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'Failed supraglottic airway': an algorithm for suboptimally placed supraglottic airway devices based on videolaryngoscopy

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Anaesthetists would not accept malpositioned tracheal tubes resulting in leak, inadequate ventilation, high airway pressures, or one-sided lung ventilation. Yet it is our impression that many, if not the majority, of surgeries are conducted with blindly placed and suboptimally sited supraglottic airway devices (SADs). The anaesthetic community appears to accept much lower standards for SAD placement than for tracheal tube placement.

Blindly inserted SADs are often malpositioned

Blind insertion of SADs often results in suboptimal positioning in the oropharynx or hypopharynx. Studies involving magnetic resonance imaging, computed tomography, and lateral neck radiography have shown that the epiglottis is deflected posteriorly in >80% of patients after blind insertion of SADs,[1] reflecting several aberrant positions.[2 3] Fibreoptic viewing also reveals that the epiglottis is deflected to suboptimal positions in 50–80% of insertions, and the epiglottis tip can be seen within the bowl of the SAD.[4–6] According to Brimacombe,[2] the anterior surface of the epiglottis is visible from the airway tube in 31% of patients, resulting in increased work of breathing and potentially obstructing tracheal intubation via the SAD if needed. Studies further suggest that blind insertion is far from ideal.[7–10] Simple cuff pressure measurement and oropharyngeal leak pressure (OPLP) are not enough. We therefore question the outcome of earlier studies that recommended measuring OPLP and intracuff pressure[11] because these are not valid if no information is provided about the position of the device.

Clinical signs of incorrect SAD position include the following: (i) resistance to SAD insertion in the hypopharynx; (ii) SAD dislodgement during cuff insufflation; (iii) bite block malaligned with incisors; (iv) poor oropharyngeal airway seal (OPLP; intracuff pressure); (v) ineffective gas exchange (by observation of thoracic excursions and front of neck, inadequate tidal volume, low arterial O_2 saturation, poor capnograph trace, high airway pressure, air leak); (vi) no drain tube patency; (vii) adverse suprasternal notch tap test (also known as the 'Brimacombe bounce'; tapping the suprasternal notch or cricoid cartilage and observing simultaneous movement of a column of lubricant or a soap bubble membrane at the proximal end of the drain tube);[2] or (viii) fibreoptic inspection through airway tube and gastric drain tube; (video)laryngoscopy); or if required, expensive radiological methods.

No particular SAD design guarantees a perfect position when inserted blindly into the hypopharynx. However, some SADs may be more prone to malpositioning than others. In our experience, the non-reinforced tip of the distal cuff of a first-generation SAD (LMA-Classic) frequently results in backwards deflection, which is hardly ever seen with reinforced-tip SADs. A circular or tubular breathing tube, as opposed to a more elliptical design, is more likely to sit less firmly in the hypopharynx and between the teeth and might be dislocated more easily than an ellipsoid one as a result of rotation in the sagittal plane. A bite block (ideally built into the SAD design) provides better fixation once a good position is achieved.[2] In general, a 'second-generation' SAD, incorporating separate ventilation and gastric channels, a bite block, and a reinforced tip, is more likely to result in the following: (i) a safer airway, reducing the risk of aspiration; and (ii) a more efficacious airway with a much better position, providing a more patent airway than first-generation SADs without gastric access channel.[12–15] Even with second-generation devices, we advocate visual verification to exclude malpositioning.

The i-gel SAD is designed anatomically to fit the perilaryngeal and hypopharyngeal structures without an inflatable cuff. The LMA-Supreme and i-gel differ significantly with regard to *in situ* position and spatial relationship with adjacent structures assessed by magnetic resonance imaging, despite similar clinical and fibreoptic findings. Whereas the LMA-Supreme (longer cuff with tapered tip) protrudes deeper into the upper oesophageal sphincter, the i-gel (wider cuff with blunter tip) causes a greater dilatation of the upper oesophageal sphincter and compresses the tongue more, thus increasing the risk of aspiration, glottis narrowing, airway resistance, and soft-tissue morbidity.[9]

Complications resulting from suboptimally positioned SADs

Complications of suboptimally positioned SADs include the following:[2 16] (i) ventilatory failure, including insufficient tidal

volume, air leak, and airway obstruction; (ii) airway or tissue trauma (sore throat, hoarseness, dysphagia, dysphonia, or arytenoid dislocation); (iii) nerve injuries (hypoglossal, lingual, or bilateral vocal cord palsy); and (iv) difficulties