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Prospective study of percutaneous tracheostomy: Role of bronchoscopy and surgical technique

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Abstract

Objective: Percutaneous tracheostomy is a common procedure but varies considerably in approach. The aim of our study was to evaluate the need for intraoperative bronchoscopy and to compare various surgical techniques.

Methods: During 1 year all percutaneous tracheostomies in three intensive care units were prospectively documented according to a unified protocol. In one unit, bronchoscopy was used routinely and in others only during the study.

Results: A total of 111 subjects (77 males) with median age 64 (range, 18–86) years and body mass index 25.4 (range, 15.9–50.7) were included. In unit A, tracheal wall was directly exposed; in unit B, limited dissection to enable tracheal palpation was made. In both units, bronchoscopy was used to check the location of an already inserted guiding needle; needle position required correction in 8% and 12% of cases, respectively. In unit C, in tracheostomies without pretracheal tissue dissection, bronchoscopy was used to guide needle insertion; needle position required correction in 66% of cases. Median duration of operations performed by thoracic surgeons and residents was 10 (range, 3–37) min and by intensive care doctors and residents was 16.5 (range, 3–63) min ($p < 0.001$). Time from the beginning of preparations for tracheostomy until the end of the whole procedure was median 32 min for bedside tracheostomies and 64 min for operations in the operating theatre ($p < 0.001$).

Conclusion: Limited pretracheal tissue dissection enabled proper guiding needle insertion and bronchoscopy was rarely needed. Percutaneous tracheostomies performed by thoracic surgeons took less time, and duration of the whole procedure was remarkably shorter when performed at bedside.

Keywords

Tracheostomy, bronchoscopy

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Introduction

Tracheostomy is a common procedure in patients requiring prolonged mechanical ventilation. During last decades, the technique of the procedure has evolved notably. A less invasive method – percutaneous tracheostomy (PT) – has become more widely used and is already considered the gold standard by some authors.[1] PT, compared to standard surgical tracheostomy, is quicker, has less intraoperative bleeding, is associated with fewer complications, and is cost effective.[2,3] PT can be performed outside the operating theatre (either at bedside or in an intensive care unit (ICU) theatre) and by different specialists – surgeons, anaesthesiologists, otorhinolaryngologists, and others.[3–5]

Considerable variation exists in the surgical technique of PT – surgical dissection to explore trachea can be performed to a various extent;[6,7] a dilatator or forceps can be used to

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create access to trachea.[8–10] In addition, the need for routine use of bronchoscopy to guide PT is still debatable.[4,11,12] It has been demonstrated in a cadaveric study that in 24% of cases blind tracheal puncture resulted in inaccurate positioning of the tracheostomy tube.[13] In case of a too high puncture site, the cricoid cartilage can be injured,[13] increasing the risk of postoperative tracheal stenosis. However, a recent study in trauma patients revealed that the use of bronchoscopy did not alter the rate of tracheostomy complications.[14]

There is no consensus about the indications for bronchoscopic guidance during PT (routine use or use in special circumstances) or the extent of surgical neck dissection to avoid tracheostomy tube misplacement. In several centres, bronchoscopy is never used.[4,6,12]

We conducted the study to compare the different surgical techniques of PT, routinely used in our hospital, and to evaluate the need for intraoperative bronchoscopy.

Materials and methods

This cross-sectional study was approved by the Tartu University Research Ethics Committee. During a 1-year period (1 January 2012 to 31 December 2012), all PT cases in three ICUs (A, B, and C) of a University Hospital were prospectively documented according to a unified protocol. Study period (1 year) was predefined. Subject data listed in Table 1 were collected.

Table 1. Criteria registered in every study subject undergoing PT.

Age (years)
Gender (male or female)
BMI (kg/m^2)
Diagnoses
Date of hospitalisation
Date of the start of mechanical ventilation
Department (A, B, or C)
Date of tracheostomy
Surgeon
Place where tracheostomy was performed (ICU bed or ICU theatre)
Size of intubation tube (Fr)
Size of tracheostomy tube (Fr)
Initial position of the guiding needle
Need for correction of the guiding needle
Number of punctations
Intraoperative complications
Conversion to open tracheostomy
Duration of the operation (min)
Duration of bronchoscopy (min)
Total time related to performing the tracheostomy
Intrahospital complications

PT: percutaneous tracheostomy; BMI: body mass index; ICU: intensive care unit.

The surgical technique in each of the three units was different, yet unified within one unit, allowing comparison of the methods used.

