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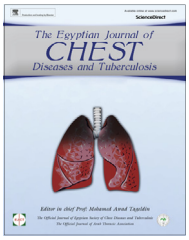

ORIGINAL ARTICLE

Emergency percutaneous tracheotomy in failed intubation

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KEYWORDS

Percutaneous dilational tracheotomy;
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Abstract *Objective:* Cricothyrotomy is the emergency surgical means of gaining access to the airways. However it holds a lot of problems to the patient and is only a temporary measure until a definitive airway is reached. Griggs' forceps technique for elective bedside percutaneous dilational tracheotomy (PDT) is safe, fast, and carries fewer complications in expert hands. This study aimed at comparing between emergency cricothyrotomy and emergency PDT in patients with failed intubation.

Design: A comparative double blind study.

Setting: Emergency room of Alexandria main university hospitals.

Patients: 169 failed to intubate, failed to ventilate patients.

Methods: They were serially randomized into group I (85 patients): percutaneous cricothyrotomy and group II (84 patients): PDT using Griggs' forceps technique.

Results: Success rate was 95.3% in group I and 97.6% in group II. Procedure duration (in minutes) was 1.85 ± 0.36 in group I versus 1.46 ± 0.31 in group II. Lung atelectasis occurred to 8.2% of patients in group I only. Vocal cord injury occurred to 4.7% of patients in group I versus 1.2% in group II.

Conclusion: Emergency PDT is feasible and safe in expert hands.

Introduction

The situation of "can't intubate, can't ventilate" in emergency room is not a common finding. However when it does occur it is life threatening and necessitates immediate intervention. According to the failed airway management algorithm in most guidelines worldwide, cricothyrotomy is the most rapid and accepted means of gaining access to the airways in such emergency conditions [1,2].

Cricothyrotomy holds a lot of problems; it might be difficult to identify the cricothyroid membrane properly, and if accessed, it may not be easy to maintain the airway. The plastic cannula is often soft and kinks easily, the more rigid cannula

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may impact on the posterior tracheal wall, and both can become easily displaced [3]. Ventilators deliver low volumes because of the small internal diameter of the cannula, and jet ventilation can cause barotrauma [4]. Another problem is the risk of injuring the cricoid cartilage, which is the only complete ring in the upper airways. Injury to which can cause scarring with subsequent subglottic stenosis [5]. Apart from this, cricothyrotomy is only a temporary solution until a definitive airway can be provided [6].

Since its introduction to work in our critical care department of the Alexandria faculty of medicine in 1999, percutaneous dilational tracheotomy (PDT) had gained a lot of familiarity. It had nearly replaced the surgical technique on elective basis. More than 1200 cases had been successfully operated and a lot of trials had been accomplished comparing surgical and percutaneous techniques, as well as different percutaneous techniques with different assisting tools, like lighted stylet, ultrasonography, and bronchoscopy. Our experience was that Griggs' forceps for PDT is faster and carries fewer complications in expert hands.

All these findings encouraged us to highlight the possible promising role of PDT in providing a definitive airway if applied on emergency basis. This study aimed at comparing between emergency cricothyrotomy and emergency percutaneous dilational tracheotomy using Griggs' forceps technique in patients with failed intubation as regards success rate, duration of the procedure, and rate of complications.

Patients and methods

Patients were those who failed intubation and/or ventilation and necessitated invasive emergency airway access according to the failed airway management algorithm. They were admitted to the Alexandria university hospitals, Alexandria, Egypt, at the period from 1st of January till the 31st of December, 2011.

Patients under 10 years of age, pregnant women, and patients with known laryngeal pathology (trauma, stenosis, or cancer) were excluded from the study. Informed consent was taken from first degree relative of every patient included in the study. This interventional study was approved from the Ethics Committee of the Alexandria faculty of medicine.

