

A Comparison of Two Emergency Cricothyroidotomy Kits in Human Cadavers

Mehdi Benkhadra, MD*

François Lenfant, MD, PhD†

Wolfgang Nemetz, MD‡

Friedrich Anderhuber, MDS§

Georg Feigl, MD*

Jean Fasel, MD*

BACKGROUND: We compared two emergency cricothyroidotomy kits designed to avoid lesions during insertion, one based on the Seldinger technique (ST), the other based on the concept of a mechanical detection of the posterior wall of the larynx, with regard to insertion time, success rate, and complication rate.

METHODS: Cricothyroidotomy was performed under fiberoptic control in 40 human cadavers embalmed according to Thiel's technique. The set chosen for use was randomized: new technique (NT) or ST. Duration of the procedure, success rates, and incidence of laryngeal injuries were compared. Traumatic lesions observed with the fiberoptic bronchoscope were anatomically confirmed after dissection.

RESULTS: The two groups had comparable epidemiological and anatomical records. Cricothyroidotomy was performed faster with the NT than with the ST (median 54 vs 71 s, $P = 0.01$). Failure rates were comparable between groups (4 vs 1, $P = 0.34$), and there were fewer major complications in the posterior tracheal wall with the ST (0 vs 8, $P = 0.003$). In the ST group, only minor punctiform lesions of the posterior trachea wall were observed in four cases.

CONCLUSIONS: In this model, despite a shorter insertion time, the NT produced more lesions and more failures than the ST.

(Anesth Analg 2008;106:182-5)

Transtracheal oxygenation through the cricothyroid ligament is one of the recommended techniques in "cannot intubate-cannot ventilate" patients.¹⁻⁴ A new cricothyroidotomy device, based on the concept of mechanical detection of the posterior wall of the larynx, has recently been developed. The purpose of this study was to compare, on cadavers, this new device to the device based on the Seldinger technique (ST).⁵⁻⁷

METHODS

The study was conducted in the Anatomical Laboratory of the University of Graz (Austria). Two skilled anesthesiologists trained to perform cricothyroidotomy on manikins using both devices⁸ were assigned

to perform cricothyroidotomies using the new technique (NT) (Portex Cricothyroidotomy Kit, PCK®) or the ST in human cadavers preserved according to Thiel's embalming technique.^{9,10} Opaque sealed envelopes were opened just before the procedure, and each cadaver was randomly assigned to one group: the NT group (with the PCK [Fig. 1]) or the ST group (with the Melker kit [Fig. 2]). For each cadaver, epidemiological data (age, sex) and morphometric data (Body MA Index, neck circumference, thyromental distance, the difficulty to manually identify the cricothyroid ligament, and the Cormack and Lehane score [laryngoscopy with a Macintosh blade No. 3]) were recorded by a third anesthesiologist for all cadavers.¹¹ Tracheal traumatic lesions were observed using a fiberoptic bronchoscope (inserted in the larynx before each procedure), analyzed after the procedure by the three anesthesiologists, and then anatomically confirmed after dissection performed by an anatomist while the device was kept in place. Duration of the procedure (measured from the incision or puncture of the skin to the inflation of the tube cuff), success rates, and incidence of laryngeal or tracheal injuries were also compared. A procedure was considered successful if the device was placed in the correct position, as confirmed by fiberoptic bronchoscope, and the procedure lasted <5 min.

In the present study, we could include a maximum of 40 human cadavers. Because an *a priori* calculation of the number of subjects was not possible, we estimated the minimum differences that could be detected using this sample size. Assuming a median

From the *Division of Anatomy, University of Geneva, Geneva, Switzerland; †Department of Anesthesiology and Critical Care, General Hospital, University Hospital Center, Dijon, France; ‡Universitätsklinik für Anaesthesiologie und Intensivmedizin, Graz, Austria; and §Anatomisches Institut der Karl-Franzens-Universität, Graz, Austria.