Surgical technique

In units A and C, PTs were performed in the ICU theatre, and in unit B in the ICU bed. In all units, the study subject was anaesthetised and the intubation tube was withdrawn under laryngoscopic guidance. The operative field was prepared with alcohol solution and covered with sterile drapes. A 2- to 3-cm horizontal skin incision approximately one finger-breadth above the sternal notch was made. The following surgical dissection was one of the biggest differences between the units: (1) in unit A, careful dissection of pretracheal tissues was performed to clearly visualise the anterior tracheal wall; (2) in unit B, moderate dissection was performed to allow tracheal wall palpation; and (3) in unit C, no dissection was used. Catheter introducer needle 16G was inserted into trachea under visual control in unit A, guided with palpation in unit B, and with bronchoscopic guidance in unit C. Although bronchoscopy was not routinely performed in units A and B to guide the procedure, in this study, we used it to define the location of the already inserted catheter introducer needle. In case of needle misplacement, trachea was punctated again under bronchoscopic guidance in all the units. The needle entry site was defined correct when it was located between '11 and 1 o'clock' and below the first and above the fourth tracheal cartilage. In case of correct entry, the needle was removed and the guiding wire was introduced through the remaining catheter. Over the wire introducer, a dilatator was inserted to widen the opening. Further dilatation was performed either by forceps (Portex Griggs Percutaneous Dilation Tracheostomy Kit, Smiths Medical) or dilatators (Ultraperc Percutaneous Introducer Kit, Smiths Medical). Then, over the guiding wire, a tracheostomy tube was inserted. The tube cuff was inflated and mechanical ventilation through the tracheostomy tube was started. After that the intubation tube was removed.

Study subjects were followed up until death or discharge from the hospital.

Statistical methods

Common graphical procedures were applied for studying the relationships between the variables in interest (scatterplot for two continuous variables, boxplots for one continuous and one discrete variable, and barplots for two discrete variables). Associations between a continuous and a discrete variable were tested with Kruskal–Wallis or Wilcoxon rank-sum test. Associations between continuous variables were analysed using Spearman's rank correlation analysis. Associations between two discrete variables were studied with Fisher's exact test. Additionally, multivariable logistic regression was used to analyse the relationship between ICU and need for catheter introduction needle position correction, and complications. Analysis of covariance was applied to study the

Table 2. Description of study subjects in units A, B, and C and the distributions of outcomes.

	Unit			Multivariable regression p-value
	A	B	C	
	N = 49	N = 33	N = 29	
Male, n (%)	35 (71)	20 (61)	22 (76)	
Age, mean (SD)	61 (14.5)	67 (19.0)	53 (16.7)	
BMI, mean (SD)	28 (7.6)	24 (4.3)	26 (5.6)	
INR, mean (SD)	1.3 (0.35)	1.2 (0.21)	1.1 (0.15)	
Needle correction				$p < 0.001$[a]
No, n (%)	45 (92)	29 (88)	10 (34)	
Yes, n (%)	4 (8)	4 (12)	19 (66)	
Operation time, min				$p = 0.003$[b]
Mean (SD)	18 (9.4)	12 (7.8)	16 (8.6)	
Median (min–max)	17 (5–63)	10 (3–37)	16 (3–37)	
Complications				$p = 0.45$[a]
None, n (%)	32 (65)	17 (52)	18 (62)	
Bleeding +, n (%)	12 (24)	10 (30)	9 (31)	
Bleeding ++/+++, n (%)	5 (10)	6 (18)	2 (7)	

SD: standard deviation; BMI: body mass index; INR: international normalised ratio.
[a]Logistic regression.
[b]Analysis of covariance; both adjusted for age, gender, BMI and INR.

association between ICU and length of operation; assumptions of the analysis were checked by graphical methods and the outcome variable was transformed if necessary. The results of both analyses were adjusted for age, gender, body mass index (BMI), and international normalised ratio (INR). Significance level of 0.05 was used. Bonferroni correction was used when comparing the distributions of complications with different surgical instruments. Statistical environment R version 3.0.1 with ggplot2 package was used for data analysis.

Results

A total of 111 study subjects (34 females, 77 males) with median age of 64 (range, 18–86; interquartile range (IQR), 48–75) years and BMI of 25.4 (range, 15.9–50.7; IQR, 22.9–29.2) were included. Study subjects' preoperative INR value ranged from 0.86 to 2.39 (IQR, 1.07–1.29).

In all, 49 PTs were performed in unit A, 33 in unit B, and 29 in unit C.

The tracheostomies were performed by:

- Intensive care doctors in 65 cases (all the 49 cases in unit A, 5 in unit B, and 11 in unit C);
- Intensive care residents in 18 cases (all in unit C);
- Thoracic surgeons in 19 cases (18 cases in unit B and 1 in unit C);
- Surgical residents in 9 cases (all in unit B).

