The patients were placed on a controlled mode of ventilation using 100% oxygen with low PEEP levels. When a PDT was bronchoscopy-guided, 6 – 8 mL/kg of tidal volume, with a volume-controlled ventilation, was used in order to avoid hypoventilation (using a higher value of peak pressure alarm limit). Monitoring included a continuous electrocardiogram monitoring, a pulse oximeter, and either an invasive or non-invasive arterial pressure measurement. The patients received fentanyl 100 – 200 mcg, midazolam 0.3 mg/kg and cisatracurium 0.2 mg/kg bolus, immediately before the procedure. Additional anesthetic bolus drugs were infused as necessary. Typical targeted physiological parameters were a systolic pressure of 100–150 mm Hg, a heart rate of 60–90 beats per minute, and with a 95%–100% oxygen saturation.

An antiseptic solution (2.0% chlorhexidine) was applied to the surgical site, followed by an alcoholic solution with chlorhexidine 0.5%. In addition, 2% lidocaine with adrenaline was injected for a local anesthesia, up to a maximum dose of 3 mg/kg. The neck was kept hyper-extended throughout the procedure.

In the ultrasound-guided PDT, after skin decontamination, a physician using an aseptic technique determined the probable puncture site using anatomical landmarks. A pre-procedural assessment of the anatomy was performed with ultrasound by an intensivist, accompanied by an intensive care medicine resident, following appropriate patient positioning.

Cervical ultrasound was performed with a 12 MHz linear probe, followed by a color Doppler examination (Logiq P5, General Electric Healthcare, Contagem, Minas Gerais, Brazil) in order to evaluate the vascular anatomy of the anterior neck region, and to identify the thyroid isthmus, the cricoid cartilage, and the first three to five tracheal rings (Figure 1). The midline distance between the skin and the trachea and the tracheal diameter were measured at the second ring level. The vessels between the skin and the tracheal rings were identified and were avoided. The endotracheal tube was then identified and pulled under direct ultrasound guidance until the cuff was at the cricoid cartilage level to avoid any cuff puncture. The puncture site was marked between the second and third tracheal rings with the ultrasound probe in the longitudinal plane and was compared with the previously defined puncture site that was based on anatomical landmarks. The trachea was then punctured under real-time ultrasound guidance with the probe in a transverse plane at the midline, with a catheter-over-the-needle device connected to a 10-mL syringe half-filled with distilled water. As soon as air aspiration
was observed in the syringe, the catheter was advanced into the trachea and the needle was removed. A flexible guide wire was then gently introduced into the catheter, which was removed after this step. A guide wire entry at the desired tracheal ring level and an entry into the anterior quadrant were then confirmed by using ultrasound before a skin incision and a blunt dissection. Thereafter, the procedure was completed as previously described by Griggs [1]. A bronchoscope (Olympus, Sao Paulo, SP, Brazil) was always available by the bedside in case of technical difficulties, but its use during the procedure was considered to be a failure of the ultrasound-guided method. After the PDT was complete, a bronchoscopy was performed in order to verify the tracheostomy positioning and to search for procedure-related complications.

In a bronchoscopy-guided PDT, the bronchoscopy was performed by trained intensivists. After sedation, as previously described, the bronchoscope was introduced and the endotracheal tube was repositioned under bronchoscopy guidance, with the tip of the tube just below the vocal cords. The thyroid cartilage, the cricoid cartilage, and the first three to five tracheal rings were identified and the puncture site was selected between the second and the third tracheal rings. Then, the trachea was punctured at the chosen site with a catheter-over-the-needle device connected to a 10-mL syringe half-filled with distilled water under real-time bronchoscopy guidance. As soon as air aspiration was observed in the syringe and the catheter was seen in the trachea, the catheter was introduced and the needle was removed during a continuous observation using bronchoscopy. A flexible guide wire was then gently introduced into the catheter. Thereafter, the procedure was completed as previously described by Griggs [1]. Bronchoscopy was maintained during the whole procedure in order to guide the puncture site, to avoid any posterior wall puncture, to confirm the correct positioning of the guide wire, and to confirm an adequate tracheal dilation. Ultrasound was always available by the bedside in case of technical difficulties during the procedure, but its use was considered to be a failure of the bronchoscopy-guided method.

An experienced surgical team was always available in case of any major technical difficulties or complications.
Figure 1. Ultrasound-guided PDT. A) Left parasagittal scan over the trachea using a linear transducer. The sonogram shows the cricoid cartilage (CC), the tracheal cartilage (T1–T3), and the air-mucosa (A-M) interface. B) Transverse scan at the level of the second tracheal ring using a linear transducer placed at the midline. The sonogram shows the trachea, thyroid gland (TG) and strap muscle (SM). Arrowheads indicate the A-M interface and comet tail artifact (CTA).
REFERENCES