Patients admitted to the emergency room (ER) with an indication for endotracheal intubation were assessed for characteristics predictive of difficult laryngoscopy and intubation using the LEMON mnemonic scoring [7–10]. Accordingly patients were classified into:

- No difficult intubation predicted, so intubation was done following the awaken technique. If successful intubation by endotracheal tube and ventilation, patients were transferred to the ICU and were not included in the study. If unsuccessful intubation by endotracheal tube and ventilation (2 attempts, each 2 min, facilitated by cricoid pressure), patients were shifted to the difficult airway management algorithm.
- Difficult intubation predicted (anticipated scenario), so intubation was done following the difficult airway management algorithm.

The study team was announced for proceeding with the difficult airway management algorithm to the targeted patients. Bag Valve Mask (BVM) ventilation using 100% oxygen was applied with cricoid pressure and manual-in-line stabilization of the cervical spine (MILS) together with re-insertion of the oro/naso-pharyngeal airway. Oxygen saturation was determined through using finger pulse oximetry to monitor SpO_2 continuously.

- If successful BVM ventilation ($SpO_2 \geqslant 90\%$), another awaken attempt for endotracheal intubation was conducted using another laryngoscope blade with a flexible stylet while ensuring patient's optimum position. Another awaken attempt was conducted, if available and not contraindicated, using intubating laryngeal mask (ILMA-Fast-Track™). If successful intubation by endotracheal tube and ventilation, patients were transferred to the ICU and were not included in the study. If unsuccessful intubation by endotracheal tube and ventilation, patients were shifted to the failed airway management algorithm.
- If unsuccessful BVM ventilation ($SpO_2 \leqslant 90\%$), (difficult to intubate, difficult to ventilate scenario), patients were directly shifted to the failed airway management algorithm.

All patients with failed airway management were serially randomized into:

- Group I: Percutaneous cricothyrotomy group: using the Seldinger 4-step cricothyrotomy technique [1,3] with insertion of a suitable sized tube to connect to the ventilator circuit to begin ventilation. If failed, percutaneous dilational tracheotomy was performed as a definitive airway (cross group drop-out was not allowed after randomization).
- Group II: Percutaneous dilational tracheotomy group: using the Griggs' forceps dilator technique [11] with insertion of a suitable sized tube to connect to the ventilator circuit to begin ventilation. If failed, surgical tracheotomy was performed as a definitive airway.

All patients in both groups were mechanically ventilated using BI-PAP mode with suitable settings according to patients' requirements. Immediate plain A-P chest X-ray was performed to all patients after airway establishment and ventilation in both groups for assessment of the position of the artificial airway and exclusion of possible complications. Fiberoptic bronchoscopic examination of the upper airways was conducted to all patients within a time window of 1 h post-intubation for assessment of early complications caused principally by artificial airway establishment.

Selective laboratory investigations were recorded to all patients in both groups shortly after airway establishment including hemoglobin concentration, platelet count, PT, INR, and arterial oxygen saturation (SaO_2) (from arterial blood gases analyses).

Airway management data were recorded for each patient and included: success rate of establishing an artificial airway that improved and maintained $SpO_2 \geqslant 90\%$, time elapsed between needle insertion till the end of procedure in both groups, and incidence of procedure-related complications. Peri-procedural bleeding was defined as a serious one when it exceeded 50 ml of blood loss.

Patients in the percutaneous cricothyrotomy group who failed to receive their needed ventilation requirements were switched to percutaneous tracheotomy as a definitive airway after bronchoscopic examination and within 24 h according to patients' condition. However this was not calculated in the rate of failure in this group. End point of the study was the next 24 h following successful establishment of an artificial airway that improved and maintained $SpO_2 \geqslant 90\%$.

Results

Total number of patients in need for intubation was 3785. 365 patients (9.6%) had difficult airways. 298 patients with difficult airways who sustained $SpO_2 \geqslant 90\%$ with BVM ventilation 196 of them were successfully intubated soon and so were excluded from the study. 102 (2.7%) patients had $SpO_2 \geqslant 90\%$ and failed to be intubated. They were defined as cannot intubate, can ventilate type of failed airway. 67 patients (1.8%) could not sustain $SpO_2 \geqslant 90\%$ with BVM ventilation and they were defined as cannot intubate, cannot ventilate type of failed airway. So the total number of failed airway patients included in the study was 169 patients (4.5%). They were serially randomized into 85 patients (50.3%) in the percutaneous cricothyrotomy group I and 84 patients (49.7%) in the percutaneous dilational tracheotomy group II (Table 1).

