Prevention of tracheal cartilage injury with modified Griggs technique during percutaneous tracheostomy – Randomized controlled cadaver study

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Abstract: *Introduction:* Tracheal stenosis is the most common severe late complication of percutaneous tracheostomy causing significant decrease in quality of life. Applying modified Griggs technique reduced the number of late tracheal stenoses observed in our clinical study. The aim of this study was to investigate the mechanism of this relationship. *Materials and methods:* Forty-six cadavers were randomized into two groups according to the mode of intervention during 2006–2008. Traditional versus modified Griggs technique was applied in the two groups consequently. Wider incision, surgical preparation, and bidirectional forceps dilation of tracheal wall were applied in modified technique. Injured cartilages were inspected by sight and touch consequently. Age, gender, level of intervention, and number of injured tracheal cartilages were registered. *Results:* Significantly less frequent tracheal cartilage injury was observed after modified (9%) than original (91%) Griggs technique ($p < 0.001$). A moderate association between cartilage injury and increasing age was observed, whereas the level of intervention ($p = 0.445$) and to gender ($p = 0.35$) was not related to injury. Risk of cartilage injury decreased significantly (OR: 0.0264, 95%, CI: 0.005–0.153) with modified Griggs technique as determined in adjusted logistic regression model. *Discussion:* Modified Griggs technique decreased the risk of tracheal cartilage injury significantly in our cadaver study. This observation may explain the decreased number of late tracheal stenosis after application of the modified Griggs method.

Keywords: percutaneous tracheostomy, tracheal stenosis, tracheal cartilage injury, cadaver, Griggs technique

Introduction

Long-term mechanical ventilation with prolonged intubation is one of the most important task of intensive care resulting in possible severe early and late complications. Ventilator-associated pneumonia (VAP), septic complications, decreased patient's comfort, increased nursing days, and late tracheal stenosis could be anticipated performing early tracheostomy [1–3]. Percutaneous dilational tracheostomy (PDT) could be superior to surgical method during prolonged mechanical ventilation [4, 5].

Progress in intensive therapy resulted in development of new percutaneous techniques. However, percutaneous techniques can also result in severe early and late complications especially acute bleeding and late tracheal stenosis [6–8]. The applied technique and the available time for mechanical hemostasis allowing careful tissue preparation between tracheal cartilages could be important factors preventing these complications.

Modified Griggs technique was used to be developed in our clinical practice in order to decrease early and late complications. Our retrospective clinical study showed that both early and late complications were reduced with these technical amendments [9]. Applying the modified Griggs technique could prevent tracheal cartilage injury during insertion of the tracheostomy tube. The aim of this randomized cadaver study was to obtain further observational data for safety of the modified bidirectional forceps dilation with special regard to tracheal cartilage destruction.

Materials and Methods

Forty-six cadavers were assessed for eligibility during 2006–2008. Gender, age, level of intervention, and number of injured cartilages were recorded. Four groups of age, two groups of gender, two groups of the level of intervention in relation to cricoid cartilage, and three groups of the number of injured cartilages were established. Inclusion criteria were as follows: a) autopsy performed in 72 hours after death, b) patient has not

suffered from laryngeal illness or from tracheal injury, c) patient was not tracheostomized before, and d) patient was older than 40 years of age. Cadavers were randomly assigned into two groups according to the method of intervention (standard versus modified Griggs technique) after inclusion.

Incisions were performed on the midpoint of cricothyroid ligament and jugulum resulting in intercartilaginous puncture in the level of 2nd or 3rd tracheal cartilages during autopsy in both groups. Standard Griggs technique: 20 mms skin incision, no surgical preparation, direct tracheal punction, and unidirectional (transverse) tracheal dilation were performed followed by the tracheostomy cannula insertion in the first group as was described by Griggs et al. [10]. Modified Griggs technique: 50-mm wide skin incision, surgical pretracheal tissue preparation, and careful visualized bidirectional (transverse and longitudinal) intercartilagenous forceps dilation of tracheal wall were performed in the second group.

The 50-mm wide horizontal skin incision provided enough place for secure pretracheal preparation until tracheal wall could be visualized and palpated as well as in our modified technique. Preparations were performed using blunt technique, and Griggs forceps were usually used in order to ascertain tissue resistance followed by the tracheal puncture according to Watters recommendations [11]. Visualized tracheal wall puncture next to the palpating finger and continuous aspiration of air secured correct intratracheal needle position as mentioned by Paran et al. [12]. Insertion of the guidewire followed by the introducer was the next step. Griggs forceps was introduced using the guidewire according to the standard method as deep as about 15 mm from the axis of rotation, and horizontal dilation was performed using both hands. Then, the forceps was rotated 90 degrees in longitudinal direction and another double-handed forceps dilation was made in the vertical direction. After removing the forceps, tracheostomy tube was inserted into the trachea using the guidewire.

Leaving the tracheostomy tube in place, the larynx, pharynx and trachea were dissected, carefully avoiding further tracheal injury in both groups. The posterior laryngeal wall was opened up, and tracheal cartilage injuries were verified by visualization and palpation as well.

