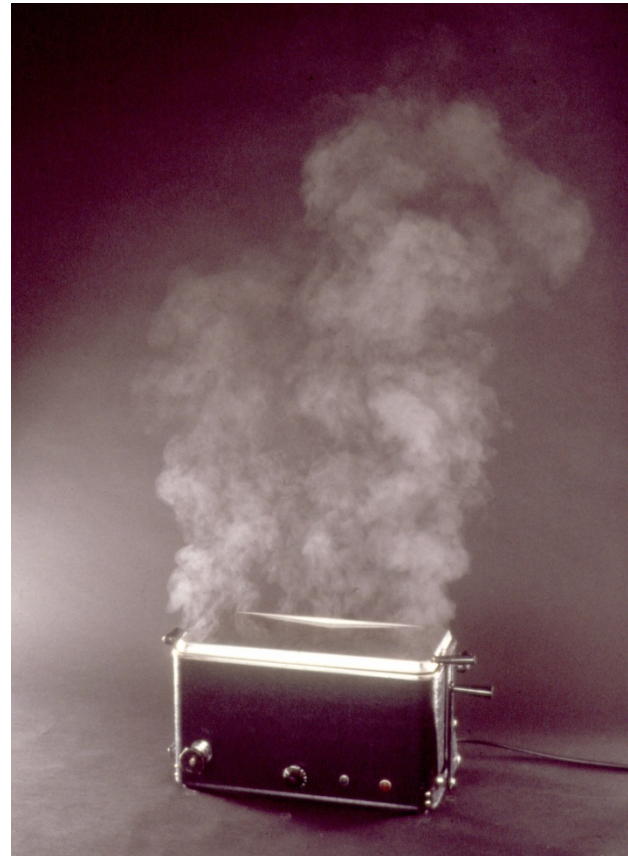
The past

In the mid-20th century, surgical instruments were “sterilized” by boiling water, either in the operating room or the preparation room.

This generated a lot of steam and heat that needed to be removed by powerful air extract systems.

The air removed would be replaced by drawing air in from adjacent clinical areas.

This air could be contaminated by microbes infecting and colonising patients.





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Contamination source 1: Bacteria from clinical areas near the theatre

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

Powerful extracts in the theatre (to get rid of steam from boiling water “sterilisers”). Contaminated air was being drawn into a theatre from adjacent clinical areas.

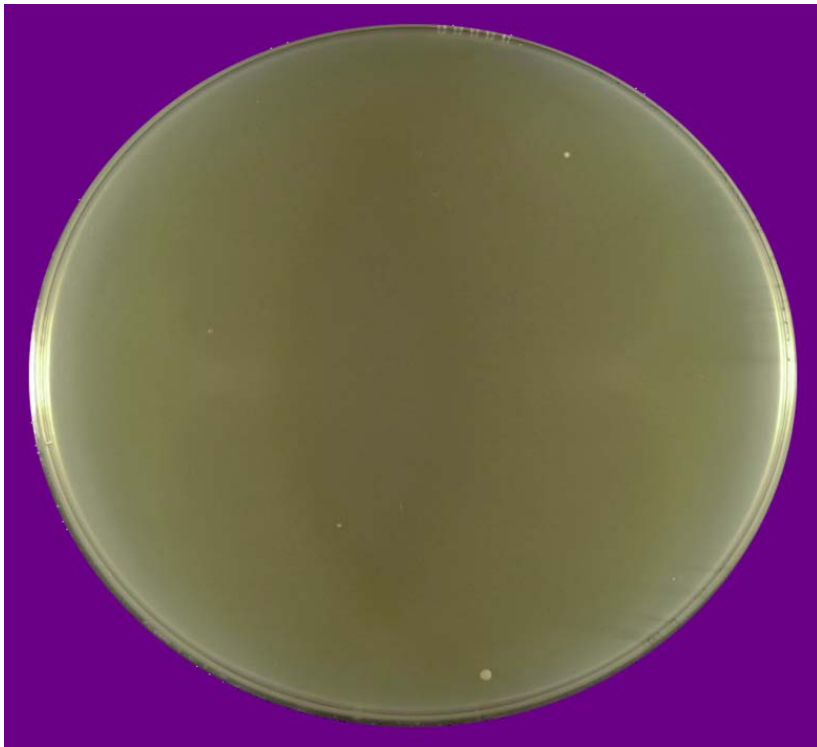
When this inward flow was reversed by supplying a lot of clean air to the theatre: ***“This was followed by an immediate reduction in the bacteria in the air and by a striking fall in the incidence of wound infections from 37 out of 427 clean operations to 5 out of 532”.***

There are other, similar papers from that era.