Table 1 Patients categorization according to difficult/failed airway management algorithm during 2 years admissions in the ER of Alexandria university hospitals.

	Number	%
Total number (in need for intubation)	3785	100
Patients with difficult airway	365	9.6
Patients with $SpO_2 > 90.0\%$	298	7.9
Successfully intubated	196	5.2
Failed intubation (failed to intubate)	102	2.7
Patients with $SpO_2 < 90.0\%$ (failed to ventilate)	67	1.8
All failed airway patients	169	4.5

Table 2 Demographic data of studied patients.

	Group I		Group II	
	Number	%	Number	%
Age				
10–18	7	8.2	5	6.0
18–30	23	27.1	20	23.8
30–50	21	24.7	23	27.4
50 or more	34	40.0	36	42.8
Range	10–72			
Mean ± S.D.	46.7 ± 32.11			
Sex				
Male	64	75.3	58	69.0
Female	21	24.7	26	31.0

Demographic characteristics of the patients

Both studied groups were matched in age and sex without statistical significant difference inbetween (Table 2).

Primary indication for intubation

Both studied groups were matched in their primary indication for intubation without statistical significant difference inbetween (Table 3).

Primary diagnosis

Severe traumatic brain injury, maxillofacial injury, facial/oropharyngeal burn, and cervical spine injury were the commonest diagnoses in both groups without statistical significant difference inbetween (Table 4).

Success rate

Percutaneous cricothyrotomy and tracheotomy could not be done to 4 patients in group I (4.7%) and 2 patients in group II (2.4%). Percutaneous and surgical tracheotomies were performed in these patients respectively (Table 5). Later, and within 24 h, 7 patients out of the resting 81 patients in group I were shifted to percutaneous tracheotomy due to failure to meet ventilatory requirements with the cricothyrotomy tube in place.

Duration of the procedure

Duration of the procedure was calculated starting from needle insertion till applying the artificial airway. In group I, mean time (1.85 ± 0.36 min.) was non-significantly higher than that in group II (1.46 ± 0.31 min.) ($p < 0.05$) (Table 6).

Procedure-related-complications

Lung atelectasis was recorded only in group I and occurred in 7 patients (statistically significant; $p = 0.011$). Vocal cord injury was non-significantly higher in group I ($p = 0.074$). Bleeding was recorded in 2 patients in group I and in 1 patient in group II. Pneumothorax was recorded in 1 patient in each group. No patient in both groups experienced hemothorax,

Table 3 Primary indication for intubation in the two studied groups.

	Group I		Group II		Total	
	Number	%	Number	%	Number	%
Mechanical ventilation	35	38.5	37	41.1	72	39.8
Airway protection	51	56.0	49	54.4	100	55.2
Cardiac arrest	5	5.5	4	4.4	9	5.0
Total	91	100	90	100	181	100

Table 4 Primary diagnosis in the two studied groups.

Primary diagnosis		Group I		Group II		Total	
		N	%	N	%	N	%
Traumatic	Mechanical airway obstruction	4	4.7	3	3.6	7	4.1
	Severe traumatic brain injury	22	25.9	19	22.6	41	24.3
	Severe maxillofacial injury	18	21.2	23	27.4	41	24.3
	Severe facial/Oropharyngeal burn	13	15.3	15	17.9	28	16.6
	Complete cervical spine injury	10	11.7	5	5.9	15	8.9
	Bilateral incomplete vocal cord paralysis	1	1.2	2	2.4	3	1.8
	Shock	5	5.9	6	7.1	11	6.5
	Cardiac arrest	5	5.9	4	4.8	9	5.3
Medical	Hypoventilation in morbidly obese	3	3.5	5	5.9	8	4.7
	Acute pulmonary edema	4	4.7	2	2.4	6	3.5
Total		85	100	84	100	169	100

Table 5 Success rate in the two studied groups.

