of equipment and timings related to specific VL intubation skills in three evolving airway scenarios, and user perception. A VR gamified simulator based on a real operating room setting was designed by the Department of Anaesthesiology of the University Hospital of Lausanne, Switzerland, in collaboration with Lucid Reality Labs (Kyiv, Ukraine) and Medtronic RMS EMEA It was developed for usage on an HTC Vive Pro and consisted of a VR-grade laptop, two infrared cameras, and a pair of VR controllers for movements tracking (1.5 mm accuracy).

Three airway scenarios were created: a 58-yr-old obese and bearded man, a 5-yr-old child, and a 42-yr-old woman. The latter scenario included an unexpected difficult visualisation of the trachea with the need to switch to a hyperangulated blade and styletted tracheal tube. An ideal VL mouth-introduction (VLMI) path was taught to the VR software. Ethical approval was granted, and data were collected during five international anaesthesia conferences and two specific airway management meetings (CHU UCL Namur, Belgium 2018 and Difficult Airway Society, Edinburgh, Scotland, 2018) on voluntary participants. A 4 min practical teaching session was followed by an automatic recording of choice of scenario, type and size of blade, tracheal tube size, time to complete intubation, force used for VL, number of vocal cord contacts, and damaged teeth. Introduction path of the VL was compared with the VLMI path. Participants were also asked about the usefulness for education and interest in acquiring a similar simulator for in-hospital usage.

We enrolled 437 participants from 18 countries who played the VR simulation on 491 scenarios; assessment was possible on 439. Participants were practising anaesthesiologists followed by department chairs, residents, nurses, and airway fellows. The 'woman' scenario was the most played (47.2%) and the 'child' the least (13.4%). The wrong blade was chosen in 160 (36.0%) situations, of which 51% were in the 'man' scenario. Time to intubate was longer and VL force higher in the 'man' scenario, whereas vocal cord contact and damaged teeth were higher in the 'woman' scenario. The 'child' scenario generated the least vocal cord contacts. The VR simulator was identified as useful for teaching by 273 participants (71%), and 248 (65%) had interest in acquiring it.

The VR simulator generated high interest during anaesthesia conferences and allowed identification of areas where further emphasis on VL teaching might be necessary. It was recognised as a useful tool to improve specific skills and performance and could complement available training tools.

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# Ultrasonography reduces vertical incision size of front-of-neck access on a non-palpable porcine larynx model

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Ultrasonography has been shown to improve correct identification of the cricothyroid membrane (CTM).[1] In patients with difficult neck landmarks, airway guidelines suggest making a vertical incision of up to 8 cm for landmark identification during front-of-neck access (FONA).[2] In this randomised controlled simulation study, we investigated the role of ultrasound (US) on FONA performance using the scalpel–bougie–tube (SBT) cricothyrotomy on a non-palpable US-compatible porcine larynx model.

After ethics approval, consented anaesthesia and emergency medicine trainees (Mount Sinai Hospital, University of Toronto) were randomised to US ($n$=14) and non-US (NUS; $n$=15) groups. All participants received didactic and hands-on teaching of ultrasonography and SBT on neck models and porcine larynx. Within 1 week later, participants performed SBT-cricothyrotomy on a non-palpable porcine larynx model, consisting of a pig larynx embedded in an US-compatible semi-solid gel covered with an opaque skin-like membrane where the CTM is non-palpable. Participants in the US group used ultrasonography and those in the NUS group used finger palpation to identify the CTM. Primary and secondary outcomes are described in Table 6. The ultrasound machine was operational and ready to use before front-of-neck access.

The vertical incision (primary outcome) in the US group was significantly shorter than that in the NUS group. The rate of injury severity and correct tube placement were similar between groups. Although the time to complete cricothyrotomy appears longer in the US group, the difference between groups was not significant. The mean time to

**Table 6** Summary of primary and secondary outcome data

| | US group ($n$=14) | NUS group ($n$=15) | P-value |
|---|---|---|---|
| *Primary outcome* **Vertical size incision (mean (STD) mm)** | 31.2 (17.3) | 77.4 (38.8) | <0.001* |
| *Secondary outcomes* None–mild/moderate –severe injuries ($n$, %) | 10/4 (71) | 10/5 (67) | 1** |
| Procedural time to complete FONA (s) | 174 (91.2) | 120 (64.8) | 0.081* |
| Time to identify CTM by US (s) | 38 (17.6) | N/A | N/A |
| Correct tube placement ($n$, %) | 8/14 (57) | 10/5 (67) | 0.7** |

*Student's *t*-test and **Fischer's exact test were used for statistical analyses with P<0.05 as statistically significant.

identify the CTM with ultrasound was relatively short (38 [17.6] s).

