Editorial

Fewer sore throats and a better seal: why routine manometry for laryngeal mask airways must become the standard of care

We have three decades of experience with the laryngeal mask airway (LMA) [1], yet most of us do not use it optimally. This is despite accumulating evidence of detrimental effects from cuff overinflation, i.e. postoperative sore throats from mucosal tissue injury and impairment of its primary function, the airway seal.

In 1983, Brain described ventilating the lungs of 23 patients for gynaecological procedures with a new airway device [2]. By gently titrating the cuff volume (as little as 7 ml), he found a good seal with little morbidity; only three (13%) patients suffered a mild sore throat. Today, the LMA has become the airway of choice for the majority of anaesthetics and is perceived as easy to insert and with minimal potential for harm. In our experience, insertion and inflation technique are often imparted without recourse to evidence, or even to the instruction leaflet. Here, we concentrate on one aspect of its use: what volume of air should we inject into the LMA's cuff? Usually, this will be the 'recommended' volume or, frequently, whatever our assistant decides. Thirty years later, the rate of sore throat is not 13% but nearer 50% [3]. What are we doing, or rather not doing, that the inventor did?

Since 1988, the instructions have advised that cuff pressures should never exceed 60 cmH_2O [4–6]. Despite this, clinical practice has tended to follow the 'recommended' (in fact maximum) volumes. These are laminated on anaesthetic room walls and recited for the examinations. Videos on YouTube explain that a size-4 LMA needs 30 ml air – no more, no less, no debate [7]. The message is that the LMA is simple and requires little attention to detail. It seems our aim is simply to restore the cuff back to its fully distended shape, since that's what we believe it should be in vivo.

However, mounting evidence over the last 20 years tells a different story. The painful truth is that we clinicians are needlessly overinflating LMA cuffs, impairing their function and giving half of our patients sore throats. We know this is the case: LMA cuff pressures frequently form the subject of trainee audits and consistently show that the vast majority of LMAs are overinflated (> 60 cmH_2O). In some reports, 70% of LMAs were overinflated and, in one, a staggering 97% [8, 9].

We recently conducted a national questionnaire that revealed that anaesthetists in the UK are not routinely checking LMA cuff pressures. Furthermore, clinicians were generally unaware of correct inflation pressures (unlike maximum recommended volumes) and half of the respondents were unaware of any evidence for potential harm. It is clear that misconceptions persist surrounding the use of the LMA. Below we aim to debunk some of these myths.

Myth 1: the recommended volumes for cuff inflation lead to the recommended cuff pressures

The LMA instruction leaflet states a maximum cuff volume of 20 ml for a size 3, 30 ml for a size 4 and 40 ml for a size 5. The same leaflet recommends a maximum cuff pressure of 60 cmH_2O. The obvious, and sadly incorrect, conclusion is that inflation with recommended volumes will result in the recommended pressures. In fact, it has been shown repeatedly that injecting the maximum recommended volume results in cuff pressures

approximately twice the maximum recommended, and even as high as 200 cmH_2O [10, 11]. Just 20 ml air in a size-5 LMA in situ frequently results in cuff pressures that exceed 60 cmH_2O [12–14]. Similar findings have been confirmed in paediatric LMAs [15].

The relationship between cuff volume and pressure is complex. With inflation, the cuff goes from negative elastic recoil at low volumes to positive recoil at higher volumes. Also, the pharynx, though not as rigid as the trachea, does significantly oppose distention. For a size-4 LMA ex vivo, the point of elastic recoil is not reached until 25 ml [13]. Hence, below this volume, the cuff pressures measured are similar to those exerted on the mucosa. Furthermore, nitrous oxide diffuses through silicone cuffs, e.g. that of the classic LMA, such that pressures rapidly exceed 60 cmH_2O, regardless of initial inflation volumes [16, 17].

So why are the recommended volumes so high? The explanation is that these volumes are based on the physical properties of the cuff; they are volumes to which the LMA could safely be distended without distorting or damaging the silicone. They are not an indication of what is suitable for most patients. That these volumes remain in the instructions is an uncorrected anomaly, and that they should be adopted by anaesthetists as clinical guidelines is unfortunate.

