Cadaveric Emergency Cricothyrotomy Training for Non-Surgeons Using a Bronchoscopy-Enhanced Curriculum

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Project Overview

Rescue cricothyrotomies may be performed by non-surgeons in "can't intubate, can't oxygenate situations." Inexperience can lead to increased complications, resulting in lower confidence and willingness to perform a cricothyrotomy when necessary.[1-3] Cadaveric training is superior to simulation training (landmark and tissue fidelity),[4] thus it's critical to provide robust curricula when cadaveric training is available. We developed the first cadaveric cricothyrotomy training program at CUSOM enhanced with live bronchoscopic visualization, allowing trainees to review technique and visualize posterior tracheal wall injuries.

Hypothesis

Bronchoschopic enhancement in cadaveric cricothyrotomy training for non-surgeons will:

1. Be a feasible addition while meeting accepted times for achieving an effective technique (primary objective)
2. Provide a useful means to detect intra-tracheal complications (secondary objective)
3. Be a high-quality program (secondary objective)
4. Provide a detectable training effect (secondary objective)

Methods

Utilized CU Anschutz Physical Therapy and Modern Human Anatomy programs donors with undissected necks for sessions and training video[5]

Primary objective measurements:

1. Feasibility: assessed whether enhanced program was feasible (reasonable cost, set-up time, operator skill)
2. Efficient technique: analyzed videos' puncture-to-tube times (PTt) for scalpel and Seldinger techniques and compared to published PTts

Secondary objectives measurements:

1. Intra-tracheal complication detection: analyzed videos for complications [potentially dangerous sharp instrument depths, posterior tracheal wall punctures (PTW), other]
2. Program quality: used Kirkpatrick model to assess pre- and post-survey responses measuring helpfulness, confidence, anxiety
3. Training effect: assessed PTW injury rates between sequences of 3 participants rotating together (trio)

References: 1. DeVore EK, Redmann A, Howell R, Khosla S. Best practices for emergency surgical airway: A systematic review. Laryngoscope Investig Otolaryngol. 2019;4(6):602-8. Epub 2020/01/01. doi: 10.1002/lio2.314. PubMed PMID: 31890877; PubMed Central PMCID: PMCPMC6929583. 2. Macedo MB, Guimaraes RB, Ribeiro SM, Sousa KM. Emergency cricothyrotomy: temporary measure or definitive airway? A systematic review. Rev Col Bras Cir. 2016;43(6):493-9. Epub 2017/03/09. doi: 10.1590/0100-69912016006010. PubMed PMID: 28273224. 3. Hubble MW, Wilfong DA, Brown LH, Hertelendy A, Benner RW. A meta-analysis of prehospital airway control techniques part II: alternative airway devices and cricothyrotomy success rates. Prehosp Emerg Care. 2010;14(4):515-30. Epub 2010/09/03. doi: 10.3109/10903127.2010.497903. PubMed PMID: 20809690. 4. Takayesu JK, Peak D, Stearns D (2016) Cadaver-based training is superior to simulation training for cricothyrotomy and tube thoracostomy. Intern Emerg Med 12:99–102. 5. CU Anschutz Cricothyrotomy Training Group. Emergency Cricothyrotomy Procedures: Quick Tutorial. YouTube2020. p. https://www.youtube.com/watch?v=hGI8MJNWJoc.

Results

Three training sessions, 24 total participants (13 attendings, 11 fellows)

Primary objective outcomes:

1. Feasibility: bronchoscope cost $160/scope (reusable 1-2x), 5-15 min prep/donor, one operator/donor (medical student volunteer)

Bronchoscopy generated high quality images

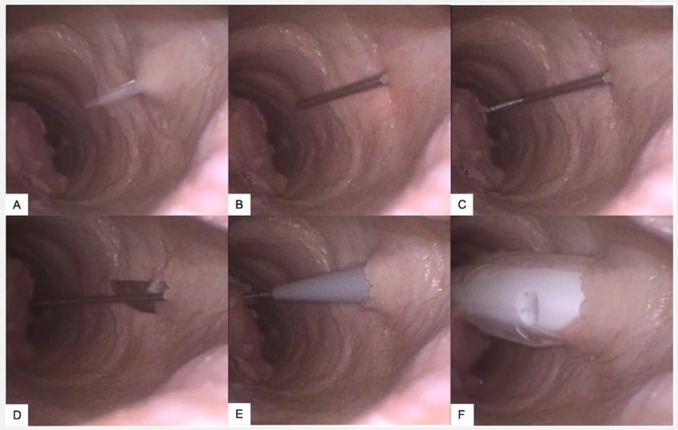

Figure 1. Representative bronchoscopic images of Seldinger technique. (A) Needle insertion (B) Needle appropriately directed inferiorly before wire insertion (C) Wire advancing through trocar needle (D) Scalpel enlarging trocar needle incision before dilator insertion (E) Introducer tip placed over wire (F) Tracheostomy tube and balloon entering