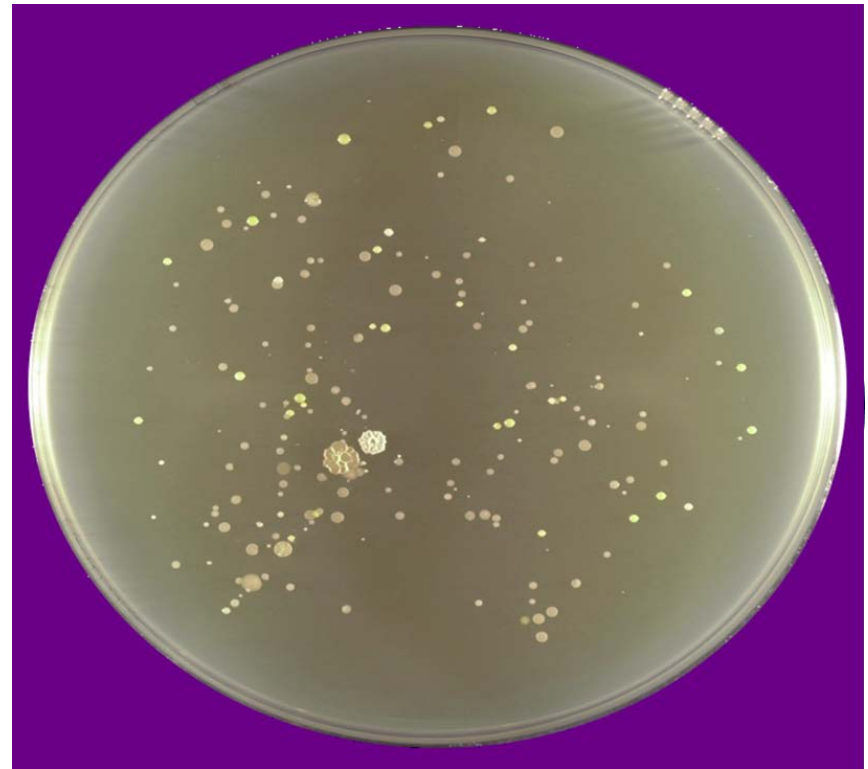


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Contamination source 2: Bacteria generated within the theatre



1,000 litres air sampled in empty room



Same, but person walking by sampler



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Contamination source 3: Bacteria and fungi from outdoor air



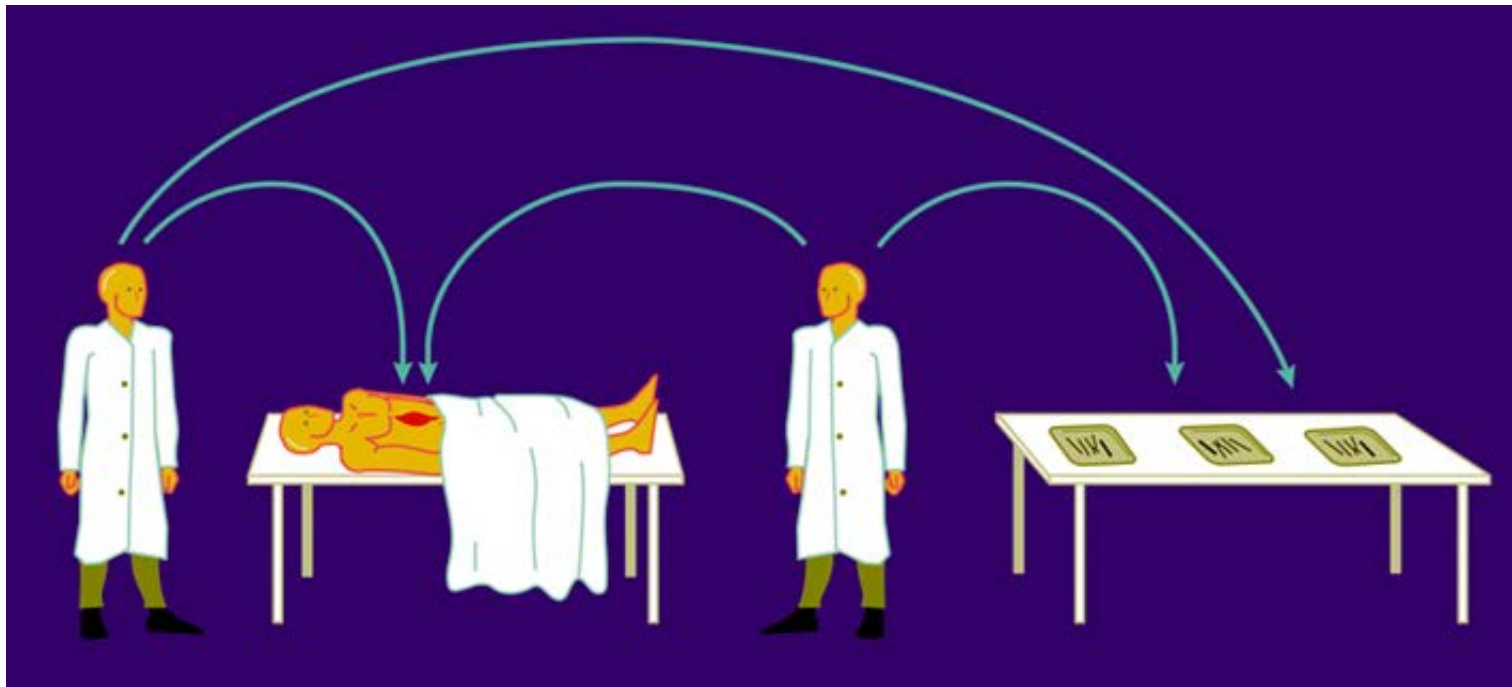
1,000 litres air – low windspeed day, rural UK



