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Letter to Editor

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Defining High-Risk Tracheostomy in the Intensive Care Unit

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Abstract

Percutaneous dilational tracheostomy (PDT) is becoming a ubiquitous bedside procedure in the intensive care unit (ICU) in patients requiring prolonged invasive mechanical ventilatory support. Complications of PDT include bleeding, airway compromise, hypoxemia, and procedural failure. There is no clear definition for which patients are considered high-risk for these complications, therefore, we set out to review existing data and define the clinical parameters of a high-risk tracheostomy in the ICU.

Keywords: Percutaneous dilational tracheostomy; Tracheostomy; Risk stratification; Procedural complications

Abbreviations: PDT: Percutaneous dilational tracheostomy; ICU: Intensive care unit; INR: International normalized ratio; APACHE: Acute physiology and chronic health evaluation; BMI: Body mass index; SOFA: Sequential organ failure assessment; OR: Odds ratio; CI: Confidence interval

Introduction

Acute respiratory failure requiring invasive mechanical ventilation is a common occurrence in the ICU. Outside of the operating room, an estimated 1 to 3 million people in the United States are expected to require mechanical ventilation annually [1]. Frequently, prolonged invasive mechanical ventilatory support requires tracheostomy placement. Tracheostomy has several advantages to orotracheal intubation including increased patient comfort, easier oral care and nutrition, reduced sedation needs, and decreased time on ventilatory support [2]. When compared to open or surgical tracheostomy, percutaneous dilational tracheostomy (PDT) is being increasingly performed for patients admitted to ICU. As with all procedures, PDT placement may lead to complication, thus careful candidate selection remains paramount. Unfortunately, there is no clear definition as to which patients are considered high-risk for PDT complications.

PDT is a bedside procedure performed by intensivists, otolaryngologists, and general surgeons. While the procedure is generally considered safe when performed by an experienced operator, complications do occur, and the procedural-related morality has been reported to be as high as 0.7% [3]. Understanding which group of patients are at highest risk for complications is therefore a critical component in risk stratification. As a formal definition or stratification tool for identifying these high-risk patients is lacking, we reviewed existing literature to gain an understanding for which factors predispose to procedural complications. We focus on early complications occurring within 7 days of the procedure, including minor bleeding (requiring dressing change, suture placement, or direct pressure) and major bleeding (drop in hemoglobin by 2 g/dl, transfusion of packed red cells, or surgical re-exploration), loss of airway, cardiac or respiratory decompensation, and intra-procedural hypoxemia. While late complications will not be addressed, a non-exhaustive list includes infection, granulation tissue formation, tracheal stenosis, and tracheoesophageal fistula [4].

There is conflicting data regarding which clinical parameters identify those at "high-risk" for tracheostomy complications.

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Some retrospective analyses suggest no additional risk using body mass index (BMI) as an independent predictor for complications, other data reports an increased risk in obese individuals [5]. This discrepancy in risk with BMI calls into question whether additional variables such as neck size, anatomical landmarks, or overall stature should be more strongly considered. Additionally, while bleeding risk stratification is typically performed using the international normalized ratio (INR), existing data suggests this parameter may be inconsistent in predicting procedural bleeding risk. Bleeding risk may be better defined by variables less commonly used such as thrombocytopenia, prior strokes, and chronic kidney disease (CKD) [6]. In addition to obesity and coagulopathy, we explore the reported risks associated with hemodynamics, ventilator requirements and the acute physiology and chronic health evaluation (APACHE II) score prior to tracheostomy, prior head and neck surgeries, and operator experience.

While many authors have provided data on risk factors for tracheostomy complications, a unified definition for high-risk tracheostomy is lacking. Hence, the purpose of this manuscript is to examine the literature to identify the most consistently cited risk factors for complications with percutaneous tracheostomy to gain a comprehensive understanding of the overall risks.

Materials and Methods

We performed a database search in PubMed using the keywords "percutaneous dilational tracheostomy," "tracheostomy complications," "high-risk tracheostomy," and "tracheostomy risk stratification." Additional references used were obtained via cross-referenced articles within our primary search. To allow more generalizability, our search was restricted to studies that enrolled patients over 18 years old at clinical sites in the United States and Europe. Baseline comorbidities examined in the studies included hypertension, coronary artery disease, diabetes mellitus, chronic kidney disease, and chronic obstructive lung disease. When incorporated, the APACHE II and SOFA was captured at ICU admission and within 24 hours of tracheostomy placement.

