Objective: To describe a novel technique for percutaneous tracheotomy (PT) that could be an alternative to current dilational techniques.

Design: An observational animal study of PT was performed using the Seldinger guide wire technique with a tracheostomy tube preloaded onto a dilational balloon catheter. A small skin incision was done with an 11-blade scalpel, but no blunt subcutaneous tissue dissection was performed.

Setting: Animal laboratory in a university hospital.

Subjects: Seven adult pigs (approximate weight, 16 to 21 kg).

Measurements and results: Successful tracheostomy was accomplished in all seven pigs without apparent complication. Vital signs and oximetry results remained unchanged throughout the procedure. The mean duration of the procedure was 5.5 min from tracheal puncture to ventilation.

Conclusion: This novel procedure is a simple and effective means of PT tube placement without subcutaneous tissue dissection and could potentially have decreased complications when compared to the standard methods of PT currently employed in humans. Human studies are pending.

Key words: balloon; percutaneous; tracheostomy

Abbreviation: PT = percutaneous tracheostomy

Percutaneous tracheostomy (PT) is gaining in popularity among critical care physicians as an effective means of airway management in patients requiring long-term ventilatory support in the ICU and respiratory rehabilitation facilities. Many studies advocate PT as a safe, efficient, and cost-effective alternative to surgical tracheostomy. Several methods for PT exist; however, two are widely used: the Ciaglia single dilator PT technique (ie, the Blue Rhino kit; Cook; Bloomington, IN) and the Griggs guide wire dilating forceps technique. The Griggs technique was reported to have significant major perioperative complications, whereas the Blue Rhino technique showed less severe but still potentially significant perioperative complications. One relatively rare but potentially serious complication of current dilational techniques is perforation or tearing of the posterior tracheal wall during insertion of the dilational device, which must be advanced into the trachea with a to-and-fro movement. We developed a technique that combines the advantages of PT by the Seldinger guide wire technique with balloon dilation, thus eliminating the need for blunt subcutaneous tissue dissection with its inherent risk for causing perioperative trauma and bleeding. Furthermore, this technique utilizes a means of dilation that
METHODS AND MATERIALS

Seven adult pigs were utilized for development of this technique. The animals were treated according to the guidelines of the US Animal Welfare Act. The protocol and anesthesia was scientifically justified and approved by our Institutional Animal Care and Use Committee. Animals used in this research received every consideration for their comfort and care; any discomfort and pain was minimized.

After overnight fasting, pigs weighing from 16 to 21 kg underwent oral endotracheal intubation. Anesthesia was accomplished with inhaled isoflurane titrated to effect and 20 mg/kg IV pentobarbital. Heart rate and rhythm were monitored by telemetry, while BP was monitored by arterial catheterization of the femoral artery. Oximetry was monitored by ear probe. A bronchoscope was used to allow for visualization of endotracheal tube placement to a position approximately 2 cm distal to the tracheal entrance. After evaluation of the palpable anatomy of the neck and local infiltration with 1% lidocaine, a 17-gauge needle was used to puncture the trachea without incision or dissection. Bronchoscopic visualization ensured the initial needle puncture was midline and that the needle did not impale the endotracheal tube or the posterior tracheal wall. A customized, stiff, 0.38-mm × 100-cm guide wire was placed and the needle removed. A 2-cm incision of the skin was made with an 11-blade scalpel in a longitudinal direction, followed by the passage and immediate removal of a 14F punch dilator taken from a Blue Rhino kit. A 16 × 50-mm long balloon dilatation catheter (Diamond Balloon Dilation Catheter; Boston Scientific; Watertown, MA) was loaded with an 8.0 tracheostomy tube (Shiley; Nellcor; Pleasanton, CA) [Fig 1] and placed 2 cm into the trachea and subsequently inflated with normal saline solution to five atmospheres for 3 to 5 s (Encore 26 Advantage Kit; Boston Scientific; Watertown, MA) to dilate the subcutaneous and tracheal tissues. Copious amounts of water-soluble lubrication were spread over the apparatus prior to insertion and, with the balloon still inflated, easily passed over the guide wire into the trachea. Once the tracheostomy tube was in place, the balloon was immediately deflated and the apparatus removed leaving only the tracheostomy tube in place. Placement of the tracheostomy tube was confirmed by bronchoscopy, and the posterior tracheal wall was further visualized for any evidence of trauma via the endotracheal tube as well as the tracheostomy tube. The newly placed tracheostomy tube was then used to successfully ventilate the pigs for approximately 3 to 5 min before destroying the animals.

