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Percutaneous dilatational tracheostomy: collaborative team approach for safe airway management

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Introduction

Since Jackson first standardized the technique in 1909 [1], surgical tracheostomy (ST) has been the golden standard surgical procedure by which to manage the airway in critically ill patients. An alternative procedure, cricothyrotomy (cricothyroidotomy) [2], has also been utilized as a surgical option to secure the failed airway in selected emergency situations. To simplify the tracheostomy procedure, Shelden (1950) described the technique of percutaneous dilatational tracheostomy (PDT). However, due to the increased potential to induce extra injury to arteries and the esophagus, the PDT as proposed by Sheldon did not gain popularity among intensive care physicians and airway surgeons. In 1985, Ciaglia et al. [3] introduced a novel PDT method to create a stoma by a series of graduated dilators following needle puncture into the trachea. This method involved the relatively easy Seldinger technique to introduce the serial dilators and a tracheostomy tube. The Griggs guidewire dilating forceps (GWDF) technique introduced in 1990 was aimed at enlargening a small tracheal aperture with a guidewire-dilating forceps especially manufactured for this purpose [4]. In 1998, a modification of the Ciaglia technique was introduced (Ciaglia Blue Rhino Percutaneous Tracheostomy Introducer kit; Cook Critical Care, Bloomington, IN). The Ciaglia Blue Rhino (CBR) technique incorporated a single, sharply tapered dilator with a hydrophilic coating, allowing complete dilation of the stoma in one step [5]. Although all of these methods have the potential to be improved and refined, the CBR is—mainly due to its simplified concept—currently the most popular PDT technique worldwide.

In Japan, as in other countries, PDT is becoming a well-known procedure. It is being performed as one of the technical options to secure the airway in multiple situations by physicians of various specialties. However, although this procedure is gaining in popularity in Japan, critical information on its indications, contraindications, and safety issues, including potential risks, have not yet been precisely defined and discussed. Thus, while the handiness of this technique is attractive to anesthesiologists and critical care physicians the best approach to perform PDT for successful airway management still needs to be considered and decided upon.

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PDT versus ST

Multiple prospective randomized trials comparing the surgery-related complication rates [6–9], procedure duration [6, 7, 10], delay from randomization to tracheostomy [7, 9], and cost-effectiveness [10] of PDT and ST have been performed. In these studies, the original Ciaglia method with multiple dilators was performed as PDT. The PDT procedures were performed at the bedside in the intensive care unit (ICU) and the ST procedures were performed in the operating room (OR) [7, 10], at the bedside in the ICU [8, 9], or at either of these two locations [6]. The results of these studies demonstrated that the procedural time [7, 10] and delay from randomization to tracheostomy [7, 9] was significantly shorter in the PDT group than in the ST group. Although tube placement was relatively more difficult in the PDT group than in the ST group [8], no other significant differences in intraoperative complications were observed between the groups [7, 9]. However, postoperative stomal infection [6, 9] and cosmetic sequelae [9] were significantly more common in the ST group than in the PDT group. Furthermore, the frequency rate of postoperative adverse events, including small hemorrhage and accidental decannulation, was significantly lower in the PDT group [6, 7]. OR scheduling [7] and the significantly smaller skin incision size [8] required for PDT may be responsible for explaining some of these advantages of PDT over ST. It should also be noted that early tracheostomy is associated with a significant decrease in the duration of mechanical ventilation and a shorter stay in the ICU and hospital compared with translaryngeal endotracheal intubation [11]. In terms of cost, PDT was found to be significantly more cost-effective than with ST [10], as has also been shown in other studies [12, 13]. The cost savings associated with PDT were considered by the authors to have resulted from eliminating the use of OR resources and personnel. However, when this cost benefit is interpreted in the Japanese context, the differences in medical insurance and socioeconomic situations in public healthcare programs between Japan and other countries should be taken into consideration [14].

Recent meta-analyses of prospective studies comparing PDT and ST have reported significantly fewer complications in the PDT group with respect to wound infection and unfavorable scarring [15, 16]. These studies showed that there was no statistically significant difference in overall peri-procedural or long-term complications, minor or major hemorrhage, and subglottic stenosis when these procedures were compared. The advantages of PDT in cost-effectiveness and procedure length over ST were also clarified in these analyses.

