

Comparison of cricothyroidotomy on manikin vs. simulator: a randomised cross-over study★

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Summary

We compared the time taken to perform cricothyroidotomy on a manikin to that on a medium fidelity simulator, to assess the effect of psychological stress and time pressure on performance. Seventy anaesthetists participated in this randomised cross-over study. Fifty-four (77%) anaesthetists took longer on the simulator, with the mean (SD) time taken to perform the procedure on the manikin and simulator 34 (18) and 48 (11) s, respectively ($p < 0.001$). Anaesthetists with more experience performed the procedure more quickly on both manikin and simulator. We conclude that psychological stress and time pressure in real-life scenarios can affect the performance of cricothyroidotomy.

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Cricothyroidotomy is a life-saving emergency airway procedure in a 'can't intubate can't ventilate' situation. It is the final step in the difficult airway algorithm of the American Society of Anesthesiologists [1] and the Difficult Airway Society [2]. However, most anaesthetists have only limited experience in the technique as it is infrequently required, nearly always in a crisis (stressful) situation. In such situations, theoretical knowledge and regular training of the skill on a manikin or simulator is the key to success [3, 4].

The majority of studies related to emergency cricothyroidotomy are performed on manikins, animals or human cadavers [5]. In an emergency 'can't intubate can't ventilate' situation, when the patient is hypoxic, cricothyroidotomy should be performed rapidly and safely to achieve rapid re-oxygenation. However, the performance of a clinical skill can be affected by stressful conditions [6] and, in a real life emergency, psychological stress and time pressure could affect the performance of this life-saving skill. It would be unethical and impractical to provide training in real life-and-death situations. Therefore, we assessed the effect of psychological stress and time pressure by comparing the time taken to perform cricothyroidotomy on a manikin to

that of an emergency 'can't intubate can't ventilate' scenario on a medium fidelity simulator.

Methods

The subcommittee of our local Research Ethics Committee decided that full committee approval was unnecessary because the study was not performed on human subjects and participation by anaesthetists was voluntary. Nevertheless, all prospective participants were fully informed about the study and data collection and a detailed information sheet was given to all participants, all of whom gave written consent before participation. Each participant was given the opportunity to withdraw from the study at any stage, and informed that if they did not consent or chose to withdraw, they could still practise the cricothyroidotomy but their data would not be recorded.

A series of cricothyroidotomy training sessions was organised for anaesthetists in our department and all anaesthetists were encouraged to attend. Each session was restricted to a group of six anaesthetists, lasted for an hour and included: a lecture and discussion on the relevant anatomy; techniques of cricothyroidotomy; and current

guidelines for managing a ‘can’t intubate can’t ventilate’ scenario. This was followed by a video demonstration of the cricothyroidotomy technique using a 13-G jet ventilation catheter (VBM Medizintechnik GmbH, Tuttingen, Germany). Once the anaesthetist was familiar with the technique and equipment, he/she was asked to perform a cricothyroidotomy twice, once on a manikin and once on a simulator. The order was randomly allocated using sealed opaque numbered envelopes, such that 50% of the participants performed the procedure first on the manikin and 50% first on the simulator. Once participants had performed one cricothyroidotomy, they moved onto the second with very little delay and both happened immediately after the training session.

For the manikin part of the study, the participants were presented with a training manikin (SimMan[®]; Laerdal Medical, Kent, UK) in a simple classroom setting, and asked to perform a cricothyroidotomy. A difficult airway trolley was available, which included a 13-G jet ventilation catheter (VBM Medizintechnik GmbH) and a ManuJet Sanders injector (VBM Medizintechnik GmbH).

For the simulator, the anaesthetist was presented with a programmed standardised emergency ‘can’t intubate can’t ventilate’ scenario on the same manikin but in the context of a medium fidelity simulator. The simulator was set up in a mock operating theatre with an operating department practitioner assisting the anaesthetist. All participants were asked to dress in operating theatre dress and hat to help with the realism of the scenario. Standard monitoring including non-invasive blood pressure, electrocardiography, pulse oximetry, and end-expired carbon dioxide partial pressure was displayed. The pulse oximeter alarm was set at high volume with a characteristic tone activated at $S_{pO_2} < 95\%$. The participants were asked to perform a rapid sequence induction on a healthy patient presenting for appendectomy. Soon after induction, a ‘can’t intubate can’t ventilate’ situation was initiated by instituting pharyngeal oedema, laryngospasm and restricted neck extension on the simulator, and a standard decline in oxygen saturation was programmed. At the time of insertion of the cricothyroid cannula, laryngospasm was reset to allow ventilation of the lungs.

The manikin’s puncturable cricothyroid membrane was replaced after each participant had performed the procedure. The ‘skin’ of the neck was moved round after each attempt, and completely replaced after 8–10 attempts. The 13-G ventilation catheter was replaced after three uses, unless it appeared to be damaged, in which case it was replaced earlier. (The average number of times the cannulae were used was 2.5. We used 55 cannulae throughout the study period).