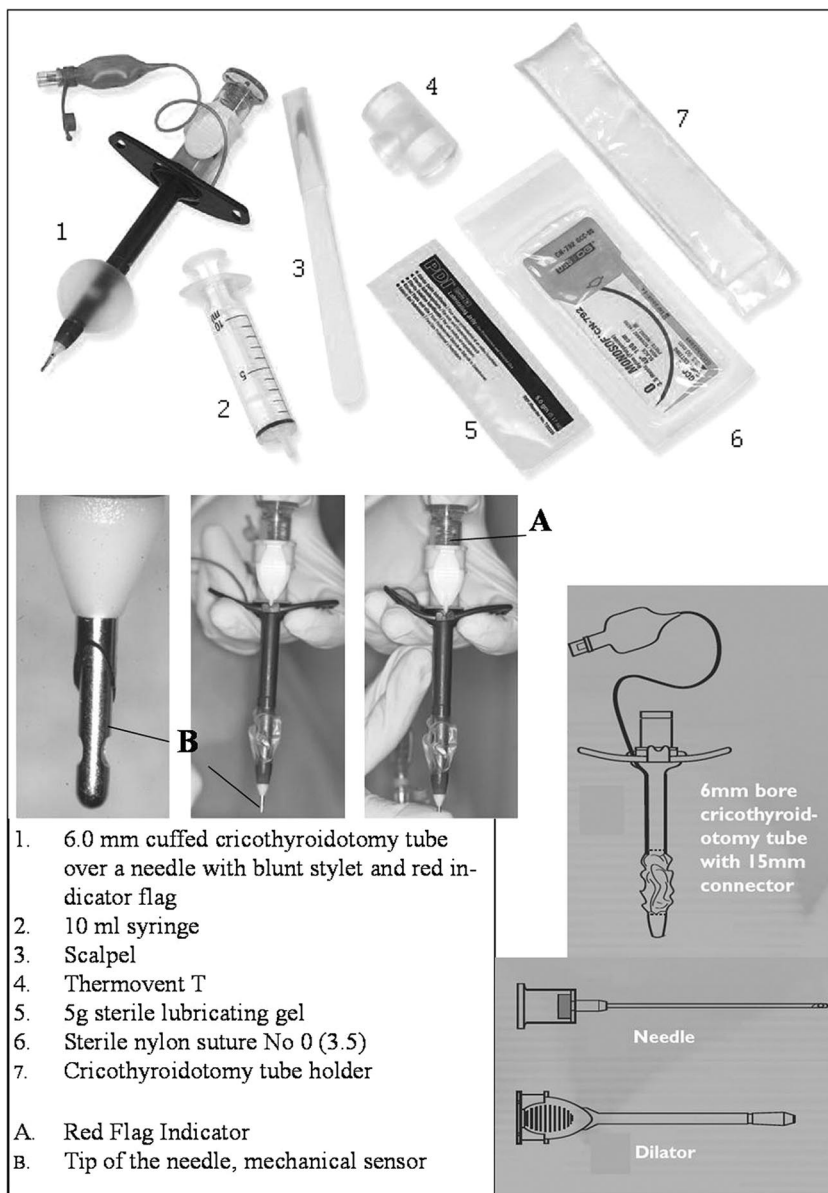
Accepted for publication September 10, 2007.

Supported solely by governmental sources (Ministères Français de la Santé de la Recherche et de l'Education Nationale). No conflict of interest has been declared. Cook® (Charenton, France), Portex®, Smiths Medical (Hythe, UK) and Olympus® (Vienna, Austria) laboratories provided the equipment, which was used and tested free of charge.

Address correspondence and reprint requests to Dr. Mehdi Benkhadra, Division d'Anatomie, Centre Médical Universitaire, 1 rue Michel Servet, 1211 Genève 4, Switzerland. Address e-mail to m.benkhadra@wanadoo.fr.