The choice of 60 cmH_2O, as with the stated maximum inflation volumes, was based on Brain's early clinical experience. Over the last 30 years, evidence has confirmed that pressures > 60 cmH_2O are indeed harmful and worsen seal pressures.

Instructions for the LMA Supreme advise a minimum volume to achieve a seal if a manometer is not to hand [5]. For the Proseal, instructions again remind us that cuff pressures should be less than 60 cmH_2O and warns that "*excessive cuff pressure can result in malposition and pharyngolaryngeal morbidity, including sore throat, dysphagia and nerve injury*" [6]. We are also reminded that at 60 cmH_2O, the pilot balloon should feel 'very compliant' and not 'olive like' [4].

Myth 2: sore throats post-LMA are infrequent and not related to cuff pressure

Randomised prospective trials of cuff inflation find incidences of sore throat of 40-50% in the control arms [3, 18, 19]. This is what we should expect in today's clinical practice, given frequent cuff pressures > 100 cmH_2O in clinical audit. Animal studies confirm extensive mucosal damage at high pressures and significant damage even at 60 cmH_2O [20, 21].

Early research ostensibly reassured us about high cuff pressures. Brimacombe and Keller attached pressure transducers to LMAs and the results seem to suggest that, even at high cuff volumes and intra-cuff pressures, the mucosal pressure is low (maximum 17 cmH_2O with a classic LMA) [12, 13, 15]. That there is a strikingly large discrepancy between 'measured' and 'calculated' (subtracting ex-vivo pressure-volume curves from in-vivo) mucosal pressures shows that one or both techniques must be wrong [22]. These incongruous results and criticism of the methodology for in-vivo pressure measurements mean that these low measurements must be treated as falsely reassuring [23].

Over the past 18 years, there have been eight randomised controlled trials of pharyngolaryngeal complications involving 2000 patients, comparing high and low cuff pressures [3, 11, 18, 19, 24–27]. With the exception of one small study [27], all report a dramatic reduction in the rates of sore throat in the low-pressure cuff groups, between one third and one half of that in the high pressure group.

Although transient in nature, sore throats are a significant concern to patients [28] and, due to their frequency, they represent a large anaesthetic morbidity burden [29].

Myth 3: higher volumes and pressures may cause problems but at least you get a good seal

One might imagine a LMA in situ to have the same shape as a distended LMA on the intubation trolley. Certainly, sagittal illustrations show a fully distended cuff over the larynx [4].

However, if a correctly inflated LMA (< 60 cmH_2O) is removed from a patient it will be seen that the cuff is soft and far from 'dinghy like', as shown in Fig. 1. When in the patient, this LMA will conform

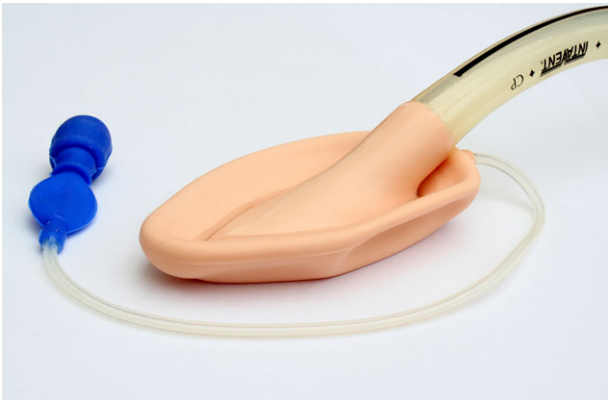

Figure 1 A size-4 LMA inflated with 15 ml air (enough to produce an in-vivo cuff pressure of just under the maximum recommended 60 cmH_2O).

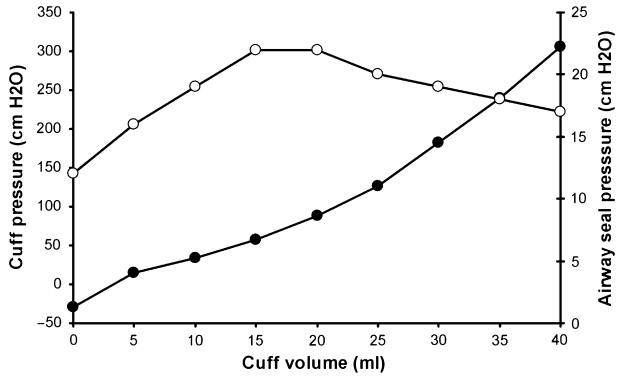

Figure 2 The effect of cuff volume on cuff pressure (●) and airway seal pressure (o) for a size-4 LMA. Data taken from Keller et al., 1998 [30].

to the tissues rather than vice versa. This may explain why, over an increasing range of inflation volumes, the airway seal pressure peaks around 15-20 ml for a size-4 LMA then progressively worsens with further inflation (see Fig. 2) [8, 10, 30].