The time taken to perform cricothyroidotomy (from when the participant started neck palpation to the first chest inflation) and the success of the procedure were noted.

From our previous work (Suri I, John B, Mendonca C, Hillermann C. Performance of cricothyrotomy on a simulator. Abstract, Difficult Airway Society, Lille; France: November 2005, P72) we derived a standard deviation (SD) of 36 s. To demonstrate a difference of 20 s for a power of 0.9 with a significance level of 0.05 we needed 70 participants. Normally distributed continuous data were analysed using Student’s *t*-test and other data were analysed using one-way analysis of variance. A value for $p < 0.05$ was considered statistically significant.

Results

All participants agreed to take part in the study. Seventy anaesthetists from our department, of varied experience and grade, participated in the study. Forty-two had previous training in cricothyroidotomy and two had experience of emergency cricothyroidotomy on patients (Table 1).

There was an 89% (62/70) success rate for correct placement of the cricothyroid cannula in both the manikin and the simulator. Most anaesthetists took longer to perform cricothyroidotomy on the simulator than on the manikin (54/70; 77%), with mean times longer in the simulator setting (Table 2).

Table 1 Previous experience of 70 anaesthetists performing cricothyroidotomy on a manikin and simulator. Values are number (proportion).

Anaesthetic experience	
< 1 years	8 (11%)
1–3 years	15 (22%)
3–6 years	19 (27%)
> 6 years	28 (40%)
Experience of cricothyroidotomy	
Manikin only	17 (24%)
Sheep larynx only	11 (16%)
Sheep larynx and manikin	12 (17%)
Patient and manikin	2 (3%)

Table 2 Time taken to perform cricothyroidotomy and failure rate in 70 anaesthetists performing the procedure on a manikin and simulator. Values are mean (SD) or number (proportion).

	Manikin	Simulator	p value
Time; s	34 (18)	48 (16)	< 0.001
Failure rate	8 (11%)	8 (11%)	NS

Table 3 Time taken to perform cricothyroidotomy against anaesthetic experience in 70 anaesthetists performing the procedure on a manikin and simulator. Values are mean (SD).

	Manikin	Simulator
Anaesthetic experience		
< 1 years	44 (12)	58 (19)
1–3 years	34 (11)	50 (15)
3–6 years	40 (27)	52 (16)
> 6 years	28 (8)	40 (13)
p value	0.04	0.03

Cricothyroidotomy times on manikin and simulator differed significantly according to the anaesthetic experience (Table 3). However, previous cricothyroidotomy experience in itself did not affect the time taken to perform cricothyroidotomy.

Discussion

Our main finding is that performing needle cricothyroidotomy using a 13-G jet ventilation catheter takes longer in a simulator setting than on a manikin. The most likely reason for this is the added psychological stress provided by the realism of the simulator, as other variables such as the manikin and equipment were standardised. Training in a simulated operating theatre with the background noise of alarms, pulse oximeter tone, etc., offers a more realistic situation for participants. It has been shown that psychological stress can affect physical performance [7]. The background theatre noise and the wish to perform the technique as quickly as possible can lead to impaired dexterity [6] and increase the time taken to perform the procedure.

Secondary findings are that both manikin and simulator times did not differ significantly with previous cricothyroidotomy experience. This is in keeping with findings from Prabhu et al. [3] who demonstrated a decline in performance after 3 months. None of our participants had performed or trained in the technique in the 3 months before the study. However, there was a difference in time depending on the grade of anaesthetist, with the consultant grade performing best. This might be due to experience in dealing with stressful situations. We did not specifically study the effect of a learning curve as each participant was only making two attempts at cricothyroidotomy. A previous study looking at the minimum number of attempts required to have a significant reduction in time performance due to a learning curve effect showed that there was no difference in the first two consecutive attempts [4]. From our data, only eight of the successful participants took longer to perform the procedure

on the manikin and most took longer on the simulator despite performing the procedure first on the manikin.

There are certain limitations in our study. We chose to use the specific technique of needle cricothyroidotomy as most anaesthetists/trainees were likely to be familiar with this technique, and re-used the jet ventilation catheter unless the cannula was damaged. A survey among Canadian anaesthetists has shown that needle cricothyroidotomy was preferred over other devices in managing a 'can't intubate can't ventilate' scenario [8]. In such a scenario, a technique that rapidly re-oxygenates the patient should be chosen. On the airway trolley, cricothyroidotomy equipment was readily available and a Sanders injector was assembled and ready to use. In real life there may be a delay in obtaining cricothyroidotomy equipment. We acknowledge that there may also be difficult anatomy, bleeding and oedema, which could not be replicated in our study.

Our study suggests that the time taken to perform cricothyroidotomy on a medium fidelity simulator under conditions of psychological stress is longer than the time taken on a manikin. The effect of psychological stress and time pressure should be considered whilst extrapolating data from manikin and simulator studies to real life scenarios. Further comparative studies using other cricothyroidotomy devices and techniques would be useful to confirm the effect of psychological stress on performance of emergency cricothyroidotomy.

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