

## Original Article

# Percutaneous Dilatational Tracheostomy via Griggs Technique

HasanAli Karimpour MD<sup>1</sup>, Kamran Vafaii MSc<sup>2</sup>, Maryam Chalechale BSc<sup>2</sup>, Saeed Mohammadi MD<sup>1</sup>, Rasool Kaviannezhad MSc<sup>3</sup>

## Abstract

**Background:** Tracheostomy is considered the airway management of choice for patients who need prolonged mechanical ventilation support. Percutaneous Dilatational Tracheostomy (PDT) is a technique that can be performed easily and rapidly at bedside and is particularly useful in the intensive care setting. The Griggs percutaneous tracheostomy is unique in its utilization of a guide wire dilator forceps.

**Objective:** We aimed to describe the early perioperative and late postoperative complications of PDT using the Griggs technique in patients in the intensive care unit (ICU).

**Patients and Methods:** This cross-sectional study was conducted on all patients who underwent tracheostomy in the ICU of the Imam Reza Hospital of Kermanshah, Iran, from June 2011 to June 2015. PDT was performed in 184 patients with the Griggs technique. Demographic variables, as well as perioperative and late postoperative complications were recorded.

**Results:** The mean age of patients was  $57.3 \pm 15.37$  years. The most common primary causes of tracheostomy were hypoxic brain damage disorders (43.2%) and pneumonia (14.8%). Perioperative and early complications occurred in 16.7 % of procedures, of which 9.3% were bleedings (minor, significant and major). Furthermore, the incidence of late complications was 8.6%, including: stomal infection, difficult replace tracheostomy tube, tracheoesophageal fistula, tracheal stenosis, and tracheomalacia.

**Conclusion:** PDT via Griggs technique is a safe, quick, and effective method. The low incidence of complications indicates that bedside percutaneous tracheostomy can be performed safely as a routine procedure for daily care implemented in the ICU.

**Keywords:** Complications, critical care, percutaneous, tracheostomy

**Cite this article as:** Karimpour HA, Vafaii K, Chalechale M, Mohammadi S, Kaviannezhad R. Percutaneous dilatational tracheostomy via Griggs technique. *Arch Iran Med.* 2017; **20**(1): 49 – 54.

## Introduction

Since the introduction and widespread acceptance of percutaneous approaches in the intensive care unit (ICU) setting, the number of critically ill patients undergoing tracheostomy has increased in recent years.<sup>1</sup> During the past years, percutaneous bedside tracheostomy has been frequently performed in critically ill patients.<sup>2</sup>

Most patients who need long-term mechanical ventilation require tracheostomy to facilitate the separation of the ventilator. It can decrease the incidence of infection, clean the lungs, improve oral health and comfort for patients, protect the airway, prevent fistula, decrease complications of endotracheal tube and enable nutrition by mouth.<sup>3</sup>

Other benefits of tracheostomy include better tolerance for the patients, easier nursing care, improve communication, and reduce dead space and respiratory work.<sup>4</sup>

The appropriate time to perform a tracheostomy in patients is after 21 days of intubation, but early tracheostomy reduces complications, morbidity and mortality.<sup>5,6</sup> Several studies have shown that early tracheostomy in patients undergoing mechanical

ventilation is associated with a reduction in weaning time.<sup>7,8</sup>

Tracheostomy can be performed by standard procedure in the intensive care unit (ICU) as bedside Percutaneous Dilatation Tracheostomy (PDT) or in the operation room (tracheostomy surgery (ST)).<sup>9</sup>

ST techniques in the operating room require anesthesia, incision of the skin, cutting the rings of the trachea and placing the tracheostomy tube the trachea under direct vision. It can have early complications including cuff leak, obstruction of the trachea, bleeding and fistula.<sup>10</sup>

PDT has gained wide acceptance and has been considered as the method of choice for tracheostomy in critically ill patients worldwide.<sup>11,12</sup> Different techniques have evolved recently for percutaneous tracheostomy (PCT) due to advances in technology and interest in minimally invasive procedures.

The duration of ventilation and length of ICU stay after PDT have been shown to be significantly shorter.<sup>13</sup>

Delaney, et al. stated that PDT reduces the overall incidence of wound infection and may further reduce clinical relevant bleeding and mortality when compared with ST.<sup>14</sup> Another study has reported that PDT technique is as effective and safe as CST with low incidence of post-operative complications.<sup>15</sup>

Several types of PDT techniques have been described. PDT is usually performed with fiberoptic guide for greater security and accurateness of the practice. The Ciaglia procedure and the Griggs procedure are the most frequently used. Moreover, recent evidence strongly suggests that the single dilation technique enhances safety and yields higher success rates.<sup>16,17</sup>

Turkmen, et al. stated that PDT is as safe and effective as ST, although the early and late postoperative complication rates were

**Authors' affiliations:** <sup>1</sup>Faculty of Medicine, Department of Anesthesiology, Kermanshah University of Medical Science, Kermanshah, Iran, <sup>2</sup>Clinical Research Center, Emam Reza Hospital, Kermanshah University of Medical Science, Kermanshah, Iran, <sup>3</sup>Faculty of Paramedical, Department of Anesthesiology, Kermanshah University of Medical Science, Kermanshah, Iran.

**Corresponding author and reprints:** Rasool Kaviannezhad MSc, Faculty of Paramedical, Department of Anesthesiology, Kermanshah University of Medical Science, Kermanshah, Iran. Tel: +98-83-38355925, Cell Phone: +98-918-9699149, E-mail: rasol\_kavyan@yahoo.com.

Accepted for publication: 14 September 2016

not significant with ST method.<sup>18</sup>

Another study reported that PDT with blue rhino technique is a safe, quick, and effective method while the overall complications were comparable in the two groups (ST and PDT).<sup>19</sup>

The meta-analysis by Higgins, et al. illustrated no clear difference but a tendency for fewer complications in percutaneous techniques.<sup>20</sup>

The technique described by Griggs, et al.<sup>21</sup> and marketed by Portex uses a dilating forceps introduced over guidewire to form the stoma. There are no published data examining long-term outcomes from percutaneous tracheostomy using the Portex kit.

Different percutaneous tracheostomy techniques can be used safely with at least a comparable rate of procedural related complications.

The aim of this study was to evaluate the complications of PDT performed at bedside by intensive care unit staff physicians.

## Patients and Methods

### Patients and Material

This cross-sectional study included all patients consecutively admitted to the ICU of the Imam Reza Hospital in Kermanshah, Iran, who underwent PDT over a four-year period (June 2011 to June 2015). All PDTs were performed in the ICU.

The exclusion criteria included patients younger than 15 years, and patients with cervical anatomy defects or infection of the cervical tissues. PDT was performed in 184 patients.

### Surgical technique

PDT was performed at bedside with the Portex Percutaneous Tracheostomy Kit by the Griggs technique<sup>12</sup> with bronchoscopic assistance.

The drugs used for anesthesia induction consisted of fentanyl (50 µg – 100 µg), midazolam (2 mg), propofol (1 – 2 mg/kg), and atracurium (0.5 mg/kg), administered intravenously. This protocol also included continuous intravenous propofol (50 mg/kg/min). Local anesthesia was administered to all patients (combination of lidocaine (5 mg/mL) 3 to 10 mL and epinephrine (1:100,000).

Before starting, fraction of inspired oxygen (FIO<sub>2</sub>) was increased to 1.0 and positive pressure ventilation (PPV) was used during the procedure. The ECG, invasive or non-invasive blood pressure and pulse oximetry were monitored routinely. FIO<sub>2</sub> decreased after the procedure, according to oxygen saturation as measured by blood analysis (SaO<sub>2</sub>) and additional blood gas control.

PDTs were performed by a team of three specialists and an assistant, such as an ICU nurse or technician. One physician was in charge of airway management, one performed the bronchoscopy, and one performed the actual tracheostomy. All PDTs were performed by the same intensivist.

The patient's neck was painted with Betadine antiseptic and then cleared. Patients were positioned to facilitate access to the trachea, mostly with the neck in a neutral position or with the head very slightly reclined by means of a pillow under the shoulders.

Fiberoptic guidance and control was used throughout the whole procedure, while the endotracheal tube cuff was empty and endotracheal tube rings were seen by bronchoscope. To prevent puncture to the vocal cords, the endotracheal tube was pulled back. The catheter needle guide was assembled in a 10 mL syringe containing the local anesthetic and perpendicularly punctured between the first and the second tracheal ring or between the second and the third ring, based on the anatomical

structure in each case and until the resistance faded away. The syringe aspiration confirmed the extraction of air that is indicative of the tip placed in the tracheal lumen. Once this position was secured, the polyvinyl catheter was advanced at 45° caudal angle and the syringe and the metallic needle were removed. Then, the “J” tip wire-guide was introduced through the catheter and the catheter was then removed leaving the guide in position. A 0.5 cm long cross incision was made on each side of the metallic guide involving the skin and the subcutaneous tissue. The “Griggs” technique was performed with Portex PDT set (manufactured by Sims Portex) and using special dilating forceps.<sup>15</sup>

Mechanical ventilation was disabled as soon as the forceps reached the tracheal lumen. Tracheal wall was dilated by opening the forceps arms with both hands. At this point, the forceps were removed, the lubricated tracheostomy tube was introduced, and assembled with the balloon deflated. Finally, the catheter holder and the two guides (the catheter's and the wire guide) were removed, the cannula was sutured to the skin and fixed with cloth tape around the neck and the cuff of the tracheostomy tube was fully inflated. The ventilator breathing circuit was connected, and the tube was fixed with tapes around the neck. Satisfactory ventilation was verified bilaterally by auscultation of the chest. Tracheal suctioning was performed to remove secretions and blood. A control chest X-ray was obtained from every patient.

### Gathering of information

A special form was used to collect patients' information: age, sex, diagnosis on admission to the ICU, the time of the procedure, intubation days prior to PDT, the success rate of weaning from mechanical ventilation, and perioperative and late complications.

Preoperative, as well as early and late, changes in the patients' clinical conditions were carefully monitored, and all complications that were potentially related to the procedure were noted. These included deterioration in respiratory function, blood loss, transfusion requirement and circulatory problems.

Intra procedural and early complications (within the first 6 days) and also late post-procedural complications (beyond 7 days within 6 months) were recorded. Patients were evaluated by a medical doctor at regular intervals after discharge. Telephone interviews were occasionally required to ask for the patient's condition in those who failed to attend follow-up appointments.

### Statistical analysis

The data were analyzed using the statistical package SPSS version 16.0 with descriptive statistics. Descriptive characteristics of the study sample were summarized using counts and percentages for categorical variables and means and standard deviations for continuous variables.

## Results

During the present study, the PDT procedure was performed successfully in 183 of 184 patients (99.4%).

Demographic data and relevant disease processes during tracheostomy are listed in Table 1. The mean age of study participants was 57.3 ± 15.37 years. Totally, 101 (55.2%) patients were female and the rest (83; 44.8%) were male. Patients' diagnoses on admission to ICU included asthma (5.5%), myasthenia gravis (4.4%), Guillain-Barré syndrome (3.3%), multiple sclerosis (6%), brain hemorrhage (5.5%), acute respiratory distress syndrome

**Table 1.** Demographic data

| Variables  | Number (Percent)/ mean $\pm$ SD |
|--|---------------------------------|
| Age (years)  | 57.3 $\pm$ 15.37                |
| <b>Gender</b>  |                                 |
| Female   | 101 (55.2%)                     |
| Male   | 82 (44.8%)                      |
| Intubation days*   | 12 $\pm$ 6                      |
| The Time of the procedure <sup>‡</sup> (min)   | 9.7 $\pm$ 2.8                   |
| Success rate of weaning**  | 109 (66.5%)                     |
| <b>Diagnosis at admission to the ICU</b>   |                                 |
| Asthma   | 10 (5.5%)                       |
| Myasthenia gravis  | 8 (4.4%)                        |
| Guillain-Barré   | 6 (3.3%)                        |
| Multiple Sclerosis   | 11 (6%)                         |
| Brain hemorrhage   | 10 (5.5%)                       |
| Acute respiratory distress syndrome  | 11 (6%)                         |
| Hypoxic brain damage   | 79 (43.2%)                      |
| Pneumonia  | 27 (14.8%)                      |
| Chronic obstructive pulmonary disease  | 21 (11.5%)                      |
| *Number of days endotracheally intubated before percutaneous dilatational tracheostomy; <sup>‡</sup> from skin incision to insertion of the tracheostomy tube; |                                 |
| **Disconnection from ventilator and breathing with tracheostomy.   |                                 |

**Table 2.** Perioperative and Early (days 1–7) Complications

| Variables   | Number (Percent)* |
|---|-------------------|
| Minor bleeding <sup>1</sup>   | 10 (5.5%)         |
| Significant bleeding <sup>2</sup>   | 5 (2.7%)          |
| Major bleeding <sup>3</sup>   | 2 (1.1%)          |
| Subcutaneous emphysema <sup>4</sup>   | 2 (1.1%)          |
| Puncture of endotracheal tube cuff <sup>5</sup>   | 3 (1.6%)          |
| Intraoperative bronchospasm <sup>6</sup>  | 1 (.5%)           |
| Simple or tension Pneumothorax <sup>7</sup>   | 1 (.5%)           |
| Loss of airway <sup>8</sup>   | 2 (1.1%)          |
| Difficult tube placement <sup>9</sup>   | 2 (1.1%)          |
| Blockage <sup>10</sup>  | 1 (.5%)           |
| Hypoxia <sup>11</sup>   | 1 (.5%)           |
| Death related to procedure <sup>12</sup>  | 1 (.5%)           |
| <b>Total Complications</b>  | <b>31 (16.7%)</b> |
| <sup>1</sup> Bleeding controlled by local measures, not requiring reexploration or transfusion; <sup>2</sup> Bleeding requiring exploration, no transfusion, not life threatening; <sup>3</sup> Life-threatening bleeding, requiring transfusion and emergency surgery; <sup>4</sup> Subcutaneous air on postoperative chest radiograph; <sup>5</sup> Perforation of tracheostomy tube balloon and Airleaks; <sup>6</sup> No hearing voices and pulmonary ventilation due to spasm of the airways; <sup>7</sup> Intrapleural air on postoperative chest radiograph; <sup>8</sup> Absence of airway access, requiring reintubation; <sup>9</sup> Need for more than two passes of tracheostomy tube/dilator combination before successful insertion; <sup>10</sup> Tracheostomy tube obstruction by a clot, discharge or hemorrhage; <sup>11</sup> Pulse oximetry arterial oxygen saturation lower than 90%; <sup>12</sup> Death during procedure related ventilation and cardiac disorders. |                   |

(6%), hypoxic brain damage (43.2%), pneumonia (14.8%), and chronic obstructive pulmonary disease (11.5%). The mean number of days in which the patients were endotracheally intubated before percutaneous dilatational tracheostomy was 12  $\pm$  6.0 days. The mean time of the procedure was calculated as 9.7  $\pm$  2.8 min and the mean rate of successful weaning was 66.5% (Table 1).

We assessed the rate of perioperative and early complications within the first 7 days after the procedure (Table 2). The total rate of these complications was 16.7%. Bleeding (minor, significant and major) was the most prevalent perioperative and early complication (9.3%) and was classified into 3 groups (minor, significant and major). Minor bleedings (5.5%) were defined as bleedings controlled by local measures, not requiring re-exploration or transfusion. Significant bleeding (2.7%) required

re-exploration, needed no transfusion and was not life threatening. Major bleedings (1.1%) were life-threatening bleedings which required transfusion and emergency surgery. Other perioperative and early complications included subcutaneous emphysema (1.1%), puncture of endotracheal tube cuff (1.6%), intraoperative bronchospasm (0.5%), simple or tension pneumothorax (0.5%), loss of airway (1.1%) difficult tube placement (needing more than two passes of tracheostomy tube/dilator combination before successful insertion) (1.1%), tracheostomy tube obstruction by a clot, discharge or hemorrhage (0.5%), hypoxia (0.5%) and death related to the procedure (0.5%). Late complications are listed in Table 3, including stomal infection (2.5%), difficult tracheostomy tube replacement (2.5%), tracheoesophageal fistula (1.2%), tracheal stenosis (1.8%), and tracheomalacia (0.6%). The total

**Table 3.** Late Complications (beyond day 7)

| Variables  | Number(Percent)* |
|--|------------------|
| Tracheal stenosis <sup>1</sup>                       | 3 (1.8%)         |
| Stomal infection <sup>2</sup>                        | 4 (2.5%)         |
| Difficult tracheostomy tube replacement <sup>3</sup> | 4 (2.5%)         |
| Tracheoesophageal fistula <sup>4</sup>               | 2 (1.2%)         |
| Tracheomalacia <sup>5</sup>                          | 1 (.6%)          |
| <b>Total Complications</b>                           | <b>14 (8.6%)</b> |

<sup>1</sup>Tracheal stenosis diagnosis through Bronchoscopy or CT; <sup>2</sup>Stomal infection: Purulent secretions accumulate around the tracheostomy tube; <sup>3</sup>Replace tracheostomy tube due to cuff problem or tube obstruction; <sup>4</sup>Create a channel between the esophagus and trachea and stomach secretions back in to the tracheal; <sup>5</sup>Tracheal collapse leading to narrowing of the trachea and lung CT is diagnosed

rate of late complications was 8.6%.

One patient died during the tracheostomy due to lung and heart disorders. Forty-two other patients in the ICU died due to complications of the disease after tracheostomy.

### Discussion

In critically ill patients, PDT is rapidly becoming the preferred method of long-term airway control. The placement of tracheostomy has gained popularity as a means of facilitating the weaning of patients from the respirator, as it reduces pulmonary dead space, provides access for clearing pulmonary secretions under various pathologic conditions, and improves the patient's comfort. However, percutaneous tracheostomy techniques might also be associated with serious, even life-threatening complications and any technique that reduces the morbidity and mortality associated with PDT is desirable. Therefore, efforts have been made to reduce the risks associated with the use of different techniques of PDT.

Based on the data found in our study, it was concluded that PDT with Griggs technique is a safe, quick, and effective method.

The mean procedure time found in this study was similar to those demonstrated in previous reports.<sup>22</sup> Thus, our finding is consistent with the results of the study by Siranovic, et al. in which PDT with Griggs technique was associated with a shorter procedure time.<sup>23</sup>

The mean number of intubation days was 12 before tracheostomy and the success rate of weaning from ventilator was 66.5% in the two first weeks after tracheostomy. Griffiths concluded that tracheostomy should be performed earlier in critically ill patients.<sup>12</sup> The study by Rumbak, et al. yielded important evidence suggesting that early tracheostomy should be considered in any patient who is unlikely to wean early. The authors reported remarkable findings in support of early tracheostomy, safety of PDT and lack of complications when the procedure is performed by qualified clinicians.<sup>24</sup>

Complications are usually minor, but life-threatening bleeding, hypoxia, and airway obstruction have been reported. There is no standard definition of a tracheostomy-related complication and this is reflected in the reported complication rate in the literature, which varies from 2.1% to more than 20%.<sup>25</sup>

In our study, the overall perioperative and early complication rate was 16.7% and the majority of complications were minor and improved quickly. The most common perioperative and early complication of tracheotomy was bleeding (9.3%). Minor bleeding occurred at the stoma site that resolved with applied pressure. In another study, 1 of 36 patients had a bleeding episode,

and 2 patients developed wound infection within seven days of the procedure<sup>26</sup> while the study by Staffer showed 36% bleeding in ST.<sup>27</sup>

One death occurred during the tracheostomy procedure (1.2%). Another study by Berrouschot, et al.<sup>28</sup> in which the multiple dilator technique was employed, reported a 7.9% major perioperative complication rate, including one death (caused by tracheal laceration).

Major perioperative bleeding (1.1%) with Griggs technique might be explained by the poorly controllable dilation with forceps.<sup>29</sup>

Goldenberg reported a case of subcutaneous emphysema,<sup>30</sup> and other rare complications, including pneumothorax<sup>31</sup> which is similar to our study. One patient developed mild subcutaneous emphysema that resolved spontaneously.

Inadvertent puncture of the ETT cuff and accidental tracheal extubation are potentially life-threatening complications that may occur during PDT. Ambesh, et al. reported cuff puncture occurred in 6.6% and accidental tracheal extubation in 3.3% in the perioperative period,<sup>32</sup> which were 1.6% and 1.1%, respectively, in our study. These complications can be reduced by bronchoscopy and expert staff.

Another study found that major complications varied from 0% to 14% (average 3.0%) in 28 studies that used the multiple dilator technique; from 0% to 4.9% (average 3.0%) in six studies on 461 patients who underwent the Griggs technique.<sup>33</sup>

Long-term complications include tracheal stenosis, tracheomalacia, and tracheoesophageal fistula. Several studies report complications ranging from 2% to 60%.<sup>34,35</sup> In our study, the late complication rate was 8.6% and that of tracheal stenosis was 1.8%. Stomal infections were treated with local antiseptics in four patients.

Escarment showed that 5.4% of patients had tracheal stenosis;<sup>36</sup> factors such as prolonged translaryngeal intubation may be associated with laryngeal stenosis or cuff pressure may result in tracheal stenosis.

The total number of perioperative and late complications in our study was not significantly different from that reported in a series from a large European center.<sup>37</sup>

Moreover, our results are supported by the results recently published by Hil, et al. who report 0.3% mortality and an overall rate of complications of 19%.<sup>38</sup>

The previous publications have reported no statistically significant difference in the incidence of complications of ST and two techniques of PCT.<sup>39</sup>

The study by Melloni, et al. showed late tracheal complications were more prevalent in the PCT group, but the difference was not

statistically significant.<sup>40</sup>

There are only few available data concerning late complications of percutaneous tracheostomy. Unfortunately, many confounders might be present, such as the disease process itself, the duration of endotracheal intubation, and other treatments in the intensive care unit (such as sedation or physical therapy).

However, in developing countries, the prohibitive cost of the fiber optic bronchoscope (FOB) is a major limitation in many institutions. The technique may be performed blindly, although visualization with FOB increases margin of safety. One of the modifications to the technique is FOB-assisted procedure for direct endotracheal visualization. However, this requires the availability of the equipment, skilled personnel and may increase the overall costs of the procedure.<sup>41</sup> Some authors have suggested the use of FOB to reduce the procedural complications and increase margin of safety. This has been mainly due to the fact that FOB can help to verify safe placement of the needle and guidewire and to avoid trauma to posterior tracheal wall during dilatation.<sup>42</sup> In this study, PT technique was performed with the aid of FOB. In addition, the free movement of guidewire at each stage of the procedure was considered as prerequisite for proceeding further. Adherence to these simple steps led to successful and accurate PCT placement of tracheostomy tube in all patients with minimal major complications.

With advanced technology and increasing interest in minimally invasive procedures, variations on standard open surgical tracheostomy have been evolved over the recent years. Therefore, it seems that percutaneous dilatational tracheostomy has gained popularity to become a common method in critically ill patients. The Griggs technique is a widely performed procedure in intensive care units. It is safe, cost-effective, and can be done rapidly at bedside.

The difficulties and limitations of studying long-term complications include a high mortality rate among the patients.

## Competing of Interest

The authors declare that there are no conflicts of interest.

## Acknowledgments

The authors wish to thank all those who contributed to this study. This research was financially supported by the Clinical Research Center of the Imam Reza Hospital in Kermanshah, Iran.

## References

- Freeman BD, Morris PE. Tracheostomy practice in adults with acute respiratory failure. *Crit Care Med*. 2012; 40(10): 2890 – 2896.
- Koksal GM, Sayilgan NC, Oz H. Percutaneous dilatational tracheostomy. *Middle East J Anaesthesiol*. 2006; 18(5): 903 – 910.
- Saboori M, Taramsari ME, Hosseini B. The Effects of Early Tracheostomy on Outcomes of Patients with Severe Head Injury. *Journal of Isfahan Medical School*. 2009; 127(95): 211 – 216.
- Griffiths J, Barber VS, Morgan L, Young JD. Systematic review and metaanalysis of studies of the timing of the tracheostomy in adult patients undergoing artificial ventilation. *BMJ*. 2005; 330(7502): 1243.
- Freeman B, Kennedy C, Robertson TE. Tracheostomy protocol: experience with development and potential utility. *Crit Care Med*. 2008; 36(6): 1742 – 1748.
- Rumbak MJ, Newton M, Truncate T. Aprospective randomized study comparing early percutaneous dilatational tracheostomy to prolonged translaryngeal intubation in critically ill medical patients. *Crit Can Mtd*. 2004; 32: 1689.
- Bouderka MA, Fakhir B, Bouaggad A, Hmamouchi B, Hamoudi D, Harti A. Early tracheostomy versus prolonged endotracheal intubation in severe head injury. *J Trauma*. 2004; 57(2): 251 – 254.
- Arabi Y, Haddad S, Shirawi N, Al Shimemeri A. Early tracheostomy in intensive care trauma patients improves resource utilization: A cohort study and literature review. *Crit Care*. 2004; 8(5): R347 – R352.
- Durbin CG Jr. Techniques for performing tracheostomy. *Respir Care*. 2005; 50(4): 488 – 496
- Bouderka MA, Fakhir B, Bouaggad A, Hmamouchi B, Hamoudi D, Harti A. Early tracheostomy versus prolonged endotracheal intubation in severe head injury. *J Trauma*. 2004; 57(2): 251 – 254
- Fikkers BG, Fransen GA, van der Hoeven JG, Briedé IS, van den Hoogen FJ. Tracheostomy for long-term ventilated patients: a postal survey of ICU practice in The Netherlands. *Intensive Care Med*. 2003; 29(8): 1390 – 1393.
- Krishnan K, Elliot SC, Mallick A. The current practice of tracheostomy in the United Kingdom: A postal survey. *Anaesthesia*. 2005; 60: 360 – 364
- Huang H, Li Y, Ariani F, Chen X, Lin J. Timing of tracheostomy in critically ill patients: A meta-analysis. *Plos One*. 2014; 9(3): e92981.
- Delaney A, Bagshaw SM, Nalos M. Percutaneous dilatational tracheostomy versus surgical tracheostomy in critically ill patients: A systematic review and meta-analysis. *Crit Care*. 2006; 10(2): R55.
- Youssef TF, Ahmed MR, Saber A. Percutaneous dilatational versus conventional surgical tracheostomy in intensive care patients. *N Am J Med Sci*. 2011; 3(11): 508 – 512.
- Dempsey GA, Grant CA, Jones TM. Percutaneous tracheostomy: A 6 yr prospective evaluation of the single tapered dilator technique. *Br J Anaesth*. 2010; 105: 782 – 788.
- Cabrini L, Monti G, Landoni G, Biondi-Zoccai G, Boroli F, Mamo D, et al. Percutaneous tracheostomy, a systematic review. *Acta Anaesthesiol Scand*. 2012; 56: 270 – 281.
- Turkmen A, Altan A, Turgut N, Yildirim G, Ersoy A, Koksall C, et al. Comparison of percutaneous dilatational tracheostomy with surgical tracheostomy. *Middle East J Anaesthesiol*. 2008; 19(5): 1055 – 1067.
- Yaghoobi S, Kayalha H, Ghafouri R, Yazdi Z, Khezri MB. Comparison of complications in percutaneous dilatational tracheostomy versus surgical tracheostomy. *Glob J Health Sci*. 2014; 6(4): 221 – 225.
- Higgins KM, Punthakee X. Meta-analysis comparison of open versus percutaneous tracheostomy. *Laryngoscope*. 2007; 117: 447 – 454.
- Griggs WM, Worthley LI, Gilligan JE, Thomas PD, Myburg JA. A simple percutaneous tracheostomy technique. *Surg Gynecol Obstet*. 1990; 170(6): 543 – 545.
- Freeman BD, Isabella K, Lin N, Buchman TG. A meta-analysis of prospective trials comparing percutaneous and surgical tracheostomy in critically ill patients. *Chest*. 2000; 118(5): 1412 – 1418.
- Siranovic M, Gopcevic S, Kelecii M, Kovac N, Kriksic V, Rode B, et al. Early complication of percutaneous tracheostomy using the Griggs method. *Signa Vitae*. 2007; 2(2): 18 – 20.
- Rumbak MJ, Newton M, Truncate T, Schwartz SW, Adams JW, Hazard PB. A prospective, randomized, study comparing early percutaneous dilatational tracheostomy to prolonged translaryngeal intubation (delayed tracheostomy) in critically ill medical patients. *Crit Care Med*. 2004; 32(8): 1689 – 1694.
- Batuwitage B, Webber S, Glossop A. Percutaneous tracheostomy. *Continuing Education in Anaesthesia, Critical Care & Pain Advance*. doi: 10.1093/bjaceaccp/mkt068.
- Kumar M, Jaffery A, Jones M. Short-term complications of percutaneous tracheostomy: Experience of a district general hospital-otolaryngology department. *J Laryngol Otol*. 2002; 116(12): 1025 – 1027.
- Staffer JL, Olson DE, Petty TL. Complications and consequences of endotracheal and tracheotomy. *AM J Med*. 1981; 70: 65 – 75.
- Oeken J, Steiniger L, Schneider D. Perioperative complications of percutaneous dilatational tracheostomy. *Laryngoscope*. 1997; 107(11 Pt 1): 1538 – 1544.
- Nates JL, Cooper DJ, Myles PS, Scheinkestel CD, Tuxen DV. Percutaneous tracheostomy in critically ill patients: A prospective, randomized comparison of two techniques. *Crit Care Med*. 2000; 28: 3734 – 3739.
- Goldenberg D, Golz A, Huri A, Netzer A, Joachims HZ, Bar-Lavie Y. Percutaneous dilation tracheotomy versus surgical tracheotomy: Our experience. *Otolaryngol Head Neck Surg*. 2003; 128(3): 358 – 363.
- Fikkers BG, van Heerbeek N, Krabbe PF, Marres HA, van den

- Hoogen FJ. Percutaneous tracheostomy with the guide wire dilating forceps technique: Presentation of 171 consecutive patients. *Head Neck*. 2002; 24(7): 625 – 631.
32. Ambesh SP, Sinha PK, Tripathi M, Matreja P. Laryngeal mask airway vs endotracheal tube to facilitate bedside percutaneous tracheostomy in critically ill patients: A prospective comparative study. *J Postgrad Med*. 2002; 48(1): 11 – 15.
  33. Dongelmans D, Lely A, Tepaske R, Schultz MJ. Complications of percutaneous dilating tracheostomy. *Crit Care*. 2004; 8(5): 397 – 398.
  34. Cheng E, Fee WE Jr. Dilatational versus standard tracheostomy: A meta-analysis. *Ann Otol Rhinol Laryngol*. 2000; 109(9): 803 – 807.
  35. Massick DD, Yao S, Powell DM, Griesen D, Hobgood T, Allen JN, Schuller DE. Bedside tracheostomy in the intensive care unit: A prospective randomized trial comparing open surgical tracheostomy with endoscopically guided percutaneous dilational tracheotomy. *Laryngoscope*. 2001; 111(3): 494 – 500.
  36. Escarment J, Suppini A, Sallaberry M, Kaiser E, Cantais E, Palmier B, et al. Percutaneous tracheostomy by forceps dilation: Report of 162 cases. *Anaesthesia*. 2000; 55(2): 125 – 130
  37. Diaz-Reganon G, Minambres E, Ruiz A, Gonzalez-Herrera S, Holanda-Pena M, Lopez-Espadas F. Safety and complications of percutaneous tracheostomy in a cohort of 800 mixed ICU patients. *Anaesthesia*. 2008; 63(11): 1198 – 1203.
  38. Hill BB, Zweng TN, Maley RH, Charash WE, Toursarkissian B, Kearney PA. Percutaneous dilational tracheostomy: report of 356 cases. *J Trauma*. 1996; 41: 238 – 244.
  39. Kiran S, Eapen S, Chopra V. A comparative study of complications and long term outcomes of surgical tracheostomy and two techniques of Percutaneous Tracheostomy. *Indian J Crit Care Med*. 2015; 19: 82 – 86.
  40. Melloni G, Muttini S, Gallioli G, Carretta A, Cozzi S, Gemma M, et al. Surgical tracheostomy versus percutaneous dilatational tracheostomy: A prospective randomized study with long-term follow-up. *J Cardiovasc Surg (Torino)* 2002; 43: 113 – 121.
  41. Kluge S, Baumann HJ, Maier C, Klose H, Meyer A, Nierhaus A, et al. Tracheostomy in the intensive care unit: A nationwide survey. *Anesth Analg*. 2008; 107: 1639 – 1643.
  42. Atweh NA, Possenti PP, Caushaj PF, Burns G, Pineau MJ, Ivy M. Dilational percutaneous tracheostomy: Modification of technique. *J Trauma*. 1999; 47: 142 – 144.