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Can we improve teaching and learning of percutaneous dilatational tracheostomy's bronchoscopic guidance?

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Abstract

Percutaneous dilatational tracheostomy has become the technique of choice in multiple intensive care units. Among innovations to improve procedural safety and success, bronchoscopic guidance of percutaneous dilatational tracheostomy has been advocated and successfully implemented by multiple groups. Most published literature focuses on the percutaneous dilatational tracheostomy operator, with scarce descriptions of the bronchoscopic particularities of the procedure. In this article, we provide 10 suggestions to enhance specific procedural aspects of bronchoscopic guidance of percutaneous dilatational tracheostomy, and strategies to optimize its teaching and learning, in order to promote learners' competence acquisition and increase patient safety.

Keywords

Bronchoscopy, tracheostomy, medical education, intensive care, airway management, critical care

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Introduction

Since its original description by Ciaglia et al.,[1] percutaneous dilatational tracheostomy (PDT) has become the preferred tracheostomy technique in the intensive care units (ICUs) worldwide.[2] Compared to the surgical technique, PDT has been associated with decreased bleeding, operative time, overall costs, and wound infections.[3–5] Even though the incidence of complications (both major and minor) range around 5% of cases,[6] some can be potentially fatal.

Multiple innovations have been developed to improve the procedure. On one hand, enhancements of the technique per se, like novel kits for single-tapering dilatation,[7] or alternative dilatation methods[8] increase procedural success. On the other hand, the use of ultrasound guidance[9] (USG) or bronchoscopic guidance[10] (BG) has been introduced to increase procedural safety, as the operator can confirm correct airway placement and supervise the procedure in real time, avoiding potential complications.

In many hospitals, BG-PDT has become the technique of choice[11] and is advocated by some authors.[12] Among its benefits, BG allows to monitor the selection of an adequate puncture site, avoid posterior tracheal wall lesions, rapidly detect bleeding, and confirm correct cannula placement, among others. Nonetheless, there is still meaningful debate whether BG of PDT should be part of routine care or should be reserved for anticipated difficult cases.[13,14]

Critics to BG routine use during PDT have drawn several valid arguments, including the increased cost and operative time,[15–17] conflicting evidence in clinical studies,[16,18] potential damage to the bronchoscope equipment if inadvertent puncture occurs during PDT,[19] and impossibility to manage stomal or skin bleeding.[20] Furthermore, as bronchoscopy is an aerosolizing procedure,[21] there is risk of cross-infection to health care workers, which becomes particularly relevant in the context of patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection.[22]

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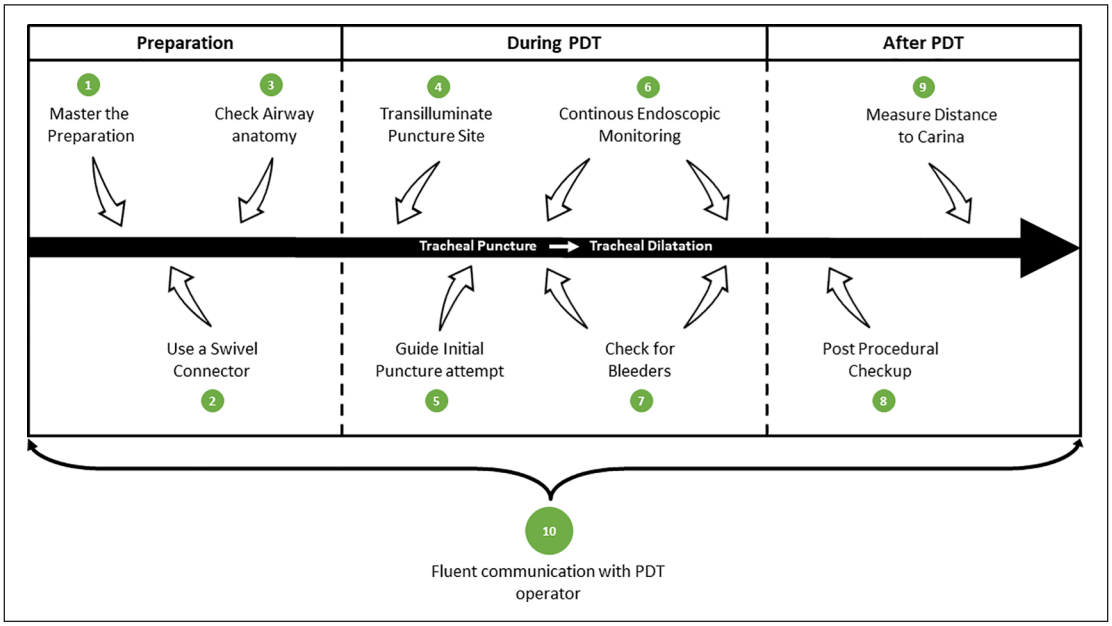

Figure 1. Summary of the 10 tips for bronchoscopic guidance of PDT.
PDT: percutaneous dilatational tracheostomy.