Age, BMI, and INR distributions differed significantly between the units (Kruskal–Wallis test p was 0.001, 0.005, and 0.04, respectively), whereas proportion of women was similar.

Correction of catheter introducer needle position

In unit A, anterior tracheal wall was directly exposed; in unit B, limited dissection to enable immediate tracheal wall palpation was made. Following the study protocol, bronchoscopy was only used to check the location of the already inserted catheter introducer needle. In these units, the needle position required correction in 8% and 12% of cases, respectively (Table 2). In unit C, bronchoscopy was routinely used to guide needle insertion, as pretracheal tissue was not dissected, and the needle position required correction in 66% of cases. Adjusted odds for needle correction in unit C were 21 times higher (95% confidence interval (CI), 6–96) than in unit A and 15 times higher (95% CI, 4–78) than in unit B.

Duration of the whole procedure

Median time from the beginning of preparations until the end of the whole procedure was 32 min in PTs performed in ICU bed and 64 min for PTs in ICU theatre ($p < 0.001$).

Median duration of operations performed by thoracic surgeons and surgical residents (unit B) was 10 (range, 3–37) min and by intensive care doctors and residents was 16.5 (range, 3–63) min ($p < 0.001$). The age-, gender-, BMI-, and INR-adjusted mean operation time in unit B was 3 min shorter (95% CI, 0.7–6.0) than in unit A and 4 min shorter (95% CI, 0.8–6.9) than in unit C.

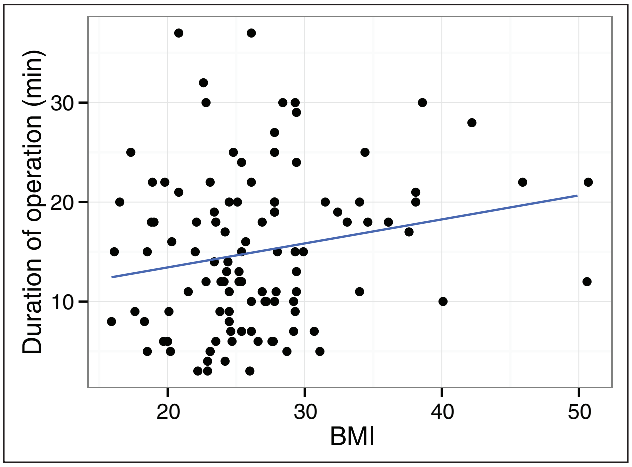

Figure 1. Relation between BMI and duration of PT.

Relation between BMI and operation duration was also analysed. One outlier with exceptionally long operation duration was excluded from this analysis. The Pearson correlation coefficient between BMI and operation time was 0.20 (95% CI, 0.01–0.37), and the p-value of the respective z-test was 0.04 (Figure 1). A one-unit increase in BMI prolonged the operation by 0.24 (95% CI, 0.01–0.47) min.

Complications

Complications were observed in 44 study subjects, in majority of cases minor bleeding requiring no intervention (Table 3). There was no difference in the distribution of complications in the three ICUs (p = 0.60) (Figure 2). The adjusted odds of the occurrence of any complications was similar in the units (logistic regression likelihood ratio test p-value 0.45).

In all, 49 study subjects had INR value above the normal 1.2. No association between INR and complication severity was seen (p = 0.39).

A total of 42 (37.8%) study subjects were overweight (BMI, 25–29.9), 14 (12.6%) were obese (BMI, 30–39.9), and 5 (4.5%) had morbid obesity (BMI ⩾ 40). There were no significant differences in BMI among study subjects with and without complications. Wilcoxon rank-sum test comparing BMI in study subjects with one tracheal punctation and in study subjects with guiding needle correction (⩾2 punctations) resulted in p-value of 0.70, indicating no difference in the central tendency of the distributions of BMI in the two groups (Figure 3).

Dilatators or dilatational forceps (or in some cases both) were used for tracheal dilatation to facilitate tracheostomy tube insertion. Difference in the distribution of complications between the different instruments used appeared statistically significant (Fisher's exact test p = 0.006) (Figure 4). In further analysis, three separate comparisons of distributions of complications, while using different instruments, were performed: forceps versus dilatators, forceps versus both instruments, and dilatators versus both instruments. These comparisons were restricted by Bonferroni correction of significance level, which was set to 0.05/3 = 0.0167. Of these three comparisons, only the difference between using forceps and using both instruments was statistically

Table 3. Intra- and postoperative complications of PT.