	Group I		Group II	
	Number	%	Number	%
Success	81	95.3	82	97.6
Failed	4	4.7	2	2.4
Total	85		84	
p	0.452			

Table 6 Duration of procedure in the two studied groups.

Time (min)	Group I	Group II
Range	1–2	1–2
Mean ± S.D.	1.85 ± 0.36	1.46 ± 0.31
p	0.106	

Table 7 Procedure-related complications in the two studied groups.

	Group I		Group II		*p*
	Number	%	Number	%	
Lung atelectasis	7	8.2	0	0.0	0.011*
Vocal cord injury	4	4.7	1	1.2	0.074
Bleeding	2	2.4	1	1.2	0.65
Pneumothorax	1	1.2	1	1.2	0.99

posterior tracheal wall injury, or false passage. No deaths were recorded due to the procedure itself in both groups (Table 7).

Selective laboratory findings

There was no significant statistical difference between both groups as regards hemoglobin concentration, platelet count, PT, or INR. As regards SaO_2, 7 patients in group I were persistently hypoxic after successful establishment of cricothyrotomy tube and beginning of mechanical ventilation (SaO_2 values: 81–85%) (Table 8).

Discussion

Percutaneous dilational tracheotomy has gained popularity and became a routine practice in most hospitals worldwide. Different techniques have been developed starting from the mid 1980s, when Ciaglia et al. [12] reported successful sequential dilations of the trachea over a guide-wire. Griggs and coworkers [11] in the early 1990s reported a plastic small pored tracheal dilator followed by dilatation using a forceps without cutting edges, through a guide-wire allowing the introduction of tracheotomy tubes with an internal diameter varying 7–9 mm.

A large number of articles have been published comparing several techniques of PDT with open surgical tracheotomy [13–22], as well as between one another [23–27]. Majority of articles reported either no statistical difference between PDT

Table 8 Laboratory findings of the two studied groups.

		Group I	Group II	*p*
Hemoglobin	Range	8.9–11.25	9.2–12.1	0.52
	Mean ± S.D.	9.25 ± 1.32	10.21 ± 2.98	
Platelet count	Range	120–220	130–240	0.25
	Mean ± S.D.	165.5 ± 25.98	170.6 ± 27.9	
PT	Range	11.0–28.0	11.9–32.0	0.62
	Mean ± S.D.	15.725 ± 6.3	16.74 ± 6.74	
INR	Range	1.00–2.20	1.00–2.7	0.098
	Mean ± S.D.	1.62 ± 0.37	1.86 ± 0.52	
SaO_2	Range	81–100	92–100	0.077
	Mean ± S.D.	93.9 ± 5.14	96.01 ± 2.98	

and surgical technique [14–28] or lower complication rate associated with performing PDT [16–19]. Less time was reported in all published articles. Most authors considered short or obese neck, enlarged thyroid gland, inability to extend the neck, coagulopathy, and/or previous neck surgery as relative contra-indications to perform PDT [13–29], whereas pediatric age group, cervical injury, and emergency airway access were regarded to as absolute contra-indications [20,30–32].

By reviewing the literature we did find a number of articles addressing the feasibility and safety of performing PDT to most if not all these contra-indications and also on emergency basis [33–36]. This has encouraged us to highlight our experience in achieving a definitive airway in a shorter time with fewer complications using the Griggs' forceps technique to perform PDT on emergency basis.

Alexandria university hospital is a tertiary hospital that presents free medical service to about 7 million people. Yearly admissions reach about 75,000 patients. Total number of patients in need for intubation in this year duration of the study was 3,785. Total number of failed airway patients included in the study was 169 patients (4.5%). This number was definitely higher than expected and was mainly attributed to rush of trauma cases in complex situations during the January 25th revolution in Egypt and the following series of events allover this year.

