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Bronchoscopy, Ultrasound, and Video Laryngoscopy as Guidelines for Percutaneous Dilatation Tracheostomy (PDT) in Patients with Difficult Airway Suspected of Laryngeal Tumor

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ABSTRACT

Introduction: Percutaneous dilatational tracheostomy (PDT) is the preferred technique for elective tracheostomy in critically ill patients. However, a laryngeal or cervical mass is a relative contraindication because landmark puncture is unreliable, bleeding risk increases, and the airway may be lost when the endotracheal tube is withdrawn. Evidence on the safe extension of PDT to such airways is limited.

Case Description: A 72-year-old man was admitted to H. Adam Malik General Hospital, Medan, Indonesia, with decreased consciousness after being struck by a motorcycle. Tracheal intubation was unexpectedly difficult and required a video laryngoscope and bougie. After eight days of ventilation, weaning failed, and tracheostomy was indicated. Pre-procedural neck ultrasound showed peritracheal soft-tissue thickening suspicious for a laryngeal tumor without compression of the tracheal lumen and identified a puncture interspace free of large vessels. Open tracheostomy was initially considered because of anticipated bleeding; however, bedside PDT was performed under triple guidance: ultrasound for site selection, video laryngoscopy to inspect the larynx and confirm endotracheal tube position, and flexible bronchoscopy through the tube for continuous intraluminal vision during needle puncture, guidewire passage, dilatation with the Ciaglia Blue Rhino system, and cannula insertion. The correct position was confirmed bronchoscopically before fixation.

Conclusion: Combined ultrasound, video laryngoscopic, and bronchoscopic guidance eliminated every blind step and converted a tracheostomy that would conventionally have been performed openly into a controlled bedside intervention. This strategy may be considered an adjunct to standard PDT in selected high-risk patients provided adequate equipment and at least two trained operators are available.

Keywords

Percutaneous Dilatational Tracheostomy, Bronchoscopy, Difficult Airway, Airway Ultrasound, Video Laryngoscopy, Laryngeal Neoplasm

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INTRODUCTION

Tracheostomy is one of the most frequently performed interventions in the intensive care unit (ICU) for patients who require prolonged mechanical ventilation. Since Ciaglia et al. introduced elective bedside dilatational tracheostomy in 1985, percutaneous dilatational tracheostomy (PDT) has progressively displaced open surgical tracheostomy in critical care practice [1]. PDT is rapid, avoids transfer to the operating theatre,

and is cost-effective; systematic reviews and meta-analyses report broadly comparable safety with a lower incidence of wound infection compared to the surgical approach [2,3].

These advantages are conditional on accurate tracheal puncture. When PDT is guided by surface landmarks alone, needle insertion and dilatation are performed blind: the operator can see neither the pretracheal vasculature nor the posterior tracheal wall. Bleeding, paratracheal or cranial misplacement of the cannula, tracheal ring fracture, posterior wall perforation, and rarely, procedure-related death has all been reported [4]. Anatomical conditions that distort the anterior neck — obesity, short neck, previous tracheostomy, prior radiotherapy, cervical spine immobilization, or cervical mass — magnify this risk and have traditionally been treated as relative contraindications to the percutaneous approach [5]. Bedside ultrasound removes some of this uncertainty. Sonography of the anterior neck identifies the cricoid cartilage and tracheal rings, estimates pretracheal soft-tissue depth, and demonstrates aberrant arteries and veins crossing the intended puncture site [6]. In a randomized controlled trial, ultrasound-guided tracheal puncture improved accuracy compared with the traditional landmark technique [7]. and a propensity-matched analysis reported fewer procedure-related complications with real-time ultrasound guidance, the benefit being most evident in coagulopathic patients [8]. Ultrasound, however, cannot visualize the tracheal lumen; it cannot confirm that the needle has entered the airway in the midline or that the posterior wall has been spared.

Two complementary tools address this limitation. Laryngoscopy — increasingly video laryngoscopy — allows the endotracheal tube (ETT) to be inspected and repositioned under vision, so that the cuff and tip are withdrawn clear of the intended puncture site while remaining within the airway, preventing both cuff puncture and inadvertent extubation; laryngoscopic control of the tube is an explicit step in published PDT protocols [9]. Flexible bronchoscopy passed through the ETT provides continuous intraluminal visualization of needle entry, guidewire trajectory, dilatation, and final cannula position, and adds suction capacity should bleeding occur. In a randomized comparison, PDT monitored with fibreoptic bronchoscopy carried significantly lower complication rates than PDT performed without it [10]. and a bedside series reported no procedure-related mortality [11]. The technique is not free of drawbacks: the bronchoscope occupies part of the ETT lumen and can impair ventilation during the procedure, it depends on equipment and operator expertise that are not universally available, and complications continue to occur even beyond the learning curve [12]. In practice, at least two trained physicians are required — one to maintain the bronchoscopic view and airway, and one to perform the puncture and dilatation.