Most technique descriptions[8] and training protocols of PDT[23,24] focus mainly on the operator performing the tracheostomy. For the BG to be truly effective, the bronchoscopist must also know in detail the key procedural aspects of the PDT. This is particularly important for residents, so they can advance faster in their learning curve and master the procedure.

We performed a literature search in the following databases: PubMed, Medline, Scopus, and Google Scholar, including the *Medical Subject Headings* keywords: tracheostomy, bronchoscopy, critical care, and education. Also, a combination search was performed, including ((tracheostomy) AND (bronchoscopy) AND (education)). The search was based on articles in English and Spanish, from 1985 to 2020.

To the best of our knowledge, there is scarce literature describing the particularities of BG of PDT.[25] Therefore, we provide 10 suggestions to enhance specific procedural aspects (summarized in Figure 1), and strategies for optimizing teaching and learning of BG, to promote learners' competency acquisition and increase patient safety.

Tip 1: Master the preparation

As in any other procedure, to maximize chances of success, preparation of the environment is mandatory. Preparation includes patient positioning, assess orotracheal tube size (in order to select an adequate bronchoscope's size), administer adequate anesthesia depth and muscle relaxation, set ventilator parameters (i.e. volume-controlled ventilation, FiO2: 100%, and alarms), monitor alarms, ensure there is an available electrical outlet, and titrate external ambient light. Both operators (PDT and bronchoscopist) must have a clear view to the bronchoscope screen, and hopefully, the screen must be in the direct line of sight of the primary PDT operator.

Tip 2: Use a swivel connector

The Swivel connector allows to maintain mechanical ventilation while performing a bronchoscopy, without major air leakage. Even though it might sound obvious for some, this connector is not universally used in some cases, especially for BG-PDT, which may be performed during a prolonged apnea, or with intermittent ventilation (which means, intermittent BG). If Swivel connectors are not available in your hospital, we have successfully used the elbow of a transport ventilator circuit, allowing patient ventilation without major air leakage, and performing a safe BG, as shown in Figure 2.

Tip 3: Check the airway anatomy first

Before starting the procedure, we routinely perform a focused airway anatomy check. Withdrawing the orotracheal tube up to the larynx under direct bronchoscopic vision avoids both accidental extubation and inadvertently covering the proposed work area, potentially interfering with the PDT puncture, or puncturing the bronchoscope.

Tip 4: Transilluminate the desired puncture site

By directly contacting the bronchoscope's light beam into the desired puncture site (i.e. 1st–2nd or 2nd–3rd intercartilaginous space), the PDT operator can identify the precise puncture area in the patients' skin, allowing to

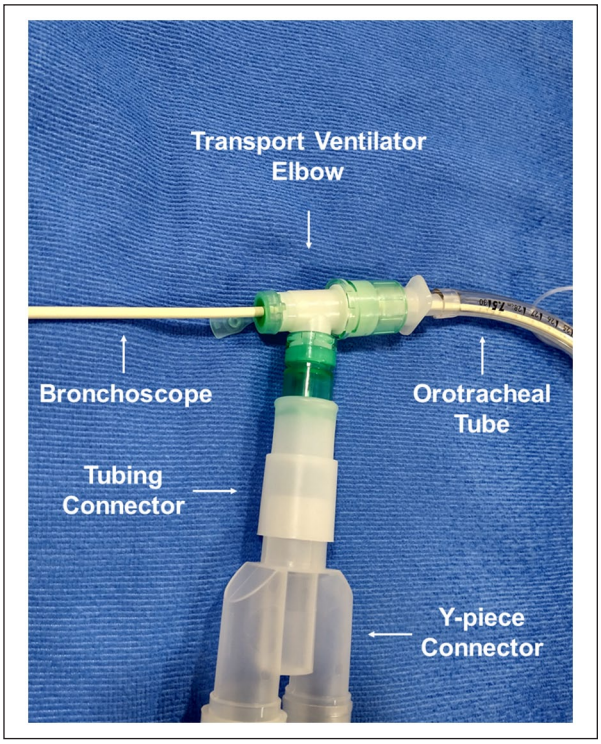

Figure 2. Assembly of an alternative Swivel connector. With the elbow of a transport ventilator circuit and a simple tubing connector, it is possible to assemble the Y-piece of the ventilator circuit, elbow, and the orotracheal tube in order to maintain controlled ventilation while performing bronchoscopy.

cross-check the intended work area previously identified by palpation.