In conclusion, when ultrasonography is readily available, ultrasound-assisted identification of the CTM in a non-palpable porcine larynx model resulted in a shorter vertical incision without affecting procedural time and complication rate. Ultrasonography-assisted might be useful when performing a FONA in patients with non-palpable neck landmarks.

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# Cannula cricothyroidotomy in simulated cannot intubate-cannot oxygenate scenarios using a live anaesthetised pig model

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Despite limited evidence to guide cannot oxygenate, cannot oxygenate (CICO) management, support is growing for scalpel over cannula-based techniques.[1] The Australian and New Zealand College of Anaesthetists continues to support both techniques and encourages regular CICO training.[2] Our group conducts training where live anaesthetised pigs are used to recreate CICO scenarios. The porcine neck represents an impalpable anatomy model. We report a study of cannula cricothyroidotomy in simulated CICO scenarios using live anaesthetised pigs.

Ethics approval was gained from both institutions, and all participants gave consent for inclusion in the study. Forty two anaesthetists were given comprehensive teaching based on the Royal Perth Hospital (RPH) CICO algorithm[3]. After cadaver training, each candidate was placed into a high-fidelity airway simulation. Under the management of veterinary anaesthetists, pigs were rendered apnoeic. When $Sp_{O_2}$ decreased to 92%, candidates were instructed to gain immediate front-of-neck access after the RPH CICO Algorithm assuming impalpable anatomy (up to three attempts at cannula cricothyroidotomy within 1 min followed by a scalpel—finger—cannula technique).

Percutaneous cannula cricothyroidotomy had a low success rate, with ability to re-oxygenate a hypoxaemic porcine model ($SpO_2$>90%); highest at first attempt (first=29%). Second and third attempts had a declining ability to re-oxygenate (21% and 12%, respectively) because of critical hypoxaemia necessitating euthanasia. Percutaneous attempts (first, second, third) were started at 44, 84, and 131 s, respectively. With a successful first cannula, average time to re-oxygenation was 110 s. After three failed percutaneous cannulas, all participants performed a scalpel—finger—cannula technique, started

at 166 s on average with a 44% re-oxygenate rate. Average pig weight was 16.2 kg (range 11—24 kg) with an internal tracheal diameter of 11 mm (range 9—15 mm).

By following a CICO management algorithm, cannula cricothyroidotomy and scalpel-finger-cannula technique can be used to successfully ventilate and re-oxygenate a hypoxaemic 'impalpable anatomy' pig model. Percutaneous cannula cricothyrotomy can be swift but participants may fixate on performing additional percutaneous attempts at the expense of transitioning to scalpel-finger-cannula. Live animal simulation is an invaluable training tool that may help prepare anaesthetists for this rare, life-threatening emergency.

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# Cric-Guide™: a more effective scalpel for surgical cricothyroidotomy

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The scalpel—bougie—tube (SBT) technique for emergency cricothyroidotomy, recommended by the Difficult Airway Society, may fail when the bougie does not follow the scalpel blade into the airway.[1] Cric-Guide™ is a novel scalpel device, designed to replace the standard size 10 scalpel; improving the technique by guiding the bougie into the airway.

The blade is stainless steel, and U-shaped in cross section. The tip is as sharp as a scalpel and flattened to make a 9 mm crescent-shaped incision. Once inserted, the inside of the blade creates a 6 mm wide channel to guide the passage of a bougie into the trachea. The curvature of the blade ensures that the bougie tip slides within its channel preventing a false passage and guiding it into the airway.

The handle is made of a three-dimensional printed Nylon. Depth guards, on each side of the blade, limit insertion to protect posterior structures (Fig. 7). Three sizes of Cric-Guide™ in the pack each have a different depth limit, with choice depending on patient's weight.[2] The insertion technique is available to view on https://youtu.be/bW-GLZjTzVY.

A Cric-Guide™ prototype was evaluated in the obese porcine model. Compared with SBT technique, the Cric-Guide™ required fewer attempts and created fewer false passages.[3] After design modification, Cric-Guide™ was more successful at accessing the airway in obese manikins than SBT 20/28 vs eight/28 (p=0.003) compared with slim manikins 27/28 vs 25/28.[4]

After Ethics Committee approval was obtained, Crawley and Maini[5] assessed participants using the Cric-Guide™ in 12

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