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Supraglottic airway *versus* tracheal intubation and the risk of postoperative pulmonary complications

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It is nearly 40 yr since Dr Archie Brain first described his prototype of the laryngeal mask airway (LMA) in the *British Journal of Anaesthesia*.[1] The introduction of the LMA as the first supraglottic airway (SGA) must surely be the outstanding development in anaesthesia for a generation. His new airway was designed for use during both spontaneous and positive pressure ventilation. Brain acknowledged that obtaining a good seal of the airway when inflation pressures were applied was of importance and that improvements would need to be made to the prototype by developing a range of sizes to improve the airway seal.[1] Subsequently, a variety of changes have updated the prototype: for instance, an even larger size 5 was introduced, a drainage tube for clearance of gastric contents was incorporated into the structure, a change in shape was made for the intubating laryngeal mask (ILMA), and different materials were used to produce a disposable LMA.

As with any new development, anaesthetists adapted their practice accordingly, introducing their own minor modifications to their anaesthetic technique when using an LMA. By 2001, concern was being expressed about the use of an LMA during abdominal surgery when neuromuscular blocking agents (NMBAs) were also given because of the risk of pulmonary aspiration of stomach contents.[2] However, in a meta-analysis of 547 publications in 1995, Brimacombe and Berry[3] had found an incidence of pulmonary aspiration of only 0.02% when an LMA had been used during all types of surgical procedure. Certainly by 1996, artificial ventilation was being used in 44% of cases when an LMA was in place in the UK, but it is unclear how many of the 5236 patients reported by Verghese and Brimacombe,[4] or in the Brimacombe and Berry[3] report, had received an NMBA. There were only 44 critical incidents in the Verghese and Brimacombe[4] report of which 18 were related to the airway. Regurgitation occurred in four patients and vomiting in two, but there was only one case of proved pulmonary aspiration of stomach contents. However, anecdotal reports continued to occur of aspiration of gastric contents even in non-obese patients undergoing upper abdominal surgery using an LMA and NMBA.[5]

Into the 21st century the practice of using NMBAs with an LMA became increasingly popular in the UK, even though some of us had expressed misgivings.[2] The 4th National Audit Project (NAP4) of the Royal College of Anaesthetists on major airway complications during anaesthesia in the UK in 2011[6] found an incidence of only 1 in 22 000 adverse airway events during anaesthesia with a resulting mortality of 1 in 180 000 cases. The rates of death or brain damage varied little between the airway devices used, although the numbers were too small to usefully discriminate. Aspiration of gastric contents had occurred in only 23 cases during anaesthesia. Planned airway management had been an LMA in 13, i-gel in one, tracheal tube in eight, and no airway in one patient. No details were provided on the use of NMBAs in the affected patients nor did the audit capture events deemed less catastrophic.

Clinical practice in the USA with respect to SGAs varies, but is generally more conservative than in Europe. In the USA, SGAs are used less frequently for patients in the non-supine position, for prolonged surgery, or during laparoscopy. In this issue of the *British Journal of Anaesthesia,* Hammer and colleagues[7] report a very large retrospective study of 59 991 adult patients in the USA on the risk of unplanned tracheal intubation in the PACU after the use of an SGA (48.9% of patients) compared with use of a tracheal tube during anaesthesia (51.1%). In every case, use of an SGA or tracheal tube was considered feasible. As this study included patients from 2008–18, the majority of the patients in the SGA group received a classic first-generation LMA. Use of an SGA increased over time with more frequent use in the later years of the study. The use of a tracheal tube was associated with a slightly higher risk of emergent tracheal reintubation than when an SGA had been used (adjusted absolute risk difference [ARD] 0.8%), and a higher risk of immediate postoperative hypoxaemia (ARD 3.9%) as measured by pulse oximetry. The incidence of postoperative pneumonia was greater in the tracheal tube than the SGA group for the length of hospital stay, but the potential causes of the pneumonia were not investigated. No attempt was made to rule out the possibility of residual neuromuscular block being a potential cause of the respiratory complications. As the use of NMBAs was more common in the tracheal intubation group, Hammer and colleagues[7] concluded that the difference in these findings between the tracheal intubation and SGA groups was mediated by the use of NMBAs. The findings were not affected by the type of surgery or patient comorbidity. Use of opioid analgesics, succinylcholine, or reversal agents did not affect the findings. The number of affected patients was relatively low: only 69 patients in the SGA group and 367 patients in the tracheal tube group required postoperative intubation.