Tip 5: Guide the initial puncture attempt

To avoid inadvertent bronchoscope puncture by the PDT operator, we usually withdraw the bronchoscope into the orotracheal tube until we reach the Murphy's eye, while maintaining direct vision of the procedure.

Key aspects of the bronchoscopist performance in this stage include maintaining adequate vision and orientation of the working space, guiding the main operator to puncture in midline trachea (between 11 and 1 o'clock), puncturing through the intercartilaginous space, and avoiding posterior wall lesion with the needle.

Tip 6: Maintain continuous endoscopic monitoring of the procedure

Once the airway is cannulated, the PDT operator will begin the dilatation process. At this stage, the bronchoscopist must check first that the guidewire advances distally into the trachea (not proximally). During the dilatation phase, the bronchoscopist must monitor potential posterior wall lesions, tearing, false passages, or dilatator misplacements, especially in older patients with stiffer and more fragile tissues.

Tip 7: Always check for the bleeders

Bleeding has been consistently described among PDT complications.[6] Multiple factors can determine bleeding location and intensity, including cervical and thyroid vasculature, size and direction of skin incision, pretracheal tissue divulsion, and coagulation disorders, among others. Distal tracheal clotting after cannula placement can provoke life-threatening airway obstructions. It is paramount that during the whole procedure, the bronchoscopist is actively checking for bleeding sites, suctioning clots, and, in case of persistent bleeding points of the airway, can intervene and perform endoscopic treatment.

Tip 8: Post procedural checkup

After the PDT operator has inserted the cannula and a correct airway positioning has been confirmed (via capnography, endoscopy, and ventilator curves), the bronchoscopist can perform an upper (through the glottis) and lower (via the tracheostomy cannula) inspection of the airway anatomy. Relevant aspects to check include bleeding points, cartilage fractures or tears, and suction of blood clots and secretions.

Tip 9: Measure the distance between the tracheostomy tube and the carina

To assess the adequacy of the tracheostomy tube length and insertion site, it is possible to measure the distance between the carina and the tip of the tracheostomy tube. Simply advance the bronchoscope up to the carina, then retrieve the bronchoscope while measuring the approximate distance it has been retrieved with the operator's dominant hand, until the tracheostomy tube appears on the screen.

Tip 10: Maintain an honest and continuous communication with the PDT operator

To increase procedural success, it is fundamental to maintain smooth communication with the PDT operator. In other words, both operators must work as a team for the benefit of the patient, as it is in everybody's best interest for the procedure to run smoothly. Bilateral and fluent communication can potentially prevent complications, and when they arise, coordinated efforts can allow to resolve life-threatening situations.

As we previously mentioned, most reports and technical descriptions focus mainly on the PDT operator.[8] Kidane, in a review article, mentioned some key elements of the bronchoscopists' role during the procedure.[5] In a retrospective report of BG-PDT outcomes in the ICU, Hinerman et al. provided a more detailed characterization of the steps undertaken by the bronchoscopist during PDT.[25] In contrast, we provide a broader description of the procedure from the bronchoscopists perspective since we have also emphasized key aspects of both the preprocedural phase and the postprocedural phase (as seen in Figure 1). Moreover, we have