Analysis of nearly 9000 emergency department (ED) intubations in the National Emergency Airway Registry (NEAR) found that surgical cricothyrotomy is required in approximately 0.8% of all emergency intubations and 1.7% of intubations of trauma patients [9,37]. An earlier, single center study of 610 emergency intubations noted a cricothyrotomy rate of 1.1% [38]. Such a percentage is almost double to three fold the percentage in the operating room (OR), and this can be attributed to nature of patients in ER whom airway problems present as an emergency with consequent lack of time for pre-intubation assessment and preparation and the severity of the patient's medical condition with a narrow window of reserve complicating the condition.

Patients younger than 10 years of age were excluded from this study because of the smaller size of their cricothyroid membrane making cricothyrotomy very difficult and hazardous to these patients. For the same idea, those with laryngeal trauma, stenosis, or cancer were also excluded from the study. Pregnant women were also excluded due to fear of X-ray radiation exposure. All the previously mentioned categories of patients were subjected to PDT as a definitive airway outside the scope of this study.

Success rate to achieve an artificial airway in the cricothyrotomy group I was 95.3%. The rest of patients who failed (4 patients) had unidentified anatomical landmarks and so percutaneous tracheotomy was performed to these 4 patients and were not calculated in the study as a privilege to PDT. On the other hand, 97.6% of patients in the percutaneous tracheotomy group II (82 patients) were successfully cannulated. The 2 remaining patients who failed showed huge goiter with unidentified landmarks and high suspicion of cervical trauma, so the trachea was deep enough to the degree that necessitated performing open surgical tracheotomy to both of them that had been achieved successfully in about 5 min duration without deleterious sequelae to either of them.

Alone Ben et al. [35] showed 100% success rate in performing PDT on emergency basis to only 10 patients. This absolute success rate can be partly attributed to the relatively fewer number of patients in his study when compared to the 84 patients in the current study.

Duration of the procedure in group I was 1.85 ± 0.36 min. Schaumann et al. [39] found that experienced clinicians need 0.7 min to complete the procedure but with higher rate of complications. This time is two thirds that recorded in our study; however the difference is seconds rather than a minute.

In group II, duration of the procedure was 1.46 ± 0.31 min. This duration was definitely shorter than Alone Ben et al. [35] who achieved the procedure in 5.5 min. Dop et al. [6] in his case report study had performed the procedure to 2 patients in 3 min duration. Klein et al. [40] in his case report study achieved emergency percutaneous tracheotomy to 4 patients in about 2 min duration.

Most of the known procedure-related complications were either nil or relatively low in both groups. 1 patient in each group showed pneumothorax. Both were COPD patients and showed multiple emphysemtous bullae on X-ray films and were managed immediately by intercostal tube insertion. Bleeding that had occurred in 2 patients in group I and in 1 patient in group II was attributed to high INR values (1.95, 2.2, and 2.7 respectively) and was controlled easily by packing and compression for 10 min duration without any residual. No patient in both groups died because of the procedure.

It deserves mention that lung atelectasis that did not occur in group II was recorded in 7 patients in group I. This was attributed to the smaller size of the tube inserted delivering low volumes of positive pressure ventilation together with the higher resistance met with these tubes, increasing the resistance with difficulties in suction procedures and higher incidence of obstruction[4]. Incidence of vocal cord injury was non-significantly higher in group I, $p > 0.05$. Again vocal cord injury is a well known complication of the Seldinger technique of cricothyrotomy [41].

As regards arterial oxygen saturation, 7 patients in group I were persistently hypoxic after successful establishment of cricothyrotomy tube and beginning of mechanical ventilation (SaO_2 values: 81–85%). Such hypoxia was attributed to lung atelectasis that occurred in these patients. However it had been corrected shortly after performing percutaneous tracheotomy as a definitive airway with insertion of a more suitable tube.

Conclusion

From the previously mentioned we can conclude that although success rate and time to complete both procedures were comparable; however performing PDT to patients on an emergency basis in such a short time is much superior in providing a definitive airway rather than the temporary solution of cricothyrotomy with all its known possible complications and ventilatory obstacles. We have a very promising future expectation for the emergency percutaneous dilational tracheotomy using Griggs' forceps technique, hoping to highlight its encouraging role in any future alterations in the algorithm of failed airway management.

Conflict of interest

We have no conflict of interest to declare.

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