SHORT REPORT

Use of the Lund University Cardiopulmonary Assist System in the MD902: a fire safety assessment

J S Farmery, M Carter

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Background: The Lund University Cardiopulmonary Assist System (LUCAS) is a gas-driven mechanical cardiopulmonary resuscitation device. If oxygen is used as the driving gas in a confined environment, there is a potential fire hazard. 24% oxygen is considered the threshold for increased risk.

Objective and methods: Three trials were conducted using different cabin ventilation settings to determine the rise in oxygen concentration in an MD902 helicopter during use of the LUCAS.

Results: The oxygen concentration rose rapidly with the aircraft at rest, but during flight, using realistic cabin ventilation settings and durations of use, the oxygen concentration failed to reach 24%.

Conclusion: The LUCAS is safe for normal-duration flights in an MD902 helicopter. It is potentially unsafe in a static MD902 and, by extrapolation, in other static aircraft of similar or smaller size such as the EC135 or Bolkow 105.

Effective cardiopulmonary resuscitation (CPR) improves outcome from cardiac arrest.¹ However, in-flight CPR is frequently interrupted and increases the risk of injury to aircraft crew.

The Lund University Cardiopulmonary Assist System (LUCAS) is reported to be better than manual CPR² and can be used during patient handling; however, it produces 70 l of expended gas per minute. If oxygen is used, concentrations may rise, and the Health and Safety Executive considers >24% oxygen to be potentially hazardous.³ Hazardous equipment might not receive a permit for use in flight by the Civil Aviation Authority. Pressurised air can be used, but helicopter operations are weight critical, and carrying air instead of other equipment reduces functionality.

We aimed to assess the rise in oxygen concentration while using the LUCAS in the MD902 helicopter.

METHODS

Phase 1: LUCAS activated with all helicopter systems off. Continued until oxygen concentration reached equilibrium, allowing identification of the maximum attainable oxygen concentration.

Phase 2: LUCAS activated in flight using maximum cabin ventilation (although without opening any windows). Confirmed whether oxygen concentration rises to the 24% level despite maximum cabin air exchange. If the 24% point was not reached, then phase 3 could be undertaken.

Phase 3: LUCAS activated in flight with minimal cabin ventilation. This reproduced typical flight conditions used in winter where vents are usually closed to conserve cabin temperature.

Simulated patient ventilation was achieved by setting the Ventipac (Smiths Industries) to provide 15 l/min to the cabin

atmosphere in addition to the waste gas produced as it is also an oxygen driven device.

Recordings were made every minute using a two-point calibrated (21% and 100% oxygen) Datex Ohmeda oxygen analyser. This was placed 1 m from the LUCAS in the midline of the cabin.

RESULTS

Figure 1 shows oxygen concentrations during the three phases.

Phase 1: Oxygen concentration reached 24% after 5 min and continued to rise to 35%, where it plateaued. The test was ended after 30 min had elapsed because (a) patients are unlikely to benefit from such lengthy CPR and (b) the amount of oxygen required (1800 l) is beyond that carried by most air ambulances.

Phase 2: Oxygen concentration rose to 22% after 10 min with no further rise before the test was ended at 15 min. Cabin oxygen concentration was allowed to fall back to 21% before phase 3 was conducted.

Phase 3: Oxygen concentration rose to 22% after 2 min, to 23% after 11 min, and remained there until the test was ended at 15 min.

DISCUSSION

Two factors are to be considered.

Firstly, the test times of phases 2 and 3 were reduced compared with that of phase 1, which reflects the different aims. Phase 1 aimed to determine if flight testing was required by identifying the maximum potential cabin concentration, whereas phases 2 and 3 aimed to identify the concentration under normal conditions. Normally G-KAAT, the helicopter used by Kent Air Ambulance Trust, carries three CD cylinders. The operating time of the LUCAS is therefore in the region of 15 min (one cylinder will be required for patient ventilation). Fifteen minutes also exceeds most of our flight times from scene to receiving unit. Although it would have been ideal to run phases 2 and 3 to equilibrium or until the 24% level was achieved, this was not possible. Despite these constraints, however, the data are still valid.

Secondly phase 3 measurements were made only a few minutes after phase 2, and therefore a true baseline oxygen concentration of 21% was probably not attained. However, this slightly elevated start point did not cause the concentration to reach 24% prematurely, and so did not alter the conclusion.

CONCLUSION

The LUCAS produces enough oxygen during use to raise the cabin oxygen concentration above normal; however, use of the LUCAS on an MD902 for up to 15 min in flight even with minimal cabin ventilation seems to be safe. The LUCAS is, however, potentially unsafe in a static MD902 and, by extrapolation, in any static aircraft or vehicle of similar or smaller size.

Abbreviations: CPR, cardiopulmonary resuscitation; LUCAS, Lund University Cardiopulmonary Assist System

Figure 1 Oxygen concentration against time for three cabin ventilation settings (static, maximum and minimum) in an MD902 helicopter during use of a Lund University Cardiopulmonary Assist System

FURTHER RESEARCH

Extending the in-flight times would identify the maximum safe duration of use—that is, time elapsed until 24% oxygen concentration is achieved. Repeated trials for other helicopter types are also required as these possess different internal volumes and cabin air exchange rates.

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Authors' affiliations

J S Farmery, M Carter, Kent Air Ambulance Trust, Marden, Kent, UK

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Correspondence to: Dr J S Farmery, Kent Air Ambulance Trust, Unit 14, Wheelbarrow Industrial Estate, Pattenden Lane, Marden, Kent TN12 9QJ, UK; jfarmery@gmail.com

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