Airway narrowing caused by a laryngeal or cervical mass is at the intersection of these problems. The mass distorts the landmarks that ultrasound must interpret, may bleed during dilatation, and reduces the luminal space in which a bronchoscope and an ETT must coexist. For these reasons, airway stenosis due to a mass is frequently listed as an exclusion criterion for PDT, and open tracheostomy is chosen by default [5]. Reports describing how the percutaneous approach can nevertheless be executed safely in this population are scarce and are largely limited to rigid endoscopic techniques requiring an operating theatre and an endoscopist [13]. We describe an intubated patient with an unanticipated difficult airway and a peritracheal mass suspicious for a laryngeal tumor, in whom bedside PDT was completed under combined ultrasound, video laryngoscopic, and flexible bronchoscopic guidance. The report follows the CARE (CAse REport) reporting guideline [14].

CASE PRESENTATION

A 72-year-old man was brought to the emergency department of H. Adam Malik General Hospital, Medan, Indonesia, with a decreased level of consciousness six hours after being struck by a motorcycle while crossing the street during a road traffic collision. He had a history of transient loss of consciousness and did not vomit. He was first taken to Wulan Windi Hospital, where plain radiography, computed tomography, and laboratory investigations were performed, and then referred to our center. On arrival, assessment of the airway and level of consciousness indicated the need for tracheal intubation. Intubation proved unexpectedly difficult; the airway was secured with a video laryngoscope and a bougie, and the patient was admitted to the adult ICU for mechanical ventilation.

By the eighth day in the ICU, weaning from the ventilator repeatedly failed, and tracheostomy was indicated to facilitate weaning and secure ventilation. Because of the earlier difficult intubation, the anterior neck was re-evaluated before the procedure. Neck ultrasound demonstrated thickening of the peritracheal soft tissue, which was suspicious for a laryngeal tumor; however, the tracheal lumen itself was not compressed. Ultrasound also mapped the anterior neck and identified an interspace free of large or vital vessels, at which the incision could be placed. In view of the mass, open surgical tracheostomy was initially considered because of the anticipated blood loss; however, the vascular anatomy defined sonographically, together with the availability of endoscopic guidance, supported a percutaneous approach instead. Bronchoscopy-guided PDT with additional ultrasound and video laryngoscopic control was therefore selected.

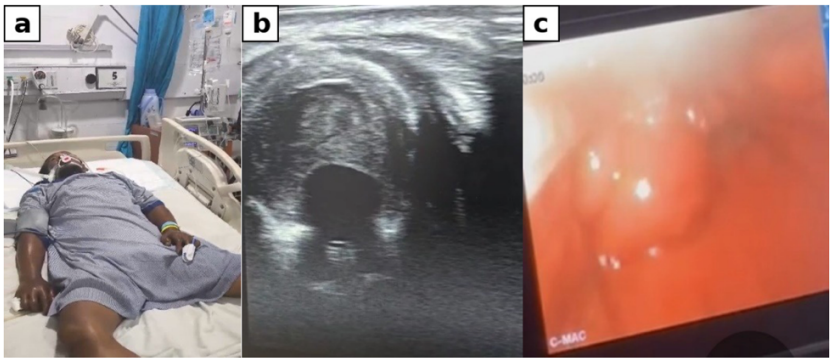

Figure 1. (a–c) pre-procedural airway assessment before percutaneous dilatational tracheostomy, showing the sonographic and endoscopic findings of the anterior neck and larynx used to plan the puncture site.

Procedure. PDT was performed at the bedside in the adult ICU using the Ciaglia single-dilator (Blue Rhino) system. The technique is as follows:

1. Ultrasound screening of the anterior neck was repeated to select the safest puncture interspace between the second and third or third and fourth tracheal rings.
2. Sedation and analgesia were provided with intravenous fentanyl (100–200 µg) and midazolam (3–5 mg).
3. The neck was placed in maximal extension on a shoulder roll.
4. A video laryngoscope was used to inspect the larynx and confirm the position of the endotracheal tube.
5. The field was disinfected with povidone-iodine, followed by 70% alcohol.
6. Local anesthesia was infiltrated with 3–5 mL 2% lidocaine.
7. A 1.5 cm transverse incision was made 2 cm below the cricoid cartilage, and the subcutaneous tissue was separated using a curved mosquito clamp.
8. Blunt retraction was continued until the fibromuscular layer over the tracheal rings was exposed.
9. The flexible bronchoscope was advanced through the endotracheal tube and positioned so that the distal end of the tube remained in view. The bronchoscopic image was maintained throughout each subsequent step.
10. The introducer needle was advanced through the selected interspace until its tip was visible within the tracheal lumen.
11. The guidewire was passed through the needle towards the carina under direct bronchoscopic vision.
12. The needle was removed, and a short 14-F dilator was passed over the guidewire and then withdrawn, leaving the guidewire in place.
13. The Ciaglia Blue Rhino guiding catheter and dilator, loaded over the guidewire, were introduced; after dilatation, the dilator was removed, and the guiding catheter was left in situ.
14. The tracheostomy tube loaded onto its dilator was advanced into the trachea, after which the guidewire and guiding catheter were withdrawn.
15. The bronchoscope was passed through the tracheostomy tube to confirm the correct intraluminal position, and the tube was secured with a dressing.

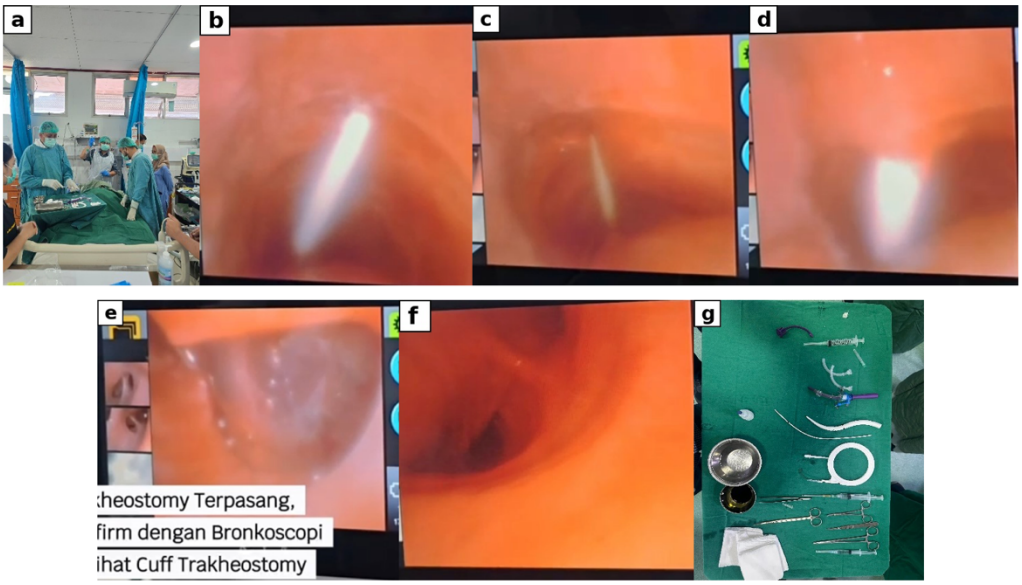

Figure 2. (a–g) Intraprocedural documentation of triple-guided percutaneous dilatational tracheostomy, following the sequence of video laryngoscopic inspection, bronchoscopic visualization of needle and guidewire entry, progressive dilatation, and final confirmation of cannula position.

DISCUSSION

Tracheostomy was indicated for ventilator weaning, but the anterior neck was not normal. Peritracheal thickening, which was suspicious for a laryngeal tumor, raised two distinct concerns: the possibility of tumor or neovascular bleeding during dilatation, and uncertainty about whether the airway would remain patent and accessible once the endotracheal tube was withdrawn. Conventionally, either concern alone would argue for open surgical tracheostomy [5]. Our decision to proceed percutaneously rested on the observation that each uncertainty could be resolved by an imaging modality already available at the bedside: ultrasound answered the vascular and anatomical questions before the skin was opened, video laryngoscopy answered the tube-position question, and bronchoscopy answered the intraluminal question continuously during dilatation. Therefore, what made PDT feasible here was not a single adjunct, but the elimination of every blind step in the procedure.

Ultrasound contributed at two levels. First, it characterized the lesion: the peritracheal soft tissue was thickened but the tracheal lumen was not compressed, which meant that a cannula of standard size could be expected to pass. Second, it defined a puncture window — the cricoid and tracheal rings were identified, the depth of pretracheal tissue was estimated, and vessels crossing the intended interspace were excluded [6]. This is precisely the contribution that randomized and propensity-matched data attribute to sonography: improved accuracy of tracheal puncture and fewer complications, with the benefit most apparent in patients whose anatomy or coagulation status places them at higher risk [7,8]. Video laryngoscopy is the least frequently emphasized component of the three, yet in a patient whose intubation had already proved difficult, it was arguably the least dispensable. Withdrawal of the endotracheal tube before puncture is a moment of genuine vulnerability: if the tube is withdrawn too far, the airway of a patient who was difficult to intubate is lost with a bronchoscope, a guidewire, and an open incision in the field; if it is left too low, the cuff or the tube itself is punctured. Direct laryngoscopic control of the tube during PDT has been incorporated into published protocols for exactly this reason [9]. Video laryngoscopy refines this step by displaying the glottis and the tube on a shared screen, so that the operator performing the puncture, the assistant holding the tube, and the anesthetist work from the same image rather than from a verbal description.

