Survey of Cuff Management Practices in Intensive Care Units in Australia and New Zealand

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Background  Cuff management varies widely in Europe and North America. Little is known about current practice in Australia and New Zealand.

Objective  To characterize important aspects of cuff management in intensive care units in Australia and New Zealand to compare with international reports.

Methods  A questionnaire was sent to all nurse managers of adult intensive care units in Australia and New Zealand.

Results  Survey response was 53% (92/175). After intubation, most units (50/92, 54%) used both minimal occlusive volume technique and cuff pressure measurement; 5 (5.5%) used these methods along with pilot balloon palpation. Twenty units (22%) used cuff pressure measurement exclusively and 16 units (17.5%) used the minimal occlusive volume technique exclusively. Only 1 unit (1%) used the minimal leak technique after intubation. For ongoing management, cuff pressure measurement was the preferred method, used exclusively in 42 units (46%), with the minimal occlusive volume technique used in 40 units (43%; sole method in 6 units [7%]) and palpation in 4 units (4%). In most units (65/92, 71%), cuffs were monitored once per nursing shift. In units using the minimal occlusive volume technique, oropharyngeal suctioning (74%) and semi-recumbent positioning (58%) were routinely incorporated; sigh breaths (6%), discontinuation of enteral feeding (10%), and nasogastric tube aspiration (26%) were uncommon. Cuff management protocols (37%) and subglottic suctioning (12%) were used infrequently.

Conclusions  Cuff pressure measurement was the preferred method, used exclusively or in combination with other methods. The minimal occlusive volume technique was used more often after intubation than for ongoing management. (American Journal of Critical Care. 2008;17:428-435)
Endotracheal and tracheostomy tubes have a balloonlike cuff that circumferentially surrounds the lower exterior part of the tube to enable the delivery of positive pressure ventilation without loss of tidal volume and to prevent aspiration of pharyngeal contents. Ongoing cuff management involves procedures to ensure appropriate inflation of the cuff. Underinflation can lead to bronchial aspiration of secretions, particularly during inspiration, and overinflation can cause tracheal ischemic damage. Importantly, aspiration of pharyngeal secretions has been associated with ventilator-associated pneumonia (VAP).

Potential injuries from overinflation of the cuff include tracheal rupture, tracheal necrosis, tracheoesophageal fistula, tracheal stenosis, and recurrent laryngeal nerve palsy. More commonly, overinflation of the cuff can result in stridor and sore throat after extubation. Four methods for monitoring cuff inflation have been described. In the minimal occlusive volume (MOV) technique, air is added to the cuff to create a seal and abolish air leak on inspiration. In the minimum leak technique (MLT), air is removed from the cuff to allow a small leak on inspiration. Cuff pressure measurement (CPM), performed with a manometer during the inspiratory phase, provides objective measurement of intracuff pressure that does not involve cuff deflation. A fourth technique, the palpation method, involves subjective estimation of cuff inflation based on gentle palpation of the pilot balloon.

Currently, there is little consensus about the best method for monitoring ongoing cuff inflation or on how often monitoring should be done. The objective of this study was to characterize important aspects of the current practice of cuff management in Australian and New Zealand intensive care units (ICUs) to enable comparison with international reports.

Methods

Items for inclusion in the questionnaire were identified through discussion with senior medical and nursing clinicians and a search of MEDLINE and CINAHL with the terms endotracheal cuff, cuff pressure, tracheal tube, airway management, and ventilator-associated pneumonia searched individually and in combination. The questionnaire was used to gather information on management of cuff inflation after intubation and during ongoing cuff monitoring. Specifically, participants in the survey were asked to identify the method used and to comment on the rationale for selection of this method. In addition, participants were asked to report on the frequency of monitoring, the professional group who performed the procedure, methods used to assess adequacy of cuff seal, presence of unit guidelines for cuff management, and demographic characteristics of the unit.

Information on the MOV and CPM techniques was also requested. Respondents from units that used the MOV technique were asked practice-focused questions pertaining to suctioning of the oropharynx, aspiration of the nasogastric tube, and discontinuation of enteral feedings before cuff deflation. If full cuff deflation was performed during the technique, respondents were asked about use of sigh breaths to assess cuff seal and positioning of patients during cuff monitoring. Respondents from participating ICUs who routinely performed CPM were asked to report on the accepted range of cuff pressures and the procedure for managing ongoing cuff leak when maximal cuff pressure was used. Before the questionnaire was distributed, it was sent to senior nursing and medical staff who were not involved in its initial development to determine content validity.