The GWDF PDT kit (Portex® Percutaneous Tracheostomy kit; Smiths Medical Japan Ltd., Tokyo, Japan) and CBR PDT kits (Ciaglia Blue Rhino® G2 Advanced Percutaneous Tracheostomy Introducer Set, Cook Japan Inc., Tokyo, Japan; Neo Perc™ Percutaneous Tracheostomy kit, Covidien Japan Inc, Tokyo, Japan; Portex® ULTRAperc® Single Stage Dilator Technique kit, Smiths Medical Japan Ltd.) are currently available in Japan. In one study comparing the surgical complication rate among PDT procedures, the Ciaglia group was found to be associated with a significantly lower number of surgical complications than the GWDF group [17]. In another study, a relatively lower number of surgical complications was observed in the CBR group than in the Ciaglia group [18]. The CBR technique was reported to require a significantly shorter time than the original Ciaglia technique [19]. These results provide support adopting the CBR technique over either the original Ciaglia technique or the GWDF technique.

Indications and contraindications of PDT

The four main indications for tracheostomy are (1) need for long-term ventilation, (2) weaning failure, (3) upper airway obstruction, and (4) copious secretions [20]. Among these, "upper airway obstruction" may be omitted from the list of PDT indications because a preexisting endotracheal tube is a prerequisite for PDT, and emergency cases in need of quick airway security are rather contraindications of this procedure. Instead, "inability to protect the airway" could be considered as one of the proper indications for PDT, as reported previously [18]. When this technique is adopted as one of the options for airway management, strict monitoring for contraindications of PDT are mandatory to ensure the security of the procedure [21]. Contraindications of the PDT procedure include (1) pediatric patient, (2) unprotected airway, (3) emergency situation, (4) presence of a midline neck mass, (5) active cervical infection, (6) inability to palpate the cricoid cartilage, (7) uncorrectable coagulopathy, (8) proximity of palpable blood vessels, (9) severe deformity of the neck and/or tracheal area, (10) inability to extend the neck, and (11) previous surgery or irradiation in the neck/tracheal area [18, 21, 22]. It can never be overemphasized that the PDT procedure should only be considered in a selected series of adult, intubated ICU patients with easily palpable cartilaginous landmarks [18, 22] to avoid serious complications [23]. In all cases, a surgical tracheostomy tray should be available at the bedside in the event that conversion to open tracheostomy is necessary [22]. The instructions for use on the package insert of every PDT kit should be thoroughly read and understood before the surgical procedure is started because these indications, contraindications, and supportive information, including the preoperative preparations, are provided here. As written in the instructions for use supplied

by Smiths Medical Japan Ltd. (Portex® Percutaneous Tracheostomy kit; Portex® ULTRAperc® Single Stage Dilator Technique kit), PDT procedures may be performed not only in the ICU but also in the OR under control of critical care specialists.

Bronchoscopic guidance and internal anatomy of the subglottis to trachea

When performing PDT, the tracheal wall puncture should be positioned at the midline of the anterior wall of the trachea between the first and third tracheal rings. In 1990, Marelli et al. [24] proposed the advantages of endoscopic guidance during the PDT procedure to increase the safety of this procedure and to prevent a number of perioperative complications. In a cadaver study with the aim to measure the accuracy of blind placement of the PDT catheter, Dexter [25] found that only 45 % of guidewires were placed at the intended level and that there was a trend for the others to enter the trachea at a higher level than intended. Furthermore, only 15 % of the catheters entered the trachea centrally without bronchoscopic guidance. High tracheostomy is known to be related to later stenosis and voice change in the patient [26]. Since these reports, bronchoscopic guidance has been recognized as standardized equipment for a safe PDT procedure [8–10, 13]. In his assessment of multiple studies comparing the complications in an endoscopic PDT group and a non-endoscopic PDT group, Kost [18] proved the benefit of bronchoscopic guidance to reduce the overall complication rate related to PDT. The endoscopic PDT group showed a significantly reduced frequency of accidental extubation, false passage, pneumothorax, pneumomediastinum, posterior injury, and technical difficulties compared with the non-endoscopic group. Moreover, bronchoscopy permits accurate withdrawal of the endotracheal tube to an appropriate subglottic level using wound transillumination and the ability to visualize palpation of the tracheal wall for puncture at the ideal position [18, 22].