2. Efficient technique: PTts compared favorably with other published procedure times (<95 seconds)

First Author	Year	#	Educational Level (N)	Surgical Technique PTt (secs)	Surgical Technique Success Rate	Surgical Technique Posterior Tracheal Injury	Seldinger Technique PTt (secs)	Seldinger Technique Success Rate	Seldinger Technique Posterior Tracheal Injury	Live Endoscopy Feedback	Injury Exam (dissection)
Holmes	1998	32	residents (32) [emergency]	43	88%	9%	134	94%	3%	No	No
Chan	1999	30	residents (13) attendings (2) [emergency]	73	87%	0%	75	93%	0%	No	Yes
Eisenburger	2000	40	Residents (10) Fellows (10) [critical care]	56	70%	15%	70	60%	10%	No	Yes
Schaumann	2005	200	residents (40) [emergency]	119	84%	0%	99	88%	0%	No	Yes
Schober	2008	63	medical (63) students	78	94%	16%	135	71%	43%	No*	Yes
Benkhadra	2008	40	attendings (2) [anesthesia]	N/A	N/A	N/A	71	95%	20%	No*	Yes
Gulsen	2010	11	attendings (3) [surgery]	88	100%	N/A	N/A	N/A	N/A	No	No
Helm	2012	30	residents (30) [anesthesia]	95	100%	0%	N/A	N/A	N/A	No	Yes
Heymans	2016	60	medical (20) students	94	95%	10%	149	50%	10%	No*	No
Zagona-Prizio (this report)	2022	48	fellows (11) attendings (13) [critical care]	35.5	96%[a]	20%	91.3	100%	56%	Yes	No

Table 1. Published cricothyrotomy training programs using human cadavers: characteristics and data.
designates number of cadavers; PTt, puncture-to-tube time; N/A, not applicable or not available; only English language reports are listed
*endoscopy was performed and/or analyzed after training to verify success and/or to assess for wounds
[a]Success rate defined as placement of endotracheal tube within tracheal lumen

Secondary objective outcomes:

1. Intra-tracheal complication detection
   - 8 instruments punctured PTW (38% injury rate)
     - 3 scalpels (20% of scalpel recordings)
     - 5 needles (56% of Seldinger recordings)
   - 58.3% of sharp instruments went beyond tracheal midpoint
   - 2 unanticipated complications (bougie inserted adjacent to the trachea, non-advanceable ET tube)

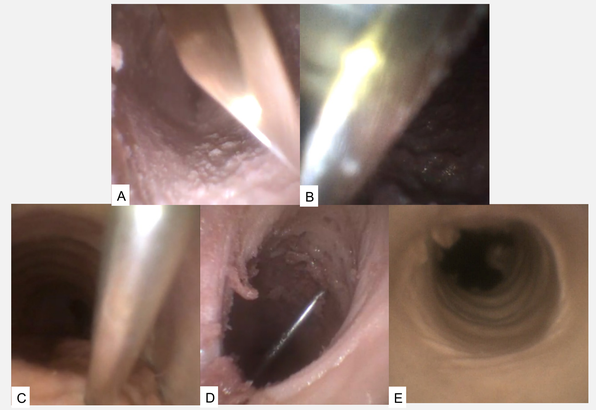

Figure 2. Bronchoscopic capture of complications (A) Scalpel puncture of posterior tracheal wall at 4 o'clock position (B) Scalpel puncture of posterior tracheal wall at 7 o'clock position (C) Needle puncture of posterior tracheal wall at 6 o'clock position (D) Needle puncture of posterior tracheal wall at 7 o'clock position (E) Absence of bougie in trachea after being placed externally

2. Program quality: achieved first 2 Kirkpatrick levels: helpful to all participants (reaction) and resulted in significantly increased confidence and decreased anxiety (learning)

Survey Question	Mean Likert score: Pre-session Mean ± SD (n=24)	Mean Likert score: Post-session Mean ± SD (n=24)	Percent Change	Z score	*P*-value
How **confident** are you that you could successfully perform an emergent cricothyrotomy on a patient in the ICU?[a]	1.87 ± 0.68	3.08 ± 0.58	64.4%	-4.34	<0.001
How **anxious** do you feel about the possibility of performing an emergent cricothyrotomy on a patient in the ICU?[b]	2.88 ± 0.74	2.54 ± 0.78	-11.6%	2.135	0.0328

Table 2. Quantitative pre- and post-session survey results.
[a]4-point Likert scale for confidence: not, slightly, moderately, extremely confident
[b]4-point Likert scale for anxiety: not, slightly, moderately, extremely anxious

3. Training effect: third trio member injured PTW significantly less often (*P=0.0395*) than preceding members

Conclusion

Bronchoscopic enhancement of cadaveric cricothyrotomy training programs may be feasibly applied at other institutions to maximize sessions and may result in fewer complications for trainees performing cricothyrotomies.

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