Survey participants were sought via the Australia and New Zealand Intensive Care Society (ANZICS) research coordinators’ closed e-mail list, and a questionnaire was mailed to all adult ICUs (n = 175) that contribute to the ANZICS Review of Intensive Care Resources and Activity. In each unit, a member of the senior nursing staff nominated by the nurse manager (clinical nurse manager or educator involved in cuff management procedures) completed the survey to describe current practice within the ICU.

The best method for monitoring cuff inflation has not been determined.
Most units used a combination of the minimal-occlusive-volume technique and cuff pressure management.

Table Cuff monitoring methods

<table>
<thead>
<tr>
<th>Method</th>
<th>After intubation</th>
<th>Ongoing management</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%) 95% CI</td>
<td>No. (%) 95% CI</td>
</tr>
<tr>
<td>MOV + CPM</td>
<td>50 (54) 44-65</td>
<td>40 (43) 33-54</td>
</tr>
<tr>
<td>CPM</td>
<td>20 (22) 14-32</td>
<td>42 (46) 35-56</td>
</tr>
<tr>
<td>MOV</td>
<td>16 (17.5) 10-27</td>
<td>6 (7) 2-14</td>
</tr>
<tr>
<td>MLT</td>
<td>1 (1) 0.03-6</td>
<td>0 (0) NA</td>
</tr>
<tr>
<td>Palpation</td>
<td>0 (0) NA</td>
<td>0 (0) NA</td>
</tr>
<tr>
<td>MOV + CPM + palpation</td>
<td>5 (5.5) 2-12</td>
<td>4 (4) 1-11</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; CPM, cuff pressure monitoring; MLT, minimal leak technique; MOV, minimal occlusive volume; NA, not applicable.

Approval for this survey was obtained from the institutional review boards of Melbourne Health and RMIT University. The return of a completed questionnaire was considered indicative of consent.

Categorical data were expressed as proportions with 95% confidence intervals and were compared by using an $\chi^2$ test or the Fisher exact test where appropriate. Acceptable pressure range was expressed as mean and standard deviation. The relative risk ratio was calculated to determine if the cuff monitoring procedure was more likely to be undertaken by 2 members of staff when the MOV technique was used than when other methods were used. A $P$ value of .05 or less was considered statistically significant. All analyses were performed by using Minitab 14. Comments sections were analyzed by using content analysis to identify themes. The data were coded initially for key phrases such as evidence-based practice or prevention of complications and then examined for repetition, characteristics, and dimensions that indicated and confirmed categories. Data were coded separately by an independent rater after discussion of the definitional criteria of the categories; interrater agreement on first review was 99%. Percentages were then calculated for the number of responses to each identified theme.

Results

Survey Response and Demographics of Participating ICUs

Of the 175 surveys sent to adult ICUs in Australia and New Zealand, 92 were returned (53% response rate). Of the 82 respondents who identified their unit classification and location, 48 (59%) were metropolitan ICUs; the remaining 34 (41%) were rural or regional units. The most frequent response was from level III ICUs (38/82, 46%), 36 responses (44%) were from level II units, and 8 (10%) were from level I ICUs. A level III unit is a tertiary referral unit capable of providing the highest level of care, a level II unit provides a high standard of general intensive care, and a level I unit provides short-term management and immediate resuscitative care.

Cuff Management

After intubation, most units (50/92, 54%) used a combination of MOV and CPM; a further 5 ICUs (5.5%) used these methods in combination with palpation of the pilot balloon (see Table). A total of 20 ICUs (22%) used CPM as the sole method, and 16 (17.5%) used MOV exclusively. Only 1 ICU (1%) reported using MLT after intubation.

For ongoing monitoring of cuff inflation, CPM was the preferred method; it was used alone in 42 ICUs (46%), in combination with MOV in 40 ICUs (43%), and in combination with MOV and pilot balloon palpation in a further 4 ICUs (4%). The MOV technique was used as the only monitoring technique in 6 ICUs (7%; see Table). The profile of preferred methods for determination of adequate cuff inflation was similar across geographic locations and levels of ICU care.