RESULTS

A total of seven pigs underwent PT tube placement facilitated by balloon dilation over the guide wire. The mean procedure time was 5.5 min from tracheal puncture to ventilation through the tracheostomy tube. No immediately detectable adverse events or complications occurred. There was no visible bleeding from the tracheostomy site, neither externally or into the trachea. Proper placement of the tracheostomy tube was confirmed by bronchoscopy, and all animals were successfully ventilated. Heart rate, rhythm, BP, and oximetry results did not show any distinguishable change at any time during or after the procedure. No damage within the trachea, either above or below the tracheostomy site, was visible by bronchoscopic examination through either the endotracheal tube or the tracheostomy tube on all pigs. Postprocedure dissection was done on one pig showing no evidence of posterior tracheal wall perforation or even minor injury to any of the surrounding structures. Transverse thoracotomy was performed on three postmortem pigs without evidence of pneumothorax.

DISCUSSION

The reported complications associated with the Ciaglia- and Griggs-based techniques in humans are due to either predilatory dissection or the downward forces applied to the surrounding tissues and posterior tracheal wall during dilation.3 The downward force necessary for dilation displaces the anatomy in an unpredictable manner, potentially enabling predictable complications to occur. The balloon dilation technique for PT differs by eliminating the need for blunt dissection of soft tissues and by removing the need for forceful dilation of the peritracheal structures using a hard dilational device that must be advanced into the trachea with a to-and-fro motion. The balloon technique dilates the structures in a radial fashion followed by immediate placement of the tracheotomy tube when passed over an apparatus whose path is compelled to run parallel with the posterior tracheal wall due to the relative stiffness of the guide wire chosen. This also decreased the total number of steps required by other PT techniques.
Pigs were chosen as the model to test this technique because the tracheal anatomy of the pig is similar to humans, although more difficult to define. The average diameter of the pig trachea in our cohort was approximately 15 mm, while the median diameter of the adult human trachea is larger. Based on our experience, the median depth from skin to trachea is approximately 1 to 2 cm in most of the patients we chose for bedside PT. However, in our pigs, the skin-to-trachea depth was 3 to 5 cm, suggesting that this technique may be feasible in obese patients. Extrapolation of these results to humans is premature, but it is conceivable that because of the relatively small tracheal size of the pigs, easy collapsibility of the trachea during tracheostomy tube placement, and the difficulty to discern the anatomy by physical examination, success in this cohort makes for a reasonable likelihood of success in humans. Of course, human studies need to be done and are currently ongoing.

An important consideration related to this procedure is that the trachea will become temporarily occluded for 10 to 15 s. Three to 5 s is required to inflate the balloon, and then another 5 to 10 s of tracheal occlusion may be needed to slide the tracheostomy tube into place. Thus, in the unlikely event that 15 s of apnea can evoke life-threatening hypoxemia in a given patient, balloon-facilitated dilational tracheostomy tube placement would not be the procedure of choice for that individual. Another potential concern is bleeding. Of course, bleeding is always a potential risk in any surgical procedure, but, at least theoretically, our proposed balloon dilational technique offers a very low risk of inducing serious hemorrhage. Nonetheless, if a relatively large blood vessel was lacerated during the placement of the tracheostomy tube by the balloon dilatation technique, intraoperative control of the bleeding is not immediately feasible since access to the damaged vessel is limited by the lack of dissection of soft tissues.

**Conclusion**

This investigation shows that balloon-facilitated tracheostomy tube placement can be done safely in pigs without blunt dissection. Whether or not this novel technique may save time or decrease complications when applied to humans has yet to be determined. If this technique is equally successful in humans as it was in our animal cohort, then the potential for less morbidity from PT is enormous. Human trials are ongoing.

**References**