Doctors develop life-saving, low-cost ventilators for emergency, rural and military use

January 25 2010

A group of UK anaesthetists have designed and tested three prototype low-cost ventilators that could provide vital support during major healthcare emergencies involving large numbers of patients or casualties. The devices, detailed in a paper published online by *Anaesthesia*, could also be used where resources are limited, such as in developing countries, remote locations or by the military.

"Our research has demonstrated that it is possible to make a gas-efficient ventilator costing less than £200, for use where 2-4 bar oxygen is available, with no pressurised air or electrical requirements" says consultant anaesthetist Dr John Dingley from Morriston Hospital, Swansea.

"Such a device could be mass-produced for crises where there is an overwhelming demand for mechanical ventilation and a limited oxygen supply."

Problems with limited oxygen supply date back to the First World War when medical professionals had to deal with the large numbers of casualties affected by poison gas.

"The physiologist J S Haldane developed a delivery system that provided a high flow of oxygen from a modest fresh gas flow" says Dr Dingley, who is also a Reader in Anaesthetics at Swansea University.

"Modern equipment has become so sophisticated that we have, in some ways, lost sight of the basic principles that can be adopted in emergency healthcare situations.

"So our aim was to extend Haldane's concept of maximally efficient oxygen delivery to include pneumatic gas-powered ventilator designs.

"The initial design was envisaged as a ventilator for difficult environments, especially military scenarios, where large oxygen cylinders would be impractical, or in short supply, and electrical power would be unavailable.

"This led to two variants that are suited to emergency construction in bulk for mass deployment prior to a respiratory failure pandemic or other major healthcare situation."

All three designs operate on the principle that the energy is taken from approximately 1 l.min-1 compressed oxygen at a supply pressure of 2-4 bar to provide the motive force to ventilate the lungs.

"After the stored energy has been used to provide motive power in this way, the waste oxygen - which is now at atmospheric pressure - is then re-used to enrich the air being drawn into the ventilator before it is delivered to the lungs" explains Dr Dingley.

"In this way, most of the breathable oxygen is obtained from ambient air."

A mechanical test lung was used to test the three devices and this showed that they would provide effective ventilation for patients who were unable to breathe unaided. The devices were also tested over a range of lung volumes and compliances, which indicated that the oxygen consumption was considerably lower than that of the commercially

available gas powered ventilators currently on the market.

This means that even if the devices had to be used over an extended period of time, they would use less than conventional units. They would also provide a viable and financially attractive alternative to buying extra critical care ventilators, which are expensive, complex microprocessor-driven devices.

"These devices could be used anywhere that 2-4 bar oxygen is available, such as a converted ward with no piped air or electricity" says Dr Dingley. "In extreme circumstances, they could even run on hospital compressed air, using very little air from the hospital's compressor reservoir.

"The concept, although unconventional, also allows an attending staff member to take over manual ventilation of the patient, with air if necessary, if a hospital's pneumatic mechanism or gas supply fails.

"The mechanism could possibly be made as a single-use device and stockpiled for crises where there is an overwhelming demand for mechanical ventilation, such as a pandemic."

Dr Dingley points out that major healthcare emergencies can call for creative solutions and that these can often be unorthodox.

For example during the 1952 Copenhagen polio epidemic, relays of medical students manually ventilated the lungs of patients with tracheostomies under the guidance of the anaesthetist. And in Beijing in 2003, trainees from unrelated specialties found themselves managing a sealed intensive therapy unit filled with avian flu victims, while receiving clinical guidance from overseas experts via a mobile phone.

"Health services are not designed to cope with the most extreme

situations and fast, easy solutions can quite literally save lives" says Dr Dingley. "We feel that the low oxygen consumption pneumatic ventilators we have designed and tested could provide a low-cost, speedy solution in a crisis. They could also be used for a wide range of applications, such as rural healthcare and armed conflicts."

More information: A low oxygen consumption pneumatic ventilator for emergency construction during a respiratory failure pandemic. Williams et al. *Anaesthesia.* Publication online ahead of print. (January 2010). DOI:10.1111/j.1365-2044.2009.06207.x

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