POSSIBLE ROLE OF VACUUM SYSTEMS AND COMPRESSED AIR GENERATORS IN CROSS-INFECTION IN THE ICU

A Radioactive Tracer Study

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Compressed air for medical use has been shown recently to be a potential source of infection in the intensive care unit (ICU) (Bjerring and Øberg, 1986). A mixture of pathogens, and normal skin bacteria, including *Pseudomonas aeruginosa*, *Bacillus* species, *Corynebacterium* species, *Micrococcus* species and *Staphylococcus epidermidis* were traced to oil-lubricated air compressors. Surprisingly, no limitation on the microbial content of the air supplied directly to seriously ill patients receiving ventilatory assistance with air–oxygen mixtures can be found in the Pharmacopoeia (Pharmacopoea Nordica, 1963), or in the recommendations of the British or International Standards Organisations.

In many hospitals air compressors are situated very close to vacuum compressors in a poorly ventilated machine room. As a result the possibility that bacteria may be transferred from the outlet of the vacuum system to the intake of the compressor used to generate air for medical use should be considered. To verify this possible route of cross-infection we conducted a study, using xenon-133 as a tracer, in a hospital in which the outlets of the vacuum generators were located 1.5 m from the intakes of the air compressors (fig. 1).

MATERIALS AND METHODS

Air containing 19.3 mCi (713 MBq) of xenon-133 was introduced to the hospital's vacuum system, which is used for pharyngeal and tracheal suction in the ICU, at a rate of 42 litre min⁻¹ for 5 min. The vacuum storage tank contained 1500 litre and the pipelines approximately 200 litre of air. From the vacuum system xenon-133 was exhausted into the compressor room (50 m³). Room air was drawn

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SUMMARY

Cross-contamination between a hospital's vacuum and compressed air systems was demonstrated using xenon-133 as a tracer. A xenon-133 bolus was introduced to the vacuum system in the intensive care unit. Calculations based on the amount of radioactive tracer recovered from the compressed air outlet at the same location as that at which the tracer was introduced indicated that 17% of the tracer had entered the compressed air system. The contamination was caused because the vacuum and compressed air systems were located in the same machine room. This could conceivably provide a route for respiratory tract contamination in patients receiving ventilatory assistance with air–oxygen mixtures.
into the compressors at a rate of 500 litre min\(^{-1}\) and stored in a tank (1000 litre) at a pressure of 6.1–8.2 atm. From this tank air was supplied to the peripheral air outlets throughout the hospital.

For measuring purposes air was drawn at a rate of 10 litre min\(^{-1}\) from the peripheral outlet at the same location as the suction intake at which the xenon-133 was introduced. Radioactivity was measured continuously by a Xenon monitor 301 (Alnor-MABO, Sweden) calibrated to monitor xenon-133 in the range 0.1–5000 MBq m\(^{-3}\).

**RESULTS**

Xenon-133 emerged from the air outlet in the ICU approximately 16 min after the tracer bolus had been introduced to the vacuum system. The levels of radioactivity are shown in figure 2. After an initial sharp increase in activity a steady state was attained, allowing calculation of the degree of cross-contamination between the vacuum and compressed air systems. Seventeen per cent of the xenon-133 administered was estimated to have entered the compressed air system.

**DISCUSSION**

This study has demonstrated the consequences of an engineering design, which allows the mixing of exhaust gases from the vacuum system with the intake for the compressed air generator. The mixing occurred because the vacuum pump and air compressor were housed in the same small room, with only 1.5 m between the outlet of the vacuum system and the compressed air intake. The design of the compressor room is not in conflict with Danish standards, and we have encountered the same arrangement in other hospitals. The reason for this is partly to facilitate servicing and maintenance of the compressors and partly to counteract the problem of noise in the hospital environment.

This study has demonstrated that it is possible for a gas to be aspirated (from the bedside) into a central suction unit and be returned to the same bedside by way of an air compressor. A radioactive isotope was used as the tracer, because bacteria introduced to the suction system might eventually have reached the lungs of any patients receiving artificial ventilation. Even though xenon-133 gas is more transferrable than a bacteria-containing aerosol, the present study has indicated that compressed air for medical use could be contaminated easily by bacteria from pharyngeal and tracheal suction procedures, and from the operative drainage of infection. In a previous study we were able to demonstrate the presence of pathogens in compressed air used for lung ventilation (Bjerring and Øberg, 1986). In the present study only a small bolus of xenon-133 was injected to the vacuum system; in everyday use the system is contaminated continuously by microorganisms from suction procedures. Over the years the inside of the pipelines and vacuum storage tanks may become lined with a film of microorganism-containing material (Øberg and Bjerring, 1986).

We believe that the practice of locating vacuum and compressed air generators in the same machine room may involve a risk of cross-infection—particularly in the ICU. Infection has been quoted as the most important single factor determining outcome in the intensive care patient (Andersen, 1984) and the airway as the most frequent source of septicaemia (Dominguez de Villota et al., 1983). Whereas a general medical or surgical patient has a 6% risk of becoming infected during his stay in hospital, the risk is 18% in the patient in the ICU (Donowitz, Wenzel and Hoyt, 1982).

The hospital in which we performed this investigation is a centre for the treatment of patients with epidemic diseases like meningitis,
severe respiratory tract infections, and the acquired immune deficiency syndrome. Thus the substantial (17%) cross-contamination from the vacuum system to the intakes of the air generators could prove particularly dangerous.

Bacteria present in medical air may also reach pneumatic surgical instruments, which are powered with 200–300 litre of compressed air per minute. During their use at least some of this air is released into the operative field (Øberg and Bjerring, 1985). It is generally accepted that airborne bacteria are responsible for a large number of postoperative infections (Hambreus and Laurell, 1980).

Good engineering practice dictates that the vacuum pump should exhaust outside the compressor room, well away from the intake to the air compressor. The fitting of bacterial filters to the air intakes in the compressor room and to mechanical ventilators is recommended to counteract unnecessary bacterial contamination of the compressed air being supplied to the seriously ill patient.

ACKNOWLEDGEMENT
The authors wish to thank Dr Med. H. Hvid Hansen, Head of the Department of Nuclear Medicine, Aarhus University Hospital, for support during the study.

REFERENCES