The most common complication due to intubation is a high cuff pressure. A high cuff pressure can cause postanesthetic tracheal mucosal injuries in patients undergoing surgery. The aim of this cross-sectional study was to describe whether anesthetic nurses and anesthesiologists identified a very high cuff pressure by manual palpation of the external cuff balloon on an endotracheal tube. An airway device was intubated with an endotracheal tube cuffed to 95 cm H₂O. Each participant palpated the external cuff balloon and then filled out a questionnaire, including estimation of the cuff pressure and user frequency of the cuff pressure manometer. The results showed that 89.1% estimated that the cuff pressure was high. Among the participants who rated the cuff pressure as high, 44.8% rated the pressure as quite high and 60.6% rated the pressure as very high. There was no significant relationship between profession and skill in identifying a very high cuff pressure (P = .843) or between work experience and skill in terms of identifying a very high cuff pressure (P = .816). These findings indicate that 10% of patients are at risk of tracheal erosion because of a high cuff pressure.

Keywords: Anesthesia staff, cuff pressure, cuff pressure manometers, manual palpation.

Damage to the trachea after intubation with a cuffed endotracheal tube is a well-known complication. The purpose of the cuff is to prevent aspiration and to reduce air leakage with mechanical ventilation. Common ways to estimate endotracheal tube cuff pressure are to perform hands-on palpation of the external cuff or to listen after the air leak when the patient is ventilated. Cuffing the tube with a predetermined amount of air also is done. The cuff pressure is dynamic, and the factors that affect the pressure are the use of nitrous oxide, different phases in the operation, and the position of the head. The most common complication due to intubation is a high cuff pressure.

There are no common guidelines in research for the ideal cuff pressure. Nordin et al suggest that the cuff pressure should be below 27 cm H₂O; in addition, an interval of 20 to 41 cm H₂O is recommended. Recent research suggests that an interval of 20 to 30 cm H₂O is optimal to prevent damage to the trachea and aspiration. If the cuff pressure exceeds 40 cm H₂O, the perfusion in the trachea decreases and the risk of developing ischemia in the trachea increases. If the patient is hypotensive, the circulation in the trachea decreases further and damage can occur even if the cuff pressure is normal.

Coughing, expectoration, edema, postoperative sore throat, and hoarseness are more commonly seen with intubation at high cuff pressure. Jaensson and colleagues found. One of the risk factors for the development of postoperative hoarseness was a 20 cm H₂O cuff pressure; one explanation can be that when the pressure is too low the endotracheal tube is likely to drift around in the trachea and thus cause injury.

Monitoring the cuff pressure is a reliable standard procedure to confirm the pressure to the tracheal wall. The use of a cuff pressure manometer is recommended in several studies. Galinski and colleagues and Parwani and colleagues recommend that the cuff pressure manometer should be attached immediately after intubation. Several studies show that manual palpation of the external cuff balloon is an insufficient method. A high cuff pressure can cause postanesthetic tracheal mucosal injuries in patients undergoing routine endotracheal intubation.

The aim of this study was to describe whether anesthetic nurses and anesthesiologists could identify a very high cuff pressure by palpation of the external cuff balloon on an endotracheal tube.

Methods

A cross-sectional study was conducted in a university hospital in Northern Sweden. The sample was consecutive, and all the anesthetic nurses and the anesthesiolo-
gists who were on duty during the 2 days the study was conducted were included in the study. All participants gave an oral consent to participate.

- **Test Procedure.** An airway management trainer (Ambu) was used, as was an endotracheal tube (Rüschelit Super Safety Clear, Ruesch GmbH), size 7.0, with a high-volume low-pressure cuff diameter of 22.5 mm, was used. The inner diameter of the trachea of the airway device was measured to 15 mm. The cuff was controlled both by manual palpation and visually, after insertion; the cuff remained inflated to a pressure of 95 cm H₂O (equal to 70 mm Hg). A cuff pressure manometer was calibrated and was used to control the cuff between each measurement. The cuff pressure manometer was connected to the endotracheal tube during palpation but was hidden from the participants.

Each participant manually palpated the cuff. After the procedure, the participants filled in a short survey that contained background characteristics such as sex, occupation, number of years as an anesthetic nurse or anesthesiologist, and their estimation of the cuff pressure by choosing one of these alternatives: very low, quite low, adequate, quite high, and very high. At the end of the survey, the participants estimated how often they used a cuff pressure monitor. The participants’ years of work experience were classified into 5 or fewer years, 6 to 10 years, 11 to 15 years, 16 to 20 years, 21 to 25 years, and 26 years and longer.

- **Definition.** In this study, an adequate cuff pressure was in the green area of the cuff pressure measurement, defined as 22 to 32 cm H₂O. A quite high cuff pressure was above 32 cm H₂O but below 50 cm H₂O; a very high cuff pressure was above 50 cm H₂O. These definitions are in accordance with those given by Seegobin and van Hasselt, who found that the blood flow in mucosa of the trachea reduces with a pressure over 30 cm H₂O, and a total occlusion occurs with a pressure of 50 cm H₂O. Quite low cuff pressure was defined as below 20 cm H₂O because of the risk that microaspiration can occur below 20 cm H₂O. A very low cuff pressure was defined as below 14 cm H₂O. As far as we know, no studies have published lower estimated values.