A total of 78 participants made 106 comments on the preferred method of cuff management for ongoing monitoring. Content analysis revealed the following themes: monitoring cuff integrity, reducing complications associated with overinflation (increased pressure), traditional practice, evidence-based practice, ease of use, and preventing complications associated with underinflation. The most frequent rationale for the method selected was to decrease complications associated with underinflation (28/106, 26%) and overinflation (26/106, 25%, identified only by respondents whose units used CPM). The other 2 most frequently identified themes were ease of use (25/106, 24%, identified only by respondents whose units used CPM) and traditional practice (14/106, 13%).

Figure 1 shows that cuff monitoring was performed once per nursing shift (either 8 or 12 hours) in most ICUs (65/92, 71%). Of the ICUs that performed cuff monitoring more than once per shift, all used CPM either exclusively or in combination with MOV. No ICUs that used the MOV technique exclusively performed cuff monitoring more than once per shift ($P = .17$).

In the 86 ICUs that used CPM, the mean acceptable pressure ranged from 17 (SD 7.6) to 30 (SD 5.8) cm H$_2$O. If a cuff leak remained once the maximum pressure was noted, most respondents (61/86, 71%) reported that medical staff would be informed and tube placement reviewed. Thirteen respondents...
stated that cuff inflation would continue until a seal was achieved regardless of the pressure. Only 2 respondents (2%) reported that a cuff leak would be accepted to maintain the cuff pressure within the desired range. An additional 5 respondents (6%) reported that the insertion length of the endotracheal tube would be checked.

Cuff management was identified as solely a nursing responsibility in most ICUs (82/92, 89%); 6 ICUs (7%) reported shared nursing and medical responsibility for the procedure. Involvement of a physiotherapist was reported by 1 ICU, and involvement of a speech therapist by another. Cuff management was mostly performed by 1 staff member (75/92, 82% of ICUs); however, 6 ICUs (7%) reported that the procedure was always carried out by 2 staff members. Four respondents (4%) reported that the number of staff members required depended on the cuff monitoring method used; MOV required 2 staff members, whereas CPM required only 1. In units that used MOV monitoring exclusively, cuff monitoring was more likely to be carried out by 2 staff members than in units where other methods were used (relative risk ratio, 8.6; 95% confidence interval, 3.3-22.2).

Figure 2 indicates the responses for specific aspects of the cuff check procedure from the 50 ICUs where MOV was used either as the preferred technique or in combination with other methods for ongoing cuff management. In most ICUs (37/50, 74%), the oropharynx was always suctioned before cuff deflation. Routine discontinuation of nasogastric feeding (5 ICUs, 10%) and aspiration of the nasogastric tube (13 ICUs, 26%) before the cuff monitoring procedure occurred infrequently. Additional inspiratory breaths used to confirm cuff seal via ventilator-activated sigh breaths or manual inflation were used rarely; 11 ICUs (22%) used the technique at times; only 3 ICUs (6%) reported routine use.

The use of full cuff deflation for assessment of the cuff volume varied among the 50 responding ICUs. Cuff volume was consistently evaluated with full cuff deflation in only 13 ICUs (26%), whereas the cuff was not fully deflated in 17 ICUs (34%). A further 16 respondents (32%) reported that full deflation of the cuff occurred only when a persistent leak was present. Four participants (8%) did not respond to this question. Of the 39 respondents who addressed the question on the maximum volume accepted to achieve a cuff seal, 29 respondents (74%) thought that 10 to 15 mL was the maximum volume to achieve a seal, whereas 10 respondents (26%) thought that 20 mL or greater was still an acceptable volume.

The semirecumbent position, defined as 30º to 45º elevation of the head of the bed, was the most frequently used position (29/50, 58%) for patients undergoing the cuff monitoring procedure in those ICUs where MOV was used either exclusively or in combination with other techniques (Figure 3). Ten respondents indicated that patients were not repositioned for cuff monitoring, suggesting that any position of a patient was regarded as acceptable. All 10 of these ICUs used CPM and MOV in combination. In all 6 ICUs where MOV was the sole method used for cuff monitoring, patients were repositioned to be semirecumbent.

Adequacy of cuff seal was assessed by a number of methods used alone or in various combinations. These techniques included auscultation of the upper airway with or without manual inspiration (14/92, 15%); assessment of the expired tidal volume as the only method (9/92, 10%) or in combination with auscultation (15/92, 16%); and ensuring that cuff
intubation and that CPM was used infrequently. Similarly, recent North American surveys of airway management practices indicated that MLT was the preferred method for cuff inflation after intubation. In contrast, use of MLT was rarely reported in our survey.