Copyright © 2007 International Anesthesia Research Society
DOI: 10.1213/01.ane.0000296457.55791.34

Figure 1. The PCK set.



duration of 70 s, a failure rate of 5% and a complication rate of 15% in the reference group (ST group), an α risk of 0.05 and a β risk of 0.20, we estimated that we could detect a decrease to 60 s in the median duration, an increase to 40% in the failure rate and an increase to 55% in the complication rate (Nquery Advisor, Statistical Solutions, Corke, Ireland). Data are expressed as mean value \pm SD, or median and 95% confidence interval when the distribution was not normal. The normality of the distribution of the variables was verified using Kolmogorov's test. The comparison of two means was performed using Mann and Whitney's test, and the comparison of proportion was performed using Fisher's exact method. All P values were two-tailed, and P values <0.05 were considered significant.

RESULTS

Forty cadavers were used for this study. The two groups, each with 20 cadavers, were comparable in

terms of age, sex, Body Mass Index, anatomical records, and Cormack and Lehane Score (Table 1). The cricothyroid ligament was easy to locate, and this maneuver required more than 10 s only once in the NT group and three times in the ST group (not significant). The insertion time was shorter in the NT group than in the ST group (median, 54 vs 71s, $P = 0.01$). We recorded more failures in the NT group than in the ST group, but the difference was not significant (Table 2) (4 vs 1, $P = 0.34$). However, in the NT group, all failures were due to the wrong position of the device, whereas the only failure in the ST group was associated with a procedure that had lasted more than 5 min with an appropriate final position of the device. There were significantly fewer major laryngeal or tracheal complications in the ST group than in the NT group (0 vs 8, respectively; $P = 0.003$) (Table 2). We observed only four minor punctiform lesions in the ST group, but major lesions in eight cases in the NT group, including perforations of the posterior wall of the trachea in four cases.