If a LMA with a cuff pressure of 60 cmH_2O has a significant leak, then the solution lies in attending to the depth of anaesthesia, repositioning the airway or changing the airway size/type. By using a manometer, under-/overinflation can be excluded as a cause for leaks.

Myth 4: clinicians can judge a cuff pressure with their finger tips on the pilot balloon

Multiple studies in tracheal tubes and LMAs have shown that clinicians, regardless of experience and seniority, are poor at judging cuff pressures manually [31–33].

In an environment where we routinely use equipment to measure pressures, it seems inconsistent that we neglect to measure cuff pressures. However, we *can* use manometers to train our fingers to the surprisingly compliant feel of a pilot balloon inflated to 60 cmH_2O. Brimacombe and Keller, in 1999, found that anaesthetists and nurses were initially poor at estimating cuff pressures from manual palpation of the pilot balloon. Impressively, after just 15 minutes of training, the accuracy improved such that 95% of operators estimated within 10 cmH_2O of the target cuff pressure [34]. Nonetheless, we still need manometers available at the point of LMA insertion to achieve this skill.

Myth 5: the worst that can happen is a sore throat

The randomised evidence linking sore throats with excessive LMA cuff pressures is compelling, but the literature contains other significant morbidity that may result from excess inflation. These may result from both increased mucosal pressure and the failure to conform to the contours of the larynx, pharynx and oesophagus. Published adverse effects include recurrent laryngeal nerve palsy [35], dysphonia, dysphagia [3, 26] and venous congestion [36], with its attendant risks of airway oedema and surgical bleeding.

As discussed above, excessive LMA cuff pressures impair the airway seal (see Fig. 2), and fibreoptic assessment of LMA position demonstrates that the position is optimal with lower LMA cuff volumes [30]. Another function of the LMA is to protect the airway from soiling – an imperfect seal will allow more leakage of secretions or blood from above. High cuff pressures may also impair the seal at the upper oesophagus,

increasing the risk of regurgitation [37].

Conclusion

After 30 years, we believe the evidence calls for a change in our practice. Numerous authors have called for manometry to become routine in LMA insertion [16, 18, 38, 39]. Others advocate titrating LMA cuffs to achieve a 'just seal' pressure, as many of us routinely do with tracheal tubes [10, 25, 40–42]. Other pragmatic suggestions include allowing the plunger of the 60-ml inflating syringe to recoil, resulting in a pressure usually just less than 60 cmH_2O [43].

This is not the first article to call for a change in our understanding and use of the LMA [42]. So why are we so resistant to a simple intervention that could have such a widespread impact on patient experience and safety? We hope to see firstly, the general adoption of the safe maximum cuff pressure of 60 cmH_2O and secondly, a shift in our perception of the LMA in vivo: soft and conforming to the supraglottic anatomy, thus optimising its function.

Competing interests

AP has previously received an honorarium from the Laryngeal Mask Company. AIJB is the inventor of the LMA.

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Editorial

Oral carbohydrate preload drink for major surgery – the first steps from famine to feast

'Nil by mouth' is a cornerstone of pre-operative care. Soon after the first anaesthetics were administered, regurgitation and pulmonary aspiration of gastric contents were described. Nearly 70 years ago, in one of the most widely cited of all medical papers, Mendelson [1] described how aspiration occurred in 66 women from over 44 000 obstetric deliveries. Although only two mothers died, he also highlighted a more common problem of liquid aspiration, causing cyanosis and dyspnoea. With its description of morbidity (from aspirated liquid) and mortality (from solid food), this paper helped to shape anaesthetic practice for over a generation as nil by mouth, often for many hours, became standard.