Results and Discussion

Bleeding risk

Among the early complications of PDT, excessive bleeding is one of the most feared given its potentially catastrophic consequences, thus identification of the pre-procedure INR, platelet count, and review of the patient's medication list to ascertain use of antiplatelet or anticoagulants is considered an essential aspect of procedural planning. In a prospective analysis of over 1000 patients by Rosseland, et al. [7], an elevated INR was identified as the most important risk factor for bleeding with an odds ratio (OR) of 2.99 (confidence interval (CI) 1.26-7.08) followed by thrombocytopenia <100,000 (OR 1.99, CI 0.99-3.95) [7]. A retrospective analysis described thrombocytopenia, CKD, and previous stroke as independent risk factors for bleeding [6]. In contrast, a small trial by Blankenship, et al. [8] reported no difference in bleeding events in patients on therapeutic anticoagulation, INR >1.5 or platelets < 20,000, though the sample size was small at 7 patients [8]. Similarly, a retrospective study demonstrated no additional bleeding risk when platelets were <50,000 or the INR was elevated [9]. This conflicting data raises concern regarding the clinical application and utility of these parameters when assessing bleeding risk. This data suggests that both minor and major bleeding are relatively rare complications of percutaneous tracheostomy, but a platelet count <50,000 and INR >1.5 inconsistently predict who is at risk for clinically significant bleeding episodes.

Obesity and body habitus

Obesity is increasingly prevalent and is associated with increased risk of early complications from a variety of procedures [10]. In a moderate sized prospective study of 227 patients, Aldawood, et al. [11] reported major bleeding more often in obese patients with a BMI > 30 kg/m2 at a rate of 12% versus 2% in the nonobese group [11]. An even more compelling study suggested a BMI of over 40 kg/m2 is associated with increased tracheostomy complications (OR 4.4). In particular, the incidence of complications was 25% in the morbidly obese group compared to 14% in the control group, though they were mostly minor complications in origin. There was a non-statistically significant increase of major complications in the morbidly obese group in the form of loss of airway patency [12]. Similarly, a larger cohort study of 73 obese patients with BMI greater than 27.5 kg/m2 showed an almost 5-fold increased risk in serious complications [13]. In contrast, a small retrospective data review of 7 patients with a mean BMI of 64.4 kg/m2 showed no increased risk of early procedural complications [5]. Finally, a larger retrospective review reported no differences in bleeding, loss of airway or increase the risk of converting a percutaneous to an open tracheostomy in obese patients [11, 14].

The variability in procedural complications related to obesity raises the question of whether a higher BMI increases risk or rather may be associated with patient factors that are more prevalent in an obese population such as a shorter neck, metabolic syndrome, or decreased lung volumes and respiratory reserve. The distortion in anatomy and respiratory physiology has been described in obese patients. For example, morbidly obese patients experience a decrease in functional residual capacity and expiratory reserve volume in the supine position, resulting in a decline in overall functional residual capacity. Reduction in lung volumes results in a decreased capacity to tolerate apnea and can result in hypoxemia [15]. It is thus imperative to explore additional factors amongst obese patients which may predispose to procedural complications. More sophisticated modeling may serve to identify independent variables associated with procedural risks within the obese population.

Patient positioning and anatomic variability

Proper positioning with neck extension and the ability to palpate anatomical landmarks are traditionally viewed as

important aspect of safely performing percutaneous tracheostomy. Occasionally, existing issues such as limited neck mobility and prior spinal surgery may limit the ability to extend the neck, and prior tracheostomy, neck surgery, or goiter may limit proper identification or anatomical landmarks. Mayberry et al performed a prospective analysis on 88 trauma patients to determine whether cervical spine clearance and neck extension was necessary to help facilitate successful PDT. The "non-cleared" group had a reported success rate of 96% (27 out of a total of 28 total patients), and there were no spinal cord injuries causes by the procedure [16].

While prior tracheostomy may be considered a relative contraindication to repeat PDT, there is no evidence to preclude this practice. There may be some concern for impaired healing at the stoma site due to prior scar tissue formation, however, there are no validated studies to confirm this concern. Furthermore, there are no large studies to suggest increased complications when performing repeated PDT.