Are any potential benefits of SGAs mitigated by neuromuscular block?

Of particular interest is that this effect was modified by use of NMBAs. Use of an NMBA in patients in whom an SGA had been used during general anaesthesia (only 459 of the 27 398 patients) led to a reduction in the preventative effects of SGA use on the need for emergent tracheal intubation. If the patient had received an NMBA and an SGA, the risk was actually higher than in the tracheal tube plus NMBA group (adjusted odds ratio 3.65), However, the risk increased whichever airway was used.

The limitations of large retrospective studies are well recognised.[8] However, Hammer and colleagues[7] made exhaustive statistical efforts to account for known confounding. Sceptics may suggest that it is impossible to identify subtle variations in clinical judgement. What actually makes anaesthetists decide on the use of an SGA rather than a tracheal tube at the beginning of anaesthesia, when use of either is feasible? Inevitably, unidentified confounders would have influenced these findings. Similarly, it is much easier to obtain accurate and reproducible measurements of SpO_2 in a patient after LMA removal whilst still anaesthetised than in a restless patient who has just been extubated after reversal of neuromuscular block. Use of an NMBA may also be an indicator of the need for positive pressure ventilation as opposed to spontaneous ventilation with or without pressure support: this was taken into account in part by Hammer and colleagues[7] with respect to the surgical procedure. Positive pressure ventilation itself can lead to postoperative diaphragmatic dysfunction that may have influenced the results.[9] Different ventilation strategies such as the mode of ventilation (pressure or volume) and degree of PEEP, and use of protective ventilation together with recruitment manoeuvres can also have differing effects on postoperative pulmonary complications.[10,11] Nevertheless, the findings reported by Hammer and colleagues[7] are important as they could affect clinical practice directly.

Ideally, findings of such clinical relevance would be substantiated by a prospective randomised cohort study, but the challenges of such are formidable. It would need to be a multicentre controlled study of many thousands of patients and funding issues could be anticipated. If such a study were funded by the medical device industry, it would be difficult to avoid conflicts of interest. Quantitative neuromuscular monitoring perioperatively would be essential with a standardised approach to reversal to rule out residual neuromuscular block as the cause of the pulmonary complications, and use of only one type of SGA would have to be considered. Finally, a recognised definition of postoperative pulmonary complications would need to be applied.[8]

Use of NMBAs during anaesthesia has been repeatedly shown to increase the risk of both immediate and longer term postoperative pulmonary complications in the days after surgery. In a prospective observational study in Europe (POPULAR), Kirmeier and colleagues[12] reported that use of NMBAs perioperatively was associated with an increased risk of postoperative pulmonary complications (odds ratio=1.86) and that use of a reversal agent, neuromuscular monitoring, or both did not decrease that risk. The odds ratio of 1.86 is not as strong as the effect of the surgical procedure or the patient's preoperative condition on outcome, but is nevertheless significant. These findings substantiated the results of retrospective studies from the USA,[13,14] and the study by Hammer and colleagues[7] lends further support to these earlier findings.

Why might an SGA be superior to a tracheal tube in terms of pulmonary complications?