In the ICUs in Australia and New Zealand that were surveyed, use of CPM was more common than described in previous reports. Sierra et al reported that CPM was used at least daily in 57% of participating Spanish ICUs. Similarly, in an early study, researchers found that CPM was used in 59% of 62 North American hospitals, and comparable rates of CPM use were reported in more recent North American studies. In contrast, British studies suggest that CPM is used infrequently. Results of a telephone survey of 24 ICUs in Northern England indicated that 75% of ICUs did not check cuff pressures. Likewise, Spittle and Beavis found that CPM was never used in 13 of 30 (43%) English ICUs surveyed, was used only if a cuff seal was problematic in 13 ICUs, and was used on a regular basis in only 4 ICUs.

Few published data describe the rationales for preferred methods of cuff management in clinical practice. Clinical adoption of cuff management techniques should be based on evidence that confirms the effectiveness of the method. Currently, no studies have confirmed the superiority of CPM over MOV or MLT. CPM provides an objective measurement of cuff pressure that does not involve cuff deflation, potentially decreasing the risk of aspiration. However, pressure readings may be influenced by a patient’s body position and head alignment, tube migration, coughing, lung compliance, and airway and intrathoracic pressures. Thus, cuff pressures may require more frequent assessment to ensure that adequate cuff inflation is maintained.

Conversely, MOV and MLT are less likely to be affected by changes in lung compliance, airway dynamics, or a patient’s position. However, noteworthy complications have been associated with MOV and MLT, including interruption of positive pressure ventilation promoting loss of positive end-expiratory pressure and an increased risk of hypoxemia, aspiration, and hyperinflation on cuff reinflation. In addition, MLT could cause tracheal wall trauma via tube movement and drying of tracheal mucosa, and may result in hypoventilation due to loss of tidal volume around the cuff.

One reason CPM has been widely adopted in ICUs in Australia and New Zealand may be that few resources are required to perform the technique. In our study, the respondents indicated that MOV was usually performed by 2 staff members because of the

### Extubation

Cuff pressure or volume was assessed before extubation as a routine practice in only 10 (11%) of the participating ICUs. Moreover, detection of low volume or high pressure was not thought to influence the decision to extubate in most responding ICUs (82/92, 89%).

### Protocols/Guidelines

Of the 92 participating ICUs, 34 (37%) had a formalized written protocol for cuff management. Of these 34, twenty-four (71%) had guidelines for the management of an inadequate cuff seal and 17 (50%) had management guidelines for cuff overinflation. Endotracheal tubes with subglottic suctioning facility were reported to be in use at only 11 of the 92 ICUs (12%).

### Discussion

In this survey of cuff management practices in ICUs in Australia and New Zealand, CPM used exclusively or in combination with other methods was the preferred method for obtaining a cuff seal after intubation (82% of ICUs) and for ongoing monitoring of cuff inflation (93% of ICUs). Practice surveys undertaken in North America and Europe indicate wide variation in the preferred method of cuff monitoring. Early North American studies indicated that respondents had a preference for using MLT and MOV to obtain an adequate seal after intubation and that CPM was used infrequently. Similarly, recent North American surveys of airway management practices indicated that MLT was the preferred method for cuff inflation after intubation. In contrast, use of MLT was rarely reported in our survey.

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need to apply tracheal suctioning during cuff deflation, whereas CPM was generally performed by a single staff member. Respondents who identified CPM as the preferred method also were more likely to list ease of use as a rationale for its use.

The palpation method was not identified as the primary method to determine adequacy of cuff inflation by any respondents. High cuff pressures are reflected by overinflation of the pilot balloon; however, this method is extremely subjective and has resulted in excessive cuff pressures in numerous studies.29,32,36 With cuff pressures as high as 100 cm H2O identified when estimation techniques are used exclusively.29,37

The optimal frequency of cuff monitoring has yet to be determined and may depend on the method used; however, serial measurements of cuff pressure or volume are advised.1 In most of the ICUs in our study, cuff monitoring was performed 1 time each nursing shift (8 or 12 hours); in 22% of ICUs, cuff monitoring took place more frequently. Texts31-33 on mechanical ventilation state that cuff pressure should be measured every 8 to 12 hours, or at least daily. Similarly, practice surveys5,18 indicate that cuff pressures are generally measured every 8 to 12 hours. More frequent monitoring may be required if cuff inflation characteristics are unstable. Cuff pressure may decrease during a 4-hour period,34 suggesting that more frequent monitoring may be beneficial. Further, failure to identify inappropriate cuff inflation increases the risk of damaging the tracheal mucosa. Tracheal mucosal damage occurs when cuff pressures exceed 30 cm H2O for 15 minutes.35,36 Conversely, unrecognized underinflation increases the risk of aspiration and subsequent development of VAP.

