Sustained life-like waveform capnography after human cadaveric tracheal intubation

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ABSTRACT

Introduction Fresh frozen cadavers are effective training models for airway management. We hypothesised that residual carbon dioxide (CO2) in cadaveric lung would be detectable using standard clinical monitoring systems, facilitating detection of tracheal tube placement and further enhancing the fidelity of clinical simulation using a cadaveric model.

Methods The tracheas of two fresh frozen unembalmed cadavers were intubated via direct laryngoscopy. Each tracheal tube was connected to a self-inflating bag and a sidestream CO2 detector. The capnograph display was observed and recorded in high-definition video. The cadavers were hand-ventilated with room air until the capnometer reached zero or the waveform approached baseline.

Results A clear capnographic waveform was produced in both cadavers on the first postintubation expiration, simulating the appearances found in the clinical setting. In cadaver one, a consistent capnographic waveform was produced lasting over 100 s. Maximal end-tidal CO2 was 8.5 kPa (65 mm Hg). In cadaver two, a consistent capnographic waveform was produced lasting over 50 s. Maximal end-tidal CO2 was 5.9 kPa (45 mm Hg).

Conclusions We believe this to be the first work to describe and quantify detectable end-tidal capnography in human cadavers. We have demonstrated that tracheal intubation of fresh frozen cadavers can be confirmed by life-like waveform capnography. This requires further validation in a larger sample size.

INTRODUCTION

Cadaveric models provide effective simulation in airway management1 and facilitate airway research that would be unethical in live patients.2, 3 The gold standard method of confirming tracheal tube placement in the clinical setting is the detection of expired carbon dioxide (CO2).4 We hypothesised that residual CO2 in cadaveric lung would be detectable using standard clinical monitoring systems, facilitating detection of tracheal tube placement and further enhancing the fidelity of clinical simulation using a cadaveric model.

RESULTS

A clear capnographic waveform was produced in both cadavers. It was visible after the third expiration in cadaver one and the first expiration in cadaver two, approximating the appearances found in the clinical setting.

The waveform from cadaver one had a flat alveolar plateau and normal morphology comparable to that found in a live patient with non-obstructed airways (figure 1). A consistent waveform was produced at least until recording ceased at 106 s postintubation, at which time, the end-tidal carbon dioxide (ETCO2) was measured at 5.5 kPa (42 mm Hg). Maximal ETCO2 was 8.5 kPa (65 mm Hg), recorded 56 s postintubation.

The waveform from cadaver two had an up-sloping expiratory phase, similar to that found in patients with airways obstruction (figure 2). This persisted until recording ceased at 56 s postintubation, when ETCO2 was measured at 1.9 kPa (13 mm Hg). Maximal ETCO2 was 5.9 kPa (45 mm Hg), which was the initial postintubation ETCO2.
The partial pressures of carbon dioxide and duration of detectable capnography until cessation of recording are detailed in table 1.

DISCUSSION
We believe this to be the first work to describe and quantify expiratory CO₂ in ventilated human cadavers. Recently deceased unembalmed and fresh frozen cadavers provide high anatomical fidelity for airway training; the ability to apply the gold standard physiological monitor for tracheal tube placement might further enhance the use of cadavers in simulation training. Prior to its adoption, further research should confirm the absence of a sustained capnograph trace resulting from cadaveric oesophageal intubation. It is unknown whether ETCO₂ would be detectable following intubation of cadavers that have been preserved using alternative methods. The source of CO₂ in cadaveric lung remains to be elucidated: it is unclear whether it is physiologically produced during life and trapped within and by collapsed airway tissue, or whether it is released as a result of a post-mortem process.

CONCLUSION
We have demonstrated that tracheal intubation of fresh frozen cadavers could be confirmed by life-like waveform capnography. This requires further validation in a larger sample size.

Contributors CR conceived and designed the study and drafted the initial manuscript. All other authors conducted the study and assisted with data collection, preparation and approval of the manuscript. All authors fulfill the criteria of authorship. There is no one else who fulfills the criteria who has not been included as an author.

Competing interests None.

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Data sharing statement Videos of the capnographic waveforms are available for viewing by contacting reidcg@me.com.

REFERENCES