Gender, age, level of intervention, number of injured tracheal cartilages, and the method of Griggs technique (standard vs. modified) were recorded by the same investigator in all cases. Pearson chi-square tests were applied for data evaluation, then logistic regression was performed, adjusting to the potential confounders in the study.

Licence number of the investigation issued by responsible Research Ethical Committee is TUKEB 117/2006.

Results

Percutaneous tracheostomy was carried out in 46 cadavers (24 men/22 women) altogether. Nine subjects were 41–60 years old, 12 were 61–70 years old, 14 were 71–80 years old, and 11 were older than 80 years of age at the time of death. Tracheal puncture was performed in the level of second tracheal cartilage in 25 cases and in the level of third tracheal cartilage in 21 cases. Standard Griggs technique was applied in 23 cases, and modified Griggs technique also in 23 cases according to randomization. There was no cartilage injury observed in 20 cases, one or two injured cartilages were noticed in 13 of the 13 cases consequently. The method of intervention was significantly associated with cartilage injury: 9% of subjects in the modified technique group, whereas 91% in the standard Griggs method group suffered any cartilage injury ($p<0.0001$). No relationship was observed between the method of intervention and interventional level ($p=0.767$), age ($p=0.642$), and gender ($p=0.555$), respectively *(Table I)*.

Furthermore, the number of injured tracheal cartilages was associated with increased age ($p=0.030$), while there was no association between the number of injured cartilages and the level of intervention ($p=0.445$) and gender ($p=0.35$) *(Table II)*.

Logistic regression analysis was performed to rule out the effect of potential confounders in our study.

Table I Association between the method of intervention during percutaneous tracheostomy (standard versus modified Griggs technique) and baseline clinical data and number of cartilage injuries

	Standard Griggs technique	Modified Griggs technique	*P*-value, Chi-square test
Level of intervention: Above the 2nd / 3rd tracheal cartilage	12 / 11	13 / 10	0.767
Age (year): 41–60 / 61–70 / 71–80 / >80	4 / 5 / 9 / 5	5 / 7 / 5 / 6	0.642
Gender: Male / Female	10 / 13	12 / 11	0.555
Number of injured cartilages: 0 / 1 / 2	2 / 11 /10	18 / 2 / 3	< 0.0001

Table II ‖ Relationship between cartilage injury and study variables

	Injured cartilages No.			*P*-value, Chi-square test
	0	1	2	
Level of intervention: Above the 2nd / 3rd tracheal cartilage	13 / 7	6 / 7	6 / 7	0.445
Age (year): 41–60 / 61–70 / 71–80 / >80	7 / 7 / 3 / 3	2 / 2 / 7 / 2	0 / 3 / 4 / 6	0.030
Gender: Male / Female	12 /8	5 / 8	5 / 8	0.350
Griggs technique: Standard / Modified	2 /18	11 / 2	10 / 3	< 0.0001

The presence of tracheal cartilage injury was significantly related to method of intervention in our model adjusted for age, gender, and the level of intervention. Application of the modified Griggs technique (bidirectional forceps dilation) resulted in a ~37-fold decrease in risk of cartilage injury (adjusted OR: 0.0264, 95%, CI: 0.005–0.153). Furthermore, increased age was also an independent predictor of injury ($p=0.019$).

Discussion

Significant number of late tracheal stenoses were observed after *(in vivo)* percutaneous tracheostomies in our clinical practice using standard Griggs technique congruently with literary data [7, 8, 13, 14]. Tracheal cartilage injuries varies 2–30% in clinical studies and may be associated with the development of tracheal stenoses [7, 15, 16]. Only a few PDT cadaver studies were found in literature reporting more common cartilage injury [17] and emphasizing the importance of mode and force of forceps dilation [11]. Stenoses frequently have subglottic type which could be reconstructed with difficulty at a later stage [13]. Age and interventional techniques could be highlighted as common independent factors of cartilage injury during percutaneous tracheostomy. Cartilage flexibility usually decreases in the elderly [18]. Importance of technical aspects could be evaluated by comparing surgical and percutaneous techniques [4, 5].

Our previous retrospective clinical study suggested that tracheal cartilage injury could be prevented with the undermentioned technical amendments [9]. Wide skin incision, surgical pretracheal tissue preparation, careful visualized bidirectional (transverse and longitudinal), and intercartilagenous forceps dilation of tracheal wall may potentially prevent cartilage injury during insertion of the tracheostomy tube. Total length of this technique is longer but critical intervention (i.e. tracheal punction with partially lost airway) is shorter than the original ones as was described in our retrospective clinical study [9].

Number of injured tracheal cartilages decreased significantly with applying the modified Griggs technique as observed in this cadaver study. Aging but not gender was also an independent risk factor of injuries. Decreased numbers of injured tracheal cartilages may result in a decreased number of late tracheal stenoses *in vivo* suggesting widespread application of the modified Griggs technique during percutaneous tracheostomy.

Limits of the study: 1. Procedures were not double-blinded, i.e. the same investigator performed and evaluated identical procedures. All of the procedures were performed by three investigators. 2. Non-original tracheostomy sets were used resulting in incidentally further injuries. 3. Cartilage flexibility could depend on the mortem period as well. Shortening this period could result in more accurate data.

Further prospective randomized clinical studies are required to support the relevance of our cadaver study.

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