Minor bleeding requiring no intervention	31
Bleeding stopped by applying haemostatic sponge	9
Bleeding that required re-intervention	4
Dislocation of the tracheostomy tube	1
Puncture of the tracheal membranous wall	1
Conversion to open tracheostomy	0

PT: percutaneous tracheostomy.

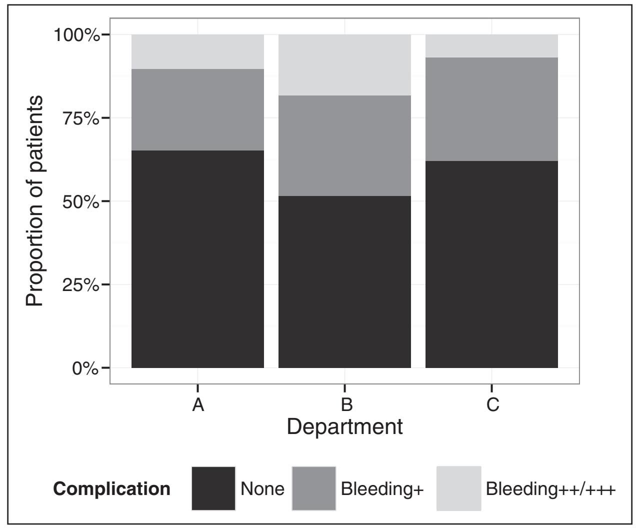

Figure 2. Distribution of PT complications in different departments (Fisher's exact test p = 0.60).

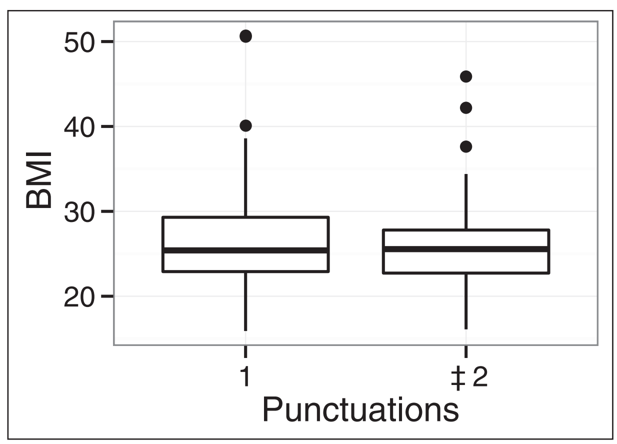

Figure 3. BMI in study subjects needed one punctation compared to study subjects who needed guiding needle correction (⩾2 punctations) (Wilcoxon rank-sum test p = 0.70).

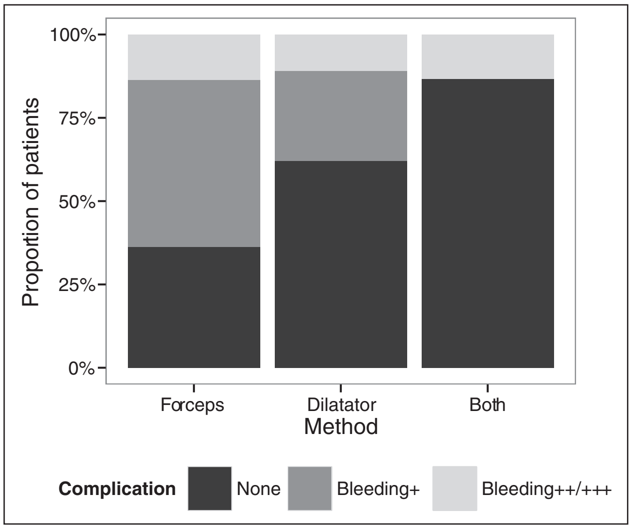

Figure 4. Distribution of bleeding complications between different dilatation methods. Significantly more bleeding occurred in forceps method compared to both methods group (Fisher's exact test $p < 0.001$). Difference between dilatators and forceps method did not reach statistical significance.

significant (Fisher's exact test $p = 0.001$), meaning that using only forceps resulted in more complications (bleeding).

Discussion

PT is performed by various medical specialists and using different surgical techniques. The main differences are the extent of surgical dissection to expose the tracheal wall before insertion of the catheter introducer needle, use of either dilatators or forceps for tracheal dilatation, and using or not using bronchoscopic guidance during the procedure.