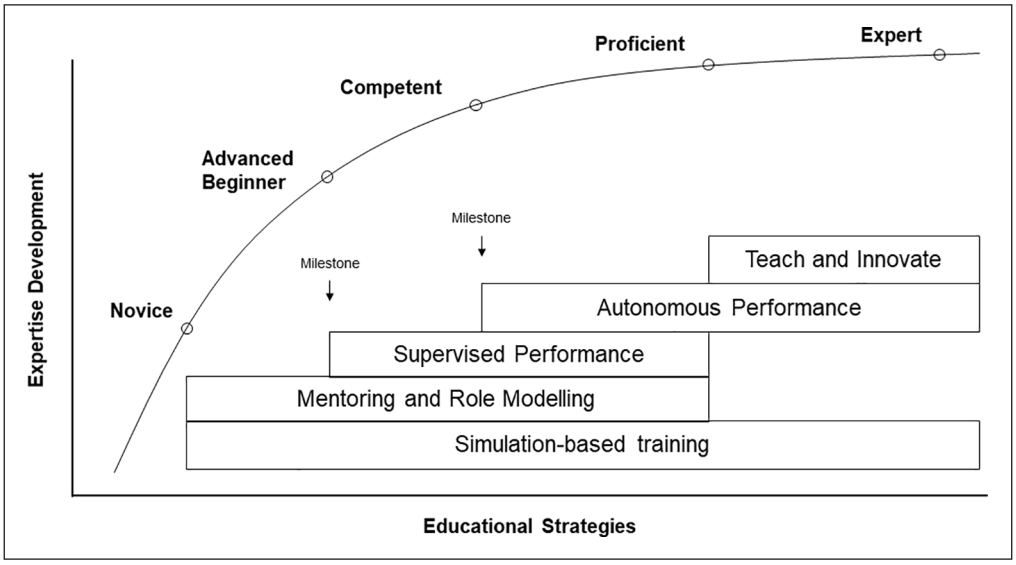

Figure 3. Development of procedural skills expertise according to Dreyfuss & Dreyfuss levels[27] and proposed educational strategies.

included non-technical aspects, such as highlighting the communication between operators (Tip 10), which can aid to improve overall situational awareness and teamwork, and enhance the decision-making process.[26]

How can we improve teaching and learning of PDT BG?

As with any other ICU-based procedures (i.e. central venous catheters [CVC], orotracheal intubation, etc.), we believe that residents' training programs should be designed in a multimodal and sequential fashion, starting with the acquisition of an adequate theoretical framework, participating in simulation-based training, performing supervised practice, and, finally, autonomous execution. Ideally, predefined milestones are established to transition from one stage to another as the students progress in their skill's development curve,[27] as seen in Figure 3.

Mentoring and role modeling play a pivotal role in procedural education,[28] as trainees can learn not only key procedural details but also communicational and relational skills, further enhancing situational awareness[26] and integrating professionalism as a fundamental aspect of their performance.

Multiple bronchoscopy training programs have reported a positive impact in satisfaction, theoretical learning, and competence acquisition, such as those involving virtual reality,[29] video gaming,[30] and low-[31] and high-fidelity simulation.[32] In this sense, a specific alternative for PDT BG is to perform synchronous training with the main PDT operator. Some PDT simulators allow BG.[33] Synchronous training not only allows to develop key procedural aspects but also can enhance and strengthen communication skills. Alternating between both roles can also help the trainees to understand each other's specific challenges.

Even though simulation might be a predominant training method during the initial learning phases, we believe that it can also play a role during the broader spectrum of skill development. This is especially relevant in less-frequent procedures, such as BG-PDT,[34] as it allows more advanced practitioners to refresh specific cognitive and technical aspects and avoid potential de-skilling.[27] Most of the 10 tips previously mentioned can be rehearsed and perfected in simulators.

Once trainees are deemed competent enough to perform in patients, transition from supervised to independent performance must be guided by experts, balancing case difficulty, exposure, assistance, and autonomy. Through all this learning process, feedback has a crucial role to achieve effective learning.[35] Both the deliberate practice approach[36] and mastery learning paradigm[37] include feedback as a pivotal aspect of competency acquisition. Thus, prior development of teachers' effective feedback skills is desirable.

One complementary teaching method we have successfully implemented is to deliver feedback with the aid of a procedural flowchart, which includes a step-by-step description of the desired procedural execution.[38] This allows trainees to develop a detailed procedural mental model, anticipate subsequent steps, and recognize flow errors.

Finally, we believe that as expertise is acquired, teaching others further cements the experts' procedural competency, as they must monitor and correct novice's procedural mistakes, especially during critical steps, and develop teaching strategies to allow trainees to overcome these barriers. In this same developmental phase, experts can design, test, and implement procedural innovations in order to optimize flow, safety, and efficiency.

Limitations

As we previously discussed, there is conflicting evidence to support the routine use of BG of PDT.[14] This fact could be perceived as a potential limitation of this report, since we are

advocating for its use and implementation in training programs of critical care physicians. Moreover, we believe that the core concept of adding extra layers of safety to a procedure that can have potentially serious complications, and optimizing its learning methodology, finally promotes a more reliable and consistent clinical practice. Parallelism can be drawn to echography-guided CVC insertion, in which a standardized training methodology finally demonstrated a positive impact on relevant outcomes,[39] even though it took almost 30 years after the technique had demonstrated its clinical benefits.[40]

Conclusion

BG of PDT has become standard of care in many hospitals worldwide, allowing to improve procedural success and decrease immediate and long-term complications. Through these 10 tips, we intend to map out key technical aspects of the procedure. Implementing these strategies into comprehensive training programs can enhance residents' skill acquisition and promote a safer patient care.

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