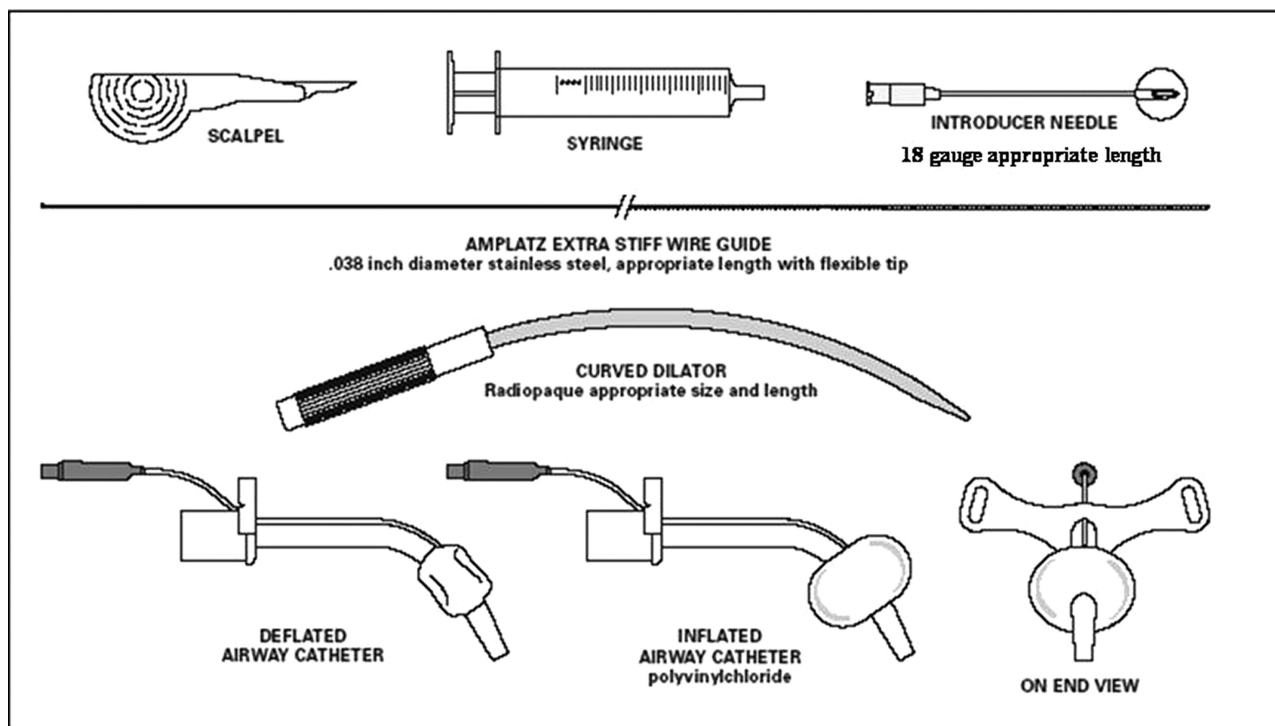


Figure 2. The Melker set.

Table 1. Main Characteristics of the Cadavers

Variable	Melker group (n = 20)	PCK group (n = 20)
Men	12 (60%)	12 (60%)
Women	8 (40%)	8 (40%)
Age (yr)	81 ± 15	77 ± 12
Body Mass Index (kg/cm ²)	21.8 ± 2.7	23.2 ± 3.1
Cervical circumference (mm)	42.0 ± 4.9	42.5 ± 5.2
Tracheal anteroposterior diameter (mm)	17.8 ± 2.4	19.1 ± 3.4
Thyro-mental distance (cm)	7.0 ± 0.9	7.0 ± 0.8
Cormack and Lehane score		
1	18 (90%)	19 (95%)
2	2 (10%)	1 (5%)

Data are expressed as mean ± SD or number (percentages). No significant differences between groups.

Table 2. Comparison of the Two Studied Groups

Variable	Melker group (n = 20)	PCK group (n = 20)	P
Procedure duration (s)	71 [60–92]	54 [47–68]	0.01
Number of failures	1 (5%)	4 (20%)	0.34
Complications			
Minor	3 (15%)	0 (0%)	0.23
Major	0 (0%)	8 (20%)	0.003
All types	3 (15%)	8 (40%)	0.11

Data are expressed as median [95% confidence interval] or number (percentages).

DISCUSSION

In our study, cricothyroidotomy performed with the NT was faster than with the ST. A mean duration of 49 s was reported for the NT in an unpublished study in 10 cadavers (A Patel: Evaluation of a New

Emergency Cricothyroidotomy Device in 10 Cadavers. Difficult Airway Society annual Scientific Meeting, 2004). When comparing the ST and the “surgical approach” (related to the NT because the PCK is inserted through an incision with a surgical blade), the ST lasted longer due to the required introduction of a guidewire before insertion of the cannula.¹²

Previous studies comparing other devices have used plastic manikins, animals, various kinds of embalmed cadavers, and live patients. Depending on the model, the success rate of the cricothyroidotomy varies. Johnson et al.¹³ reported an 86% success rate for cricothyroidotomy by “surgical approach” and a 73% rate with percutaneous devices. A 100% success rate with the standard Melker kit was reported in plastic manikins,¹⁴ whereas a similar high success rate of 92% was observed with the cuffed Melker device.¹⁵ On fresh cadavers, Eisenburger et al.¹² had a lower (60%) success rate using ST, but Schaumann et al.¹⁶ reported an 88% rate in 200 cadavers. Our study recorded a success rate of 95%. Tissue elasticity and neck rigidity of the cadavers and the experience of the operators may be among the many possible explanations for such differences. Concerning the new device, no consistent data are available in the literature, and we found a nonsignificantly lower success rate of 80%. This global success rate could be considered acceptable when compared with the global success rate of the Seldinger device. The 5-min duration limit was chosen arbitrarily, considering the fact that such a technique should be performed rapidly to avoid prolonged apnea.

Both the number and the severity of the lesions observed were lower with the ST than with the NT.