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Objective:

To prevent airborne contamination of the surgical wound



The majority, usually around 70%, of airborne contamination that ends-up in the wound, does so via exposed “sterile” instruments



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Ventilation strategy - 1

Supply lots of filtered air to those rooms you want to be the cleanest

Encourage it to flow out to adjacent less clean rooms

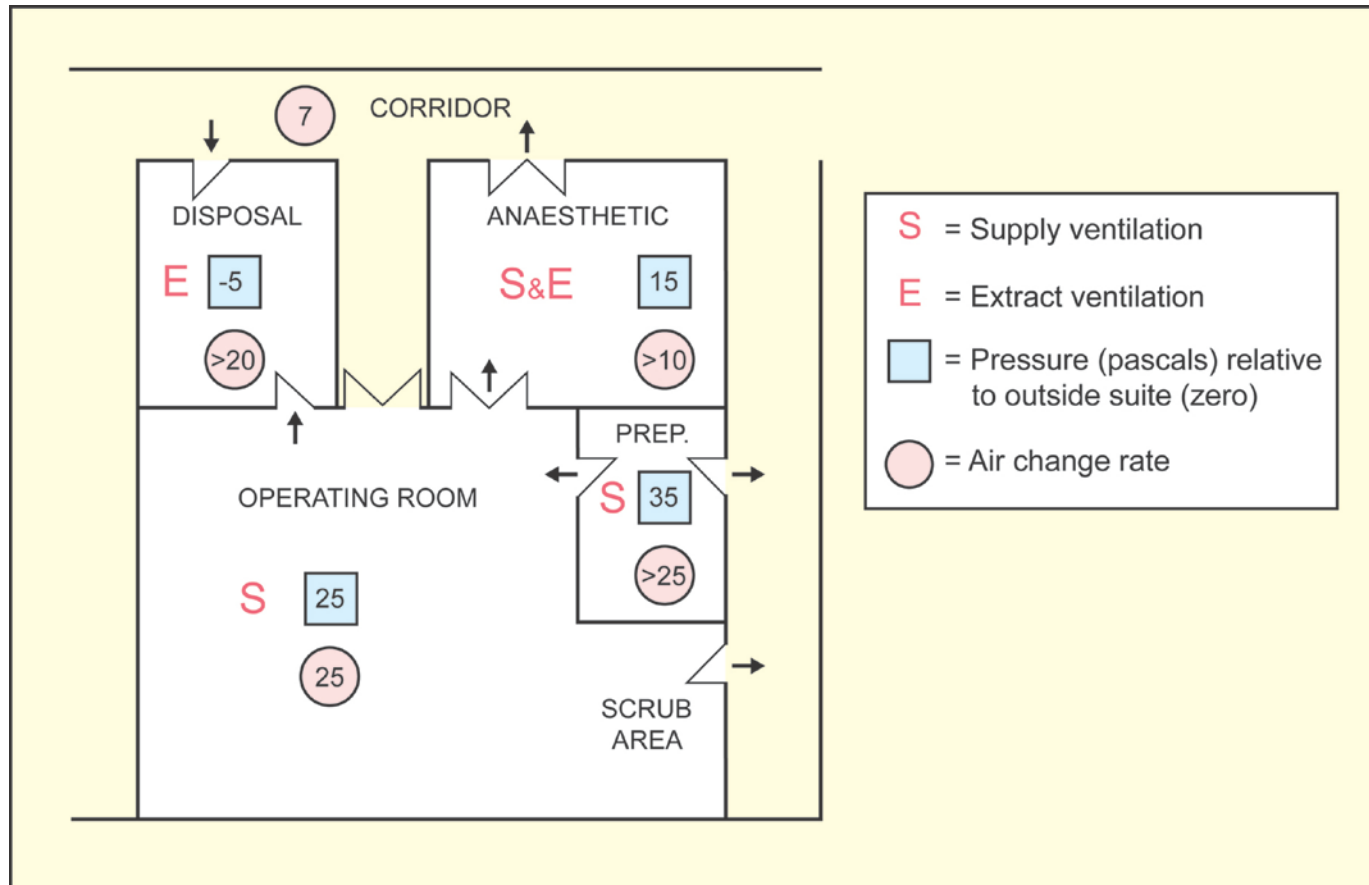
In doing so it will:

- a) Remove contamination generated in that room
- b) Prevent ingress of uncontrolled air (if air is flowing outwards from a clean area, contaminated air from outside is not going to flow back in)

This is known as “conventional theatre ventilation”; accounts for about 80 - 90% of UK theatres.



Conventional theatre suite ventilation





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Ventilation strategy 2

Supply clean air from the centre of the theatre ceiling in an organised downward flow

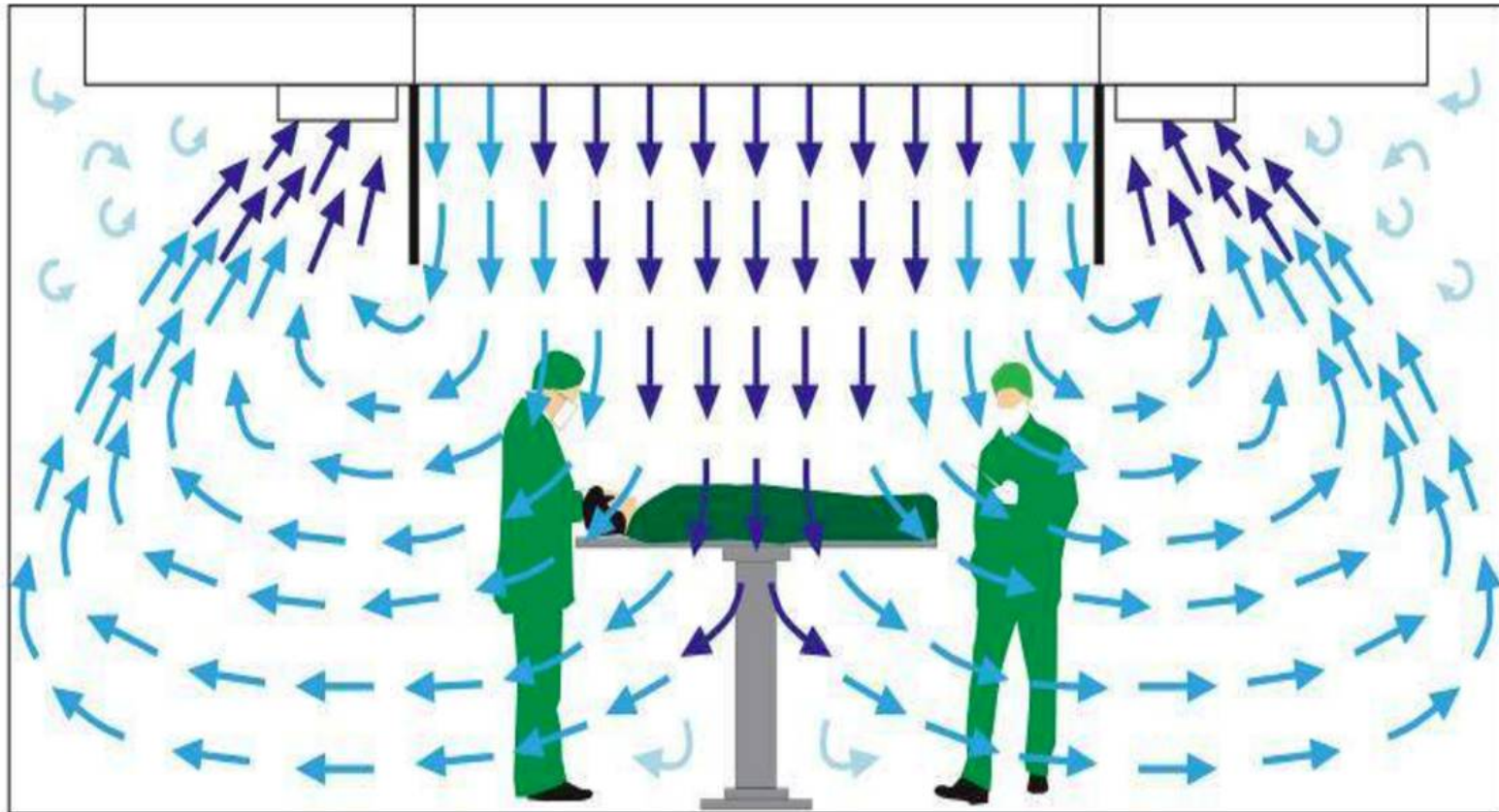
Contamination generated within this area of organised downward flow will be entrained in this airflow and removed within a few seconds