According to our study, limited surgical dissection for tracheal wall palpation and the more extensive dissection enabling direct visualisation of trachea, both result in proper insertion of the catheter introducer needle without bronchoscopic control in about 90% of cases. Either of these techniques allow to avoid routine use of bronchoscopy. Similarly, it has been demonstrated that blunt dissection of pretracheal tissue and tracheal palpation by finger ensure safe tracheal puncture without bronchoscopic guidance.[6] Another approach is to make a skin incision and to puncture trachea without surgical dissection of pretracheal tissues. That caused misplacement of catheter introducer needle during first attempt to puncture the trachea in two-thirds of cases in our study, making bronchoscopic guidance obligatory.

The main postoperative complication after PT is bleeding.[15,16] We observed bleeding in 39.6% of study subjects, yet in majority of cases, it was very mild and stopped without any intervention. Higher bleeding rate, compared to reports from other studies, is probably related to strict registration of any bleeding in our prospective study. Major bleeding occurred in 3.6% of cases, a result similar to other studies.[10,16] There were no differences in postoperative bleeding in study subjects with different extent of surgical dissection, neither was bleeding influenced by to study subjects' preoperative INR value. Using forceps for tracheal wall dilatation seemed to cause more postoperative bleeding, compared to the use of dilatators; however, the difference did not reach statistical significance. In a recent meta-analysis, considerably more intraoperative bleeding was reported while using forceps versus single dilatator technique (19.3% vs 7.6%, respectively; $p = 0.018$), but there was no difference in postoperative bleeding.[9]

Other complications after PT are very rare. We observed only one case of posterior tracheal wall puncture by catheter introducer needle, which occurred in the group where bronchoscopy was used during the whole procedure. The puncture site healed spontaneously. The same complication has been described in a few cases by several authors.[7,15,17] In a study of 500 PTs performed under continuous bronchoscopic guidance, three cases of posterior tracheal wall injury were registered. As all these complications occurred during first 50 PTs performed, it was attributed to the learning curve.[15] In general, intraoperative complications of PT are rare; however, a few cases of pretracheal insertion of cannula, hypoxaemia, hypotension, and death have been described.[2,4,10]

Increased body weight is a common problem nowadays, potentially influencing the selection of PT technique. In patients with morbid obesity, landmarks of neck anatomy are difficult to identify, making PT contraindicated.[11,15] Still, in many obese study subjects PT can be safely performed, especially with increasing experience, when most traditional absolute PT contraindications become relative.[18] In our study, PT duration in study subjects with increased BMI was longer; however, the complication rate was not higher. Conflicting results concerning the rate of complications have been reported earlier. In one large study, Byhahn et al.[19] found that obese patients had a 2.7-fold increased risk for perioperative complications, and a 4.9-fold increased risk for serious complications, compared to non-obese patients. In another study of 120 PTs, Romero et al.[20] found no statistically significant difference in the incidence of perioperative complications between obese and non-obese patients.

One advantage of PT is that the procedure can be performed in an ICU bed.[4] In our hospital, it is routinely performed in the ICU bed in one of the departments and in the ICU theatre in the two others, which allowed us to compare the total time spent for the procedure, starting with preparations to the end of the whole procedure, when the study subject is back in his or her bed and everything is cleaned up. Operating in the ICU bed considerably saved time, the resource valuable in the era of shortage of medical staff. Looking at the duration of the surgical procedure, we saw that operations performed by thoracic surgeons or surgical residents took less time than operations performed by anaesthesiologists or respective residents. This finding supports the importance of experience when performing any surgical procedure. The importance of previous neck surgery experience and improvement in results after a learning curve have also been demonstrated by other researchers.[4,6]

We acknowledge that our study was limited by the relatively small number of study subjects in each group, not allowing us to analyse in depth the differences in complications between study groups. In addition, tracheostomies were performed by either surgeons or anaesthesiologists with different surgical experience, influencing the duration of the operation and likely also the need for bronchoscopy to guide tracheal puncture.

Conclusion

Surgical dissection of pretracheal tissue to expose the anterior wall of the trachea allowed proper guiding needle insertion and bronchoscopic support was rarely needed. PTs performed by surgeons took less time, and the duration of the whole procedure was remarkably shorter when performed in ICU bed.

Higher BMI prolonged the operation, but did not increase the number of complications. The main complication of PT was postoperative bleeding, although mild in majority of cases. Using forceps compared to dilatator for tracheal dilatation increased bleeding, but the difference was not statistically significant.

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Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was obtained from Tartu University Ethics Committee (approval number 243/T-23).

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Informed consent

No informed consent was obtained from study subjects before the study. As the study was performed in ICU and all study subjects were in general anaesthesia, it was not possible to obtain any informed consent for the study. We did not change the routine practice in the department; therefore, the content was not necessary.

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