Although use of an NMBA reduces the trauma of tracheal intubation,[15] insertion of a tracheal tube is more traumatic to the pharynx and larynx than insertion of an SGA.[16] However, data from NAP4[6] would suggest that in clinical practice neither device is a cause for major concern in this respect. Importantly, Hammer and colleagues[7] found that even without the use of an NMBA, tracheal intubation was associated with harm, but the causes were not clear. Observation of gastric aspiration is an important outcome, but micro-aspiration may be more frequent and more relevant than we acknowledge during airway management, and is difficult to detect reliably in clinical studies. Use of cricoid pressure will not necessarily reduce this risk.[17] It remains plausible that micro-aspiration is more frequent around an SGA than a tracheal tube, but these effects may be mitigated by a higher rate of vocal cord dysfunction after tracheal extubation compared with SGA removal.[18] As laryngeal morbidity is reduced with use of an SGA compared with tracheal intubation,[19] the protective functions of the larynx may serve to reduce postoperative pulmonary complications with the use of an SGA, especially if no NMBA has been given. The well-recognised residual effects of NMBAs on pharyngeal and laryngeal muscles at the end of anaesthesia[11] may be another factor in the reduced benefits of using an SGA together with an NMBA.

Can second-generation SGAs further improve the perceived benefits?

In the report by Hammer and colleagues,[7] the study population primarily utilised a first-generation LMA, although practice was changing in this respect over the course of their study. However, when they repeated their analysis using only data from the final 5 yr of their study, when use of various second-generation SGAs was becoming commonplace, their findings were unchanged. Evidence and guidance from translational models and expert opinion suggests that use of a second-generation SGA such as the ProSeal rather than an LMA may reduce the risk of pulmonary aspiration.[20,21] However, evidence supporting use of second-generation SGAs is more robust for outcomes related to improved placement success and pharyngeal seal than the risk of aspiration,[22–24] although these factors may be inter-related. It remains possible that patients in the SGA group in the study by Hammer and colleagues,[7] who received an NMBA, simply had a poor airway seal and the NMBA had been used to improve ventilatory parameters. Hence, drawing the conclusion from this study that NMBA use with an SGA may be harmful could be premature. A difficult seal of the SGA may be the risk exposure of interest in future studies of pulmonary outcomes. It is also possible that the requirement for NMBA use is reduced with the use of second-generation SGAs that provide a better seal. Comparative studies of different SGA designs have generally demonstrated similar seal pressures,[25–27] but comparative evaluation of aspiration risk remains too difficult to conduct in most clinical trial designs. As such, recommendations for use of specific second-generation SGAs tend to be guided by the experience and preference of the anaesthesiologist, but the class as a whole may improve sealing pressures and reduce the requirement for NMBAs.

What is the best airway management practice for an SGA?

Hammer and colleagues[7] should be congratulated for applying the most rigorous standards of observational research to their cohort to help answer a question, exploring variables associated with their findings, and offering conclusions based on study limitations. Their findings indicate the need for a prospective study, preferably using only one type of second-generation SGA. There may well be variation between different second-generation SGAs in this respect which also needs to be determined. The findings should motivate clinicians once again to consider critically the need for positive pressure ventilation when the surgery itself does not indicate it and importantly, whether NMBAs are really required. Similar messages arose from the POPULAR study.[12] Kirmeier and colleagues[12] stressed that their findings suggest the potential benefits of NMBAs must always be balanced against the increased risk of postoperative pulmonary complications after using these drugs. SGAs are less traumatic to the larynx than laryngoscopy with tracheal intubation, so the preserved functions of the larynx may have influenced the findings of Hammer and colleagues.[7] We suggest that anaesthesiologists should focus increasingly on the avoidance of NMBAs whenever possible, and we advise caution in the use of an SGA with an NMBA. The selection of an SGA suitable for optimal seal in the individualised patient, based on the experience of the anaesthesiologist, may serve to reduce the need for NMBAs. The findings of Hammer and colleagues[7] provide us all with food for thought.

Authors' contributions

Both authors contributed equally to the writing of this manuscript.

Declarations of interest

JMH was editor-in-chief of the *British Journal of Anaesthesia* from 1997 to 2005, and chair of the *British Journal of Anaesthesia* Board from 2006 to 2012. MA is a member of the associate editorial board of the *British Journal of Anaesthesia*, senior editor of *Anesthesia and Analgesia*, and editor-in-chief of the *Journal of Head and Neck Anesthesia*.

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