Based on our own cadaver experience, we emphasize that an accurate knowledge of the endoscopic internal anatomy of the subglottic-tracheal region is also indispensable for a safe PDT procedure. The anatomical landmark is an endoscopically visualized subglottic bulge in the anterior wall. This bulge represents the lower edge of the cricoid cartilage to the first tracheal ring. Once this bulge is recognized, the ideal puncture position for starting the procedure is decided upon (Fig. 1).

Collaborative team approach for safe airway management

The decision to allow nonsurgically trained intensivists to adopt and perform PDT because of its relative technical ease remains controversial, especially to surgeons classically trained in ST [22], and has formed the basis for multiple prospective randomized trials and meta-analyses comparing PDT and ST to define the superior procedure with respect to both resource use and morbidity. As mentioned above, these studies did not prove any disadvantage of PDT compared with ST in terms of complication rates, procedure duration, delay from randomization to

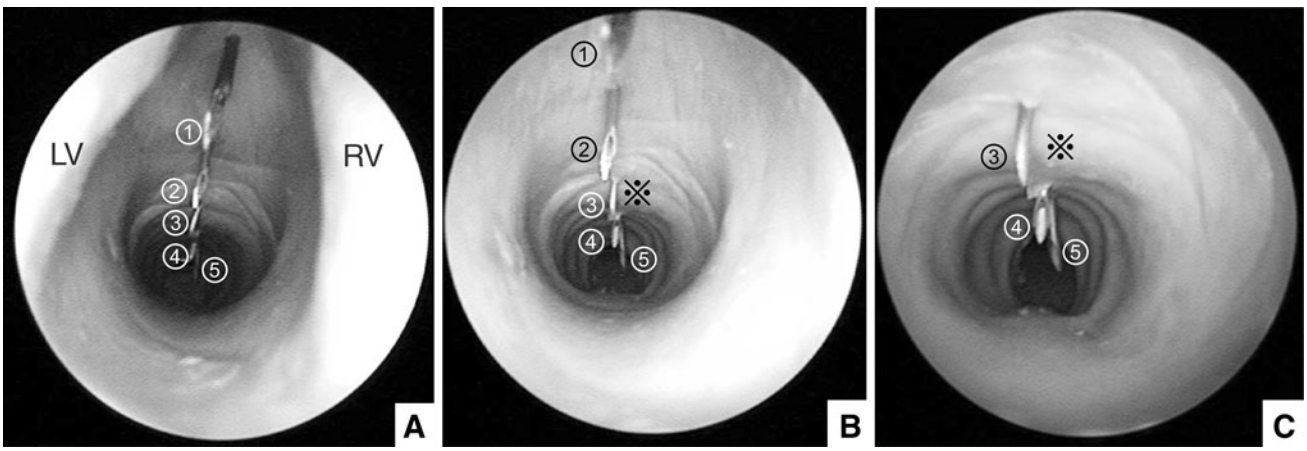

Fig. 1 Endoscopic internal anatomy of the subglottic-tracheal region. In this cadaver, needles are put at the lower edge of the thyroid cartilage (①), upper edge of the cricoid cartilage (②), lower edge of the cricoid cartilage (③), between the first and second tracheal rings (④), and between the second and third tracheal rings (⑤) in the midline. Tip of the camera was set at the glottis (**a**), cricothyroid membrane level (**b**), and cricoid cartilage level (**c**). Bulge in the anterior wall representing the inferior edge of the cricoid cartilage to the first tracheal ring is visualized (※). Lower 2 needles (④ and ⑤) are set at the ideal puncture positions for percutaneous dilatational tracheostomy (PDT). *LV* Left vocal fold, *RV* right vocal fold

tracheostomy, and cost-effectiveness. Furthermore, no association between physician specialty and complication rate was reported, supporting the notion that non-surgeons can also safely perform PDT as long as the procedure is performed on proper elective cases with bronchoscopic guidance [12]. A learning curve was also not observed when the simple CBR technique was incorporated, and successful procedures were completed independent of the experience [18].