This area of organised downward flow will also resist ingress of contamination from outside that area.

This is known as ultraclean ventilation (UCV), also known as “laminar flow” or “orthopaedic” theatre ventilation.

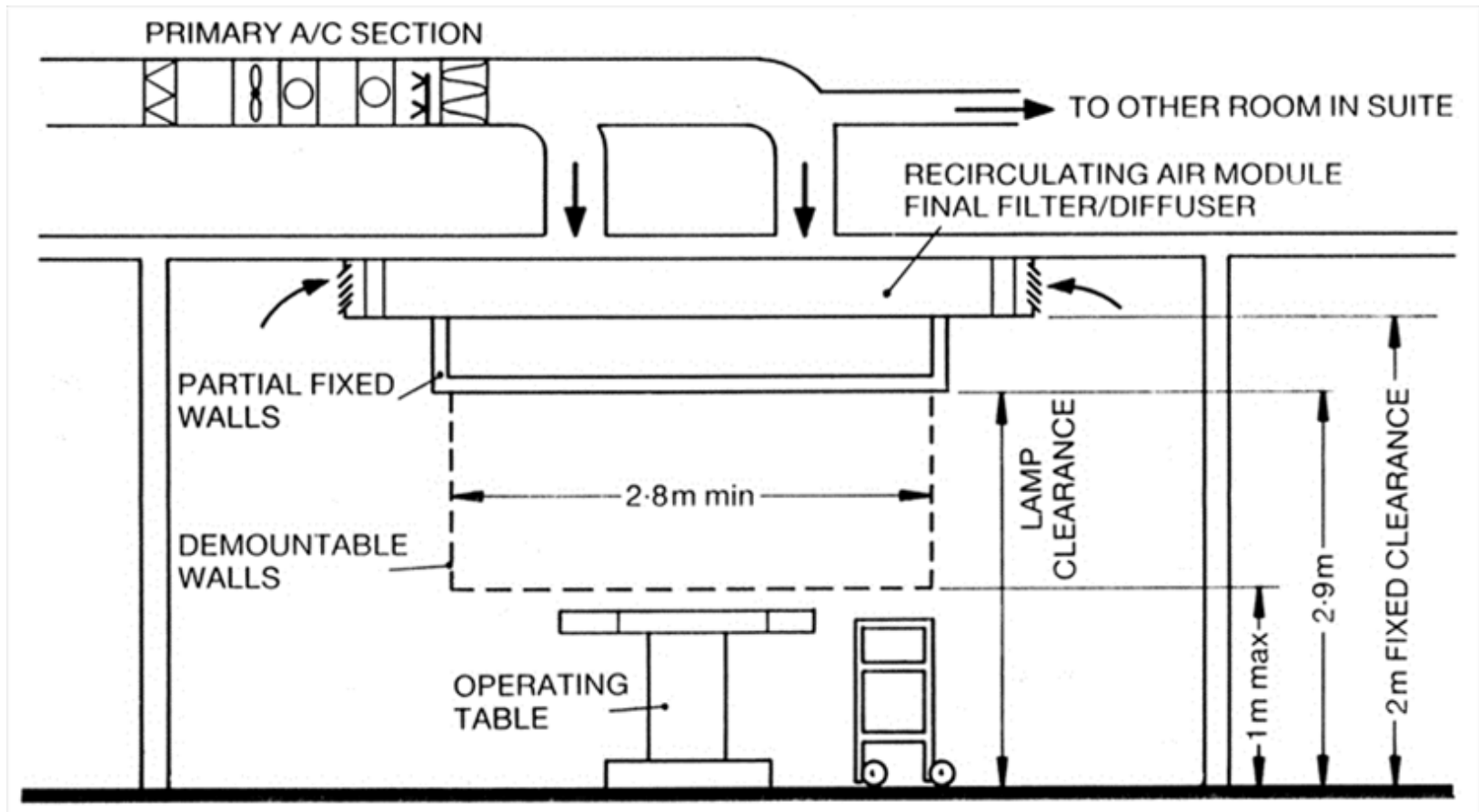


Ultraclean ventilation (UCV) airflow pattern





Ultraclean ventilation (UCV) design





Air cleanliness levels in operating theatres

Measures as microbially-contaminated particles (“colony forming units”), **during a surgical procedure**, per cubic metre (1,000 litres) of air there should be no more than:

Conventional theatre	Ultraclean theatre
180	10

The air in an ultraclean operating theatre is very much cleaner than in a conventionally ventilated theatre.



In the 1970/80s

Work by Owen Lidwell showed (BMJ 1982 **285** 10-14) a definite protective effect from ultraclean ventilation in total hip replacements (THR) and total knee replacements (TKR)

Dataset of about 8,000 procedures

➤ Infection rates: 1.5% in conventional and 0.6% in ultraclean

This demonstrated that cleaner air equates with fewer infections

- 98% UK hip & knee arthroplasties now done in ultraclean ventilation (so any control group lost)



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But maybe things are not that straightforward

The keeping of national registers of orthopaedic surgical infection has enabled large-scale but crude analysis.

Other countries still use both conventional and ultraclean for orthopaedic surgical procedures



New Zealand

Hooper (2011) J Bone & Joint Surg (Br) **93 B**; 85-90

Looked at 51,485 1st total hip replacements (THRs) and 36,826 1st total knee replacements (TKRs)

Deep infection rates (%)	THR	TKR
Ultraclean	0.148	0.193
Conventional	0.061	0.100



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Germany

Brandt (2008) Ann Surg; **248**: 695–700

Looked at 28,623 THRs and 9,396 TKRs

Deep infection rates (%)	THR	TKR
Ultraclean	1.37	0.918
Conventional	0.903	0.646



German non-orthopaedic data

Deep infection rates (%)	Appendectomy	Cholecystectomy	Colon surgery	Herniorrhaphy