There are various reasons for this finding. First, the ST does not require any contact between the needle and the posterior wall of the larynx. In the NT, this contact is recommended, and turned out to be responsible for the lesions we encountered. Second, the guidewire may avoid a possible dissection of the posterior wall of the trachea, whereas in the NT there is no way to confirm the correct position of the device. Third, the curved form of the Melker directs the device preferentially in the caudal direction and avoids any contact with the posterior wall of the trachea, whereas the rectilinear and rigid PCK does not. In our experience, the smaller diameter of the cuffed Melker device makes it easier to insert than the PCK. In anesthetized dogs, Abbrecht et al.¹⁷ established a linear correlation between insertion force and device diameter, and the incidence of complications.

CONCLUSION

In a human cadaver model, despite requiring a shorter time to achieve the cricothyroidotomy, the NT using mechanic detection of the posterior wall of the larynx was responsible for more lesions and more failures than the standard set in which cricothyroidotomy was based on the ST.

REFERENCES

- Henderson J, Popat M, Latto P, Pearce A. Difficult Airway Society guidelines. *Anaesthesia* 2004;59:1242–3; author reply 1247
- Boisson-Bertrand D, Bourgain JL, Camboulives J, Crinquette V, Cros AM, Dubreuil M, Eurin B, Haberer JP, Pottecher T, Thorin D, Ravussin P, Riou B. Intubation difficile: Société française d'anesthésie et de réanimation Expertise collective. *Ann Fr Anesth Reanim* 1996;15:207–14
- Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005;103:33–9
- Crosby ET. Airway management in adults after cervical spine trauma. *Anesthesiology* 2006;104:1293–318
- Melker JS, Gabrielli A. Melker cricothyrotomy kit: an alternative to the surgical technique. *Ann Otol Rhinol Laryngol* 2005;114:525–8
- Chan TC, Vilke GM, Bramwell KJ, Davis DP, Hamilton RS, Rosen P. Comparison of wire-guided cricothyrotomy versus standard surgical cricothyrotomy technique. *J Emerg Med* 1999;17:957–62
- Craven RM, Vanner RG. Ventilation of a model lung using various cricothyrotomy devices. *Anaesthesia* 2004;59:595–9
- Wong D, Prabhu A, Coloma M, Imasogie N, Chung F. What is the minimum training required for successful cricothyroidotomy? A study on mannequins. *Anesthesiology* 2003;98:349–53
- Thiel W. Die Konservierung ganzer Leichen in natürlichen Farben. *Ann Anat* 1992;174:185–95
- Thiel W. Ergänzung für die Konservierung ganzer Leichen nach W. Thiel. *Ann Anat* 2002;184:267–9
- Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984;39:1105–11
- Eisenburger P, Laczika K, List M, Wilfing A, Losert H, Hofbauer R, Burgmann H, Bankl H, Pikula B, Benumof JL, Frass M. Comparison of conventional surgical versus Seldinger technique emergency cricothyrotomy performed by inexperienced clinicians. *Anesthesiology* 2000;92:687–90
- Johnson DR, Dunlap A, McFeeley P, Gaffney J, Busick B. Cricothyrotomy performed by prehospital personnel: a comparison of two techniques in a human cadaver model. *Am J Emerg Med* 1993;11:207–9
- Vadodaria BS, Gandhi SD, McIndoe AK. Comparison of four different emergency airway access equipment sets on a human patient simulator. *Anaesthesia* 2004;59:73–9
- Sulaiman L, Tighe SQ, Nelson RA. Surgical vs. wire-guided cricothyroidotomy: a randomised crossover study of cuffed and uncuffed tracheal tube insertion. *Anaesthesia* 2006;61:565–70
- Schaumann N, Lorenz V, Schellongowski P, Staudinger T, Locker GJ, Burgmann H, Pikula B, Hofbauer R, Schuster E, Frass M. Evaluation of Seldinger technique emergency cricothyroidotomy versus standard surgical cricothyroidotomy in 200 cadavers. *Anesthesiology* 2005;102:7–11
- Abbrecht PH, Kyle RR, Reams WH, Brunette J. Insertion forces and risk of complications during cricothyroid cannulation. *J Emerg Med* 1992;10:417–26