Polderman et al. [21] and Blankenship et al. [22] advocated the collaborative approach to the performance of PDT through the establishment of multidisciplinary teams consisting of otolaryngologists and either intensivists [21] or pulmonary/critical care specialists [22]. In their collaborative systems, anesthesia support and airway management during the bronchoscopic guidance were provided by an intensivist or anesthesiologist. Moreover, the option of conversion to ST was readily available by the participation of an otolaryngologist in the procedure.

In our institution, the collaborative team approach to perforing PDT has been in place since 2008. Sequential responsible decisions are necessary for the success of cooperative tracheostomy by a team consisting of multidisciplinary participants (Fig. 2). When the anesthesiologists first invited us to join them in establishing a collaborative PDT procedure, it had not yet been clarified who was responsible for each step and who was to make specific decisions. During the period leading up to our adoption of the CBR technique, we organized a committee to build a collaborative system with unequivocal rules for performing a safe and smooth tracheostomy in our institution. Within the framework of this system, after a few months of training, anesthesiologists are able to perform PDT by themselves at the bedside in the ICU, with support as needed from the on-site or on-call otolaryngologist on each case. The original intramural protocol for tracheostomy was established in 2010. This protocol clarifies the role and responsibility of each participant in term of the respective decisions and procedures necessary to perform smooth tracheostomy with minimal risk. This protocol is currently under evaluation for possible future improvement.

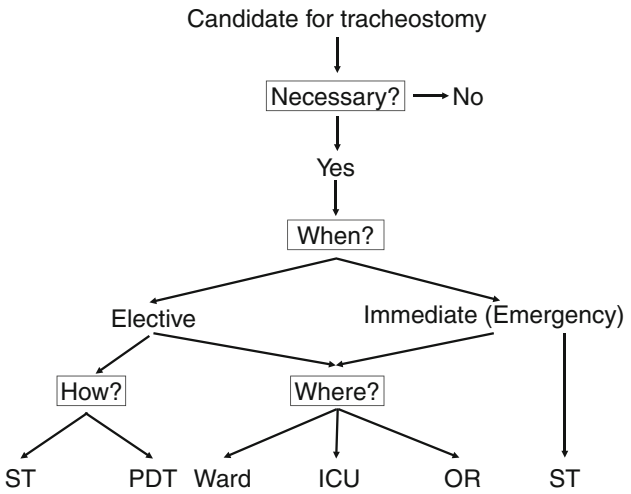

Fig. 2 Sequential decisions necessary for successful tracheostomy. When there is a candidate for tracheostomy, the first step is determine the necessity of the procedure. Subsequently, the timing to perform tracheostomy is determined (elective or immediate). Following decisions include the selection of procedure [surgical tracheostomy (*ST*) or PDT] and the place where the tracheostomy should be performed [ward, intensive care unit (*ICU*), or operating room (*OR*)]. Note that PDT is a contraindication for emergency cases. The person responsible for each respective step and for each decision has to be clarified to ensure smooth cooperation among multidisciplinary participants engaged in the tracheostomy

Summary

Following the introduction of the Ciaglia technique, PDT has become increasingly popular due to its relatively easy procedure to secure the airway. Multiple prospective studies and meta-analyses have compared PDT and ST to define the superior procedure. The results favor PDT with respect to wound infection and cosmetic sequelae. To ensure the safety of the procedure, it is indispensable to strictly observe the indications and contraindications of PDT without being preoccupied by only the handy aspect of this technique. While some authors recommend that PDT should only be performed by surgically trained individuals, others have reported that successful PDT can be performed with no association between physician specialty and complication rate as long as patient selection and bronchoscopic assistance are performed properly.

Considering the present situation surrounding PDT, now may be the time to promote the collaborative multidisciplinary team approach to perform successful PDT utilizing the specialty of each participant and the benefit of this technique itself. Recent reports advocate the implementation of PDT teams consisting of otolaryngologists and either intensivists or pulmonary/critical care specialists and suggest the potential benefits of such team approaches. Our PDT team consists of anesthesiologists and otolaryngologists, and to date the system runs smoothly. Future assessments and improvements of these approaches are warranted.

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