Ultraclean	1.32	0.707	2.55	0.576
Conventional	1.09	0.484	2.73	0.354



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Cleaner air = more infection?!?!?!?

This seems so counterintuitive yet reasonably robust.

Are there issues other than microbial numbers at play here?

There is a correlation between low body temperature during surgery and increased rates of infection.

It seems possible that failure to maintain patient body temperature in fast moving UCV air could play a role.

But even if those factors could be identified and corrected, would ultraclean theatres be only just-as-good as conventional?



WHO guidance 2016



4.23 Laminar airflow ventilation systems in the context of operating room ventilation

Recommendation

The panel suggests that laminar airflow ventilation systems should not be used to reduce the risk of SSI for patients undergoing total arthroplasty surgery.

(Conditional recommendation, low to very low quality of evidence)



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Lancet Infectious Diseases

(Bischoff - *In Press, Corrected Proof, Available online 17 February 2017*)

From Summary

Interpretation: The available evidence shows no benefit for laminar airflow compared with conventional turbulent ventilation of the operating room in reducing the risk of SSIs in total hip and knee arthroplasties, and abdominal surgery. Decision makers, medical and administrative, should not regard laminar airflow as a preventive measure to reduce the risk of SSIs. Consequently, this equipment should not be installed in new operating rooms.



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The future

UCV is expensive both to install and to maintain.

The evidence showing that it reduces surgical site infection is old – many things have changed since the 1970s.

Have surgical techniques and the efficacy of antibiotic prophylaxis tipped the balance such that the negative effects of UCV now outweigh the positive?

Whether the extra cost of installation and maintenance of ultraclean theatres can be justified is currently under debate.