In Vitro Fluid Leak Around the Endotracheal Tube Cuff Is Easily Remedied

In the August 2010 issue of Respiratory Care, Deem and Treggiari reviewed the current evidence regarding endotracheal tube (ETT) design and the incidence of ventilator-associated pneumonia. This letter is in regards to polyurethane-cuffed ETTS and seepage of secretions into the tracheobronchial tree. The theoretical advantage of polyurethane and silicone cuffs, compared to high-volume low-pressure polyvinyl chloride (PVC) cuffs, is the absence of creases on the inflated cuff surface, which can allow secretions to pass into the tracheobronchial tree, thereby increasing the incidence of ventilator-associated pneumonia. Deem and Treggiari gave an overview of the few clinical studies that have been performed, and pointed out some inadequacies in the current body of knowledge. I agree with them that more clinical studies are needed to better assess the efficacy and cost-effectiveness of polyurethane and silicone cuffs.

Included in Deem and Treggiari’s paper were 2 photographs from an in vitro study, depicting the theoretical advantage of polyurethane cuffs. Dye was instilled on the top of a cuff inflated inside a plastic tube. After 15 minutes all of the dye had leaked past the PVC cuff, whereas none had leaked past the polyurethane cuff. They say a picture is worth a thousand words, and these pictures certainly are remarkable and I would expect them to be very influential on clinicians. It is obvious from the text that Deem and Treggiari did not use these photographs in an attempt to convince the reader that polyurethane cuffs should replace PVC cuffs; however, these photographs do exaggerate the superiority in vitro performance of polyurethane cuffs, given that leakage around a PVC cuff in vitro is easily remedied.

Dullenkopf et al performed an in vitro study like the one described above, and found that after 10 min nearly all the fluid had passed by the PVC cuff, whereas none had leaked past the polyurethane cuff. However, when they treated the PVC cuff with a lubricating gel, leakage was substantially reduced. Lucangelo and colleagues also performed a similar in vitro experiment, and found that PEEP of 5 cm H2O essentially eliminated seepage around the PVC cuff, both in vitro and in vivo.

I performed a similar in vitro experiment (unpublished) with a couple of other modifications. I used a Mallinckrodt 7.5-mm inner-diameter ETT with a lubricated PVC cuff, 2 hours after 3 mL of colored whole milk was instilled above the cuff and the model was mechanically ventilated at 5 cm H2O PEEP and 5 cm H2O inspiratory pressure (ie, pressure below the cuff). Immediately after taking this picture, I agitated the cuff by moving the endotracheal tube up and down and side to side. Right: Three hours later (2 hours after agitating the cuff plus 1 hour after disconnecting the ventilator and thus removing the positive pressure below the cuff).

Fig. 1. Left: Mallinckrodt 7.5-mm inner-diameter endotracheal tube with a lubricated PVC cuff, 2 hours after 3 mL of colored whole milk was instilled above the cuff and the model was mechanically ventilated at 5 cm H2O PEEP and 5 cm H2O inspiratory pressure (ie, pressure below the cuff). Immediately after taking this picture, I agitated the cuff by moving the endotracheal tube up and down and side to side. Right: Three hours later (2 hours after agitating the cuff plus 1 hour after disconnecting the ventilator and thus removing the positive pressure below the cuff).
than water. I applied PEEP 5 cm H₂O, inspiratory pressure 5 cm H₂O, respiratory rate 10 breaths/min, and inspiratory time 0.9 s, to more closely simulate mechanical ventilation. There was no leakage past the cuff after 2 hours (Fig. 1). After taking the first photograph in Figure 1, I agitated the cuff within the syringe by moving the ETT up and down and side to side. A small amount of the colored milk seeped into a few of the cuff creases, but after 2 more hours of mechanical ventilation, none of the colored milk had even made it to the middle of the cuff. Two hours after agitating the cuff (ie, at the 4-hour mark) I disconnected the ventilator, and 1 hour later none of the dyed milk had leaked past the cuff (see Fig. 1).

There are, of course, other issues that may affect cuff performance, such as the maintenance of cuff pressure, cough, tracheobronchial suctioning, the limited protection from cuff lubrication, the interface with a natural trachea, and the impact of other concomitant ventilator-associated-pneumonia prophylactic measures. That being said, I think that photographs depicting superior in vitro cuff leak protection from a polyurethane cuff (under ambient pressure, with a low-viscosity liquid, and without cuff lubrication) project an exaggerated view of how polyurethane cuffs might outperform PVC-cuffed ETTs in patients.

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The author has disclosed no conflicts of interest.

REFERENCES