- **Statistics and Ethics.** Result were analyzed using statistical software (IBM SPSS Statistics version 21). Descriptive statistics were employed and χ² tests were used to estimate differences between groups; a P value less than .05 was considered significant. The study was approved by the head of the department, and the participants were informed that their attendance was optional. The integrity of participants as well as data from the survey were treated according to the 1964 Helsinki declaration and its revised versions, which are meant to protect study participants.

**Results**

A total of 66 persons participated in this study. The sample consisted of 46 anesthetic nurses and 20 anesthesiologists, which in the total sample of employees in the operative setting made a participation rate of 83.6% of anesthetic nurses and 67% of anesthesiologists.

The anesthetic nurses had a work experience of a mean of 13 years (SD, 12.4 years) and the corresponding figure was above 32 cm H₂O but below 50 cm H₂O; a very high cuff pressure was above 50 cm H₂O. These definitions are in accordance with those given by Seegobin and van Hasselt, who found that the blood flow in mucosa of the trachea reduces with a pressure over 30 cm H₂O, and a total occlusion occurs with a pressure of 50 cm H₂O. Quite low cuff pressure was defined as below 20 cm H₂O because of the risk that microaspiration can occur below 20 cm H₂O. A very low cuff pressure was defined as below 14 cm H₂O. As far as we know, no studies have published lower estimated values.

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**Figure 1.** Estimation of Cuff Pressure by Each Work Category and for Total Sample

A total of 48.5% estimated that the cuff pressure was very high.
for the anesthesiologists was a mean of 16.1 years (SD, 12.0 years). The distribution between the sexes was 30 women and 34 men in the total sample. The gender distribution among the anesthetic nurses was 55.6% female (n = 25) and 44.4% male (n = 20). The corresponding percentages for the anesthesiologists were 26.3% female (n = 5) and 73.7% men (n = 14). Information was missing from 3% of participants (n = 2).

Among all the participants, 89.1% (n = 57) estimated that the cuff pressure was high. Among the participants who rated the cuff pressure as high, 44.8% (n = 26) rated the pressure as quite high and 48.5% (n = 31) rated the pressure as very high (Figure 1). Among the participants, 63.6% (n = 42) stated that they always use a cuff pressure monitor (Figure 2).

There was no significant difference between work experience and how many of the participants identified a very high cuff pressure (P = 0.816). Neither was there a difference between anesthetic nurses and anesthesiologists in identifying a very high cuff pressure (P = .843).

Discussion
The results show that even though a high percentage (89.1%) of the participants identified a high cuff pressure by manual palpation of the cuff balloon, 10.9% did not.

Similar findings are described by Ozer and colleagues.13 The participants in their study were requested to inflate a tracheal tube and estimate an appropriate cuff pressure after intubation by manually palpating the cuff. The result pointed out that approximately 70% of the participants cuffed the tracheal tube to a pressure greater than 30 cm H2O. Liu and colleagues17 described that the cuff pressure was 58 cm H2O after intubation and after the participants manually palpated the external cuff balloon. Galinski and colleagues21 measured cuff pressure among patients who were transported by ambulance and were intubated; the cuff pressure was higher than 27 cm H2O among 79% of the patients. Galinski and colleagues21 questioned the use of 10-mL syringes because studies have shown that a cuff pressure of 20 to 30 cm H2O needs only 4.4 ± 1.8 mL of air.3

There was no relationship between years of work experience and the ability to discern a very high cuff pressure in our study. Chan and colleagues20 found that for participants who had a work experience between 5 and 10 years, there was no significant correlation between

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**Figure 2. Participants’ Estimation of Their Use of a Cuff Pressure Monitor**

* A total of 63.6% of the participants estimated that they always used a cuff pressure monitor.
work experience and the skill of identifying a very high cuff pressure. These findings are not supported by studies that found a correlation between work experience and the skill of estimating a high pressure by palpating the external balloon. Several studies have found that training the anesthetic staff in estimation of the external cuff balloon results in short-term knowledge. Even though a study showed that the knowledge endures for 8 months, other studies found a decrease in the learned skill after just 1 month. The conclusion is that it is difficult to train for the skill needed to identify a high cuff pressure, and objective methods such as a cuff manometer should be employed. It is important to check the cuff pressure throughout the operation because the cuff pressure varies at different phases of the operation.

One can question why so few members of the anesthetic staff pay attention to the cuff pressure. One explanation could be that the staff seldom sees the consequences that a high cuff pressure can cause. A limitation of our study must be noted; the artificial trachea used was not as unreisiting as a human trachea. However, because the cuff pressure was very high, that factor should not have affected the participants. A high cuff pressure should be identified by all anesthetic staff members.

**Conclusion**

Although almost 90% of clinicians could correctly identify a dangerously high cuff pressure by palpation, 10% could not. Given that the cuff pressures used were high enough to completely occlude blood flow in the tracheal wall, placing 10% of patients at risk of tracheal erosion is unacceptable. This finding suggests that a manometer could be a useful adjunct for enhancing patient safety and should be connected immediately after intubation.

**REFERENCES**


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**DISCLOSURES**

The authors have declared they have no financial relationships with any commercial interest related to the content of this activity. The authors did not discuss off-label use within the article.