For our respondents, the ideal cuff pressure ranged from 17 to 30 cm H2O (the lower end of that range is lower than current recommendations). The respondents were asked to identify clearly the unit of measurement used; however, the availability of manometers that measure either millimeters of mercury or centimeters of water may result in some uncertainty in ideal ranges. Cuff pressures less than 20 cm H2O (15 mm Hg) are associated with an increased risk of aspiration and a 2.5-fold increase in VAP.29,37-40 whereas pressures greater than 30 cm H2O (22 mm Hg) may impede capillary blood flow to the area of the tracheal wall in contact with the cuff, resulting in damage of the tracheal wall mucosa. Total obstruction of tracheal blood flow occurs at pressures greater than 50 cm H2O.35,51-53 In patients with hypotension, cuff pressures of 34 cm H2O may exceed the perfusion pressure of the trachea, resulting in significant tracheal damage.29

In those ICUs that used the MOV method, either exclusively or in combination with CPM, considerable variation was noted in certain aspects of the technique. In most ICUs, the oropharynx was suctioned before cuff deflation to reduce the volume of secretions potentially aspirated on cuff deflation; however, unless the region above the cuff is visualized directly, clinicians cannot adequately determine effective removal of secretions pooled above the cuff.45

Continuous aspiration of subglottic secretions (CASS) has been advocated as a means of removing secretions that may be difficult to reach with standard suctioning methods. A reduction in the rate of VAP when CASS is used has been reported in several studies.44-46 In addition, CASS is recommended by the current guidelines of the American Thoracic Society for the management of adults with hospital-acquired or ventilator-associated pneumonia.38 CASS was available in only 12% of the ICUs in our study; however, this availability is greater than that reported in a study of Franco-Canadian strategies for managing secretions.

Interestingly, few respondents who used the MOV technique reported aspiration of gastric contents or discontinuation of feeding as routine practice before cuff monitoring. Both practices may decrease the risk of aspiration that may result from cuff manipulation and stimulation of the gag reflex during oral suctioning. Similarly, a positive pressure breath via a manual resuscitation bag or a ventilator sigh breath was used infrequently, even though this technique is recommended in clinical practice guidelines.33

Placing patients in the semirecumbent position is recommended to reduce stimulation of the gag reflex and the risk for aspiration53,45; supine positioning has been associated with a higher incidence of clinically significant aspiration.55 Therefore, it was encouraging to note that in most ICUs that used the MOV technique, patients were placed in a semirecumbent position.

A notable finding was the infrequent testing of cuff inflation volume or pressure before extubation. Furthermore, the availability of this information did not inform decision making related to extubation. Although the accuracy of methods for monitoring cuff inflation in detecting laryngeal edema has not been tested, the endotracheal cuff-leak test performed by using cuff deflation and then calculating the difference between expired tidal volume as measured with and
without cuff deflation has high levels of sensitivity and specificity for detection of severe laryngeal edema, as confirmed by video bronchoscopy. Arguably, the presence of increased cuff pressure or decreased cuff volume may similarly be helpful in detecting patients whose airway may be compromised.

**Limitations**

As is the case with all self-administered questionnaires, we did not directly observe clinical practice; rather, senior ICU nurses were asked to report on current practices used for cuff management. Practice may vary among individuals within each ICU, and this survey cannot account for such variation. In addition, survey responses were from self-selected ICUs and therefore may not necessarily be representative of cuff management in ICUs in Australia and New Zealand.

**Conclusion**

Often practice surveys indicate a substantial gap between research-based recommendations and clinical practice. Within the ICUs in Australia and New Zealand that participated in our survey, although some variation in practice was noted, generally cuff monitoring practices conformed to existing practice recommendations. The most variation in practice was apparent in certain aspects of the MOV technique, indicating a need for further education about and evaluation of this procedure. Currently, no studies have confirmed that CPM is better than MOV or MLT; however, our survey suggests that the MOV technique may be more resource intensive than CPM. Further studies are needed to compare cuff monitoring methods for their effectiveness in preventing aspiration and subsequent development of VAP.

**ACKNOWLEDGMENTS**

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**REFERENCES**

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