Bronchoscopy converted puncture and dilatation from a blind maneuver into an observed one. Needle entry was confirmed within the lumen, the guidewire was seen to run towards the carina rather than into the submucosa, the posterior wall was observed throughout dilatation, and the final position of the cannula was verified before fixation. The supporting evidence is consistent: bronchoscopic monitoring is associated with significantly lower complication rates in a randomized trial [10]. and a bedside series performed under

bronchoscopic guidance reported no procedure-related mortality [11]. Bronchoscopy also brings suction capacity to the airway at precisely the moment when intratracheal bleeding — the complication a peritracheal mass makes more likely — would otherwise be least controllable. These benefits are not unconditional. The bronchoscope competes for the endotracheal tube lumen and can impair ventilation, the equipment and expertise are not universally available, and complications persist even in experienced hands [12]. Our procedure required two trained physicians in addition to the ICU team, which remains a real resource constraint in many Indonesian centers and should be weighed honestly before the technique is adopted.

Published experience in patients with cervical or laryngeal masses is limited, and the techniques used have moved in a different technical direction. Fiorelli et al. used a rigid bronchoscope instead of a flexible bronchoscope in intubated patients with tracheal stenosis due to a cervical mass, arguing that rigid instrumentation offers better visibility and greater suction capacity [13]. performed PDT under laryngosuspension with a rigid endoscope, obtaining control of both ventilation and hemostasis throughout the procedure [15]. and a multicenter study confirmed the feasibility and safety of dilatational tracheotomy performed with a rigid tracheotomy endoscope. These techniques are attractive, but they import the operating theatre, an otolaryngologist or thoracic surgeon, and rigid endoscopic equipment into a procedure whose principal advantage is that it can be done at the bedside. The present case suggests that when a mass narrows but does not occlude the lumen, the combination of ultrasound, video laryngoscopy, and flexible bronchoscopy may achieve comparable control without these requirements. Combined ultrasound and bronchoscopic control has been described previously in the trauma ICU and rests on the same logic: the two modalities answer different questions [16]. Ultrasound and bronchoscopy are frequently framed as competitors rather than partners. In the TRACHUS randomized noninferiority trial, ultrasound-guided PDT was noninferior to bronchoscopy-guided PDT in critically ill patients [17]. and a large single-centre series confirmed that bronchoscopically guided PDT is safe and simple in unselected ICU populations [18,19]. We do not dispute either finding. Our argument is narrower: in an airway already known to be difficult and containing a mass, the modalities cease to be interchangeable, because each covers a blind spot that the other cannot. The evidence for equivalence was generated in patients with essentially normal anterior neck anatomy, and it does not obviously transfer to the population described here.

Several limitations apply. This is a single case without a comparison group, and the feasibility we describe cannot be generalized to masses that compress the tracheal lumen, to coagulopathic patients, or to centers without immediate bronchoscopic and surgical backup. The nature of the peritracheal lesion was suspected sonographically rather than confirmed histologically at the time of the procedure. Longer-term airway outcomes, including tracheal stenosis, were not the subject of this report. Finally, the technology is evolving: endotracheal tube-mounted cameras have been compared with bronchoscopy in a randomized trial and may eventually provide continuous visualization without occupying the tube lumen, although bronchoscopy retained superior visualization of tracheal structures in that comparison [20].

CONCLUSION

In a patient with an unanticipated difficult airway and peritracheal mass suspicious for laryngeal tumor, percutaneous dilatational tracheostomy was completed bedside under ultrasound, video laryngoscopic, and bronchoscopic guidance. Ultrasound identified a vessel-free puncture site; laryngoscopy confirmed that the endotracheal tube was clear of the site; bronchoscopy provided vision during puncture and cannula placement. This strategy requires two operators and equipment while preserving surgical fallback. It may be considered adjunctive to standard PDT in otherwise excluded patients.

DECLARATIONS

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CONSENT FOR PUBLICATION

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All authors have reviewed and approved the final version of the manuscript, and they all agree to be accountable for all aspects of the work.

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