Hypoxemia and ventilatory requirements

In the era of SARS-CoV2 and increasing acute respiratory distress syndrome (ARDS) in the ICU requiring percutaneous tracheostomy, understanding the optimal timing of safely performing tracheostomy warrants discussion. While the TracMan trial found no mortality benefit between early versus late tracheostomy, of particular importance to the proceduralist is understanding which respiratory and hemodynamic factors may create higher risks of complications [17]. There were no differences in hypoxemia, airway loss, or para-tracheal placement in a retrospective review of 177 patients with FiO2 >70% or positive end expiratory pressure (PEEP) >10 cmH20, however, there were increased reports of hypotension (36% vs 8%) and procedure duration [18]. Despite this reassuring study, caution is advised when performing a tracheostomy in patients with higher ventilator settings.

Hemodynamics

Hypotension is generally considered as a relative contraindication to PDT, and there is a lack of data about the safety of performing PDT in patients with shock requiring vasopressors. Some authors have mentioned avoiding PDT in patients on multiple vasopressors or high dose single vasopressor. In addition, the hemodynamic effects of paralytics and sedatives used for PDT should also be kept into consideration [19]. Similarly, cardiac arrhythmias pose a challenge due to dearth of information. Taken together, hemodynamic instability should raise concern in performing PDT, however, there is limited data regarding the exact risk.

Operator experience and tracheostomy timing

With the increasing incidence of tracheostomy placement in the ICU, there is also increasing heterogeneity in terms of tracheostomy approach and operator subspecialty. Thus far, there have been no head-to-head studies comparing outcomes of tracheostomies amongst the various subspecialty of physicians. Traditionally, open tracheostomy is a procedure performed by both general surgeons and otolaryngologists, whereas percutaneous tracheostomy is more often performed by bedside intensivists. A potential complication of bedside, percutaneous tracheostomy placement may require conversion of an open tracheostomy in the operating room, necessitating the proper surgical support be readily available.

While operator subspecialty may not result in differences in procedural complications, individual experience does appear to have a significant association. In a large retrospective review of 500 adults undergoing PDT, oxygen desaturations and bleeding events were increased if the operator had performed less than 30 tracheostomies [16].

The optimal timing of tracheostomy remains a subject of ongoing debate. One of the largest trials looking at early versus late tracheostomy found no mortality benefit between the groups [20]. Early tracheostomy is typically defined as occurring within 14 days of intubation and has both positive and negative outcomes in the literature. Early trach is associated with a reduced ICU length of stay of approximately 6 fewer days, though there were no differences in time to decannulation, ventilator wean, or overall mortality [20]. The operator should be aware of potential risk in performing an earlier tracheostomy regarding overall outcomes.

APACHE II

In a retrospective review, early tracheostomy performed within 14 days from intubation was associated with a higher 60-day mortality [21]. It is important to note the higher APACHE II scores (15 vs 11) in the early tracheostomy group, as higher scores seem to correlate with those at higher overall risk for death. Thus, exploring the APACHE II as a risk factor for tracheostomy outcomes warrants discussion. There is limited data evaluating the APACHE II score as a predictor for outcomes of tracheostomy placement. Though the APACHE II may identify those patients at high-risk, a small retrospective review of 54 patients suggested against this. This study identified high-risk patients as those with higher APACHE II scores of 10.1 vs 5.4, morbid obesity with BMI > 40 kg/m2, and with coagulopathic conditions. Only one complication was reported in the low-risk group in which bleeding from an anterior jugular communicating vein was reported, and there were no complications in the high-risk group [22].

In summary, there are many variables to consider when evaluating the overall risk of patients undergoing percutaneous tracheostomy. We discussed some of the existing literature looking at variables such as BMI, coagulation parameters, derangements in anatomy, difficulties with positioning, operator experience, hemodynamics and ventilatory requirements, and APACHE II score. While these individual components do not necessarily predict those patients at highest risk, per se, perhaps a comprehensive assessment of these variables will better predict overall risk. Thus, we believe there is a need for a comprehensive scoring system to help better

risk-stratify those patients at highest risk for complications related to tracheostomy placement.

Conclusion

Percutaneous dilational tracheostomy is a procedure increasingly performed given the increased need for invasive mechanical ventilatory support in the setting of the SARS-CoV2 pandemic. While a true definition for patients at highest risk for tracheostomy complications is lacking, we discussed several parameters with correlation to risk including BMI, coagulopathy, anatomic derangements, difficulties with positioning, operator experience, hemodynamics and ventilatory requirements, and APACHE II score. Finally, we propose the need for establishing a formalized scoring system to identify those patients in whom percutaneous tracheostomy can be more safely performed with fewer complications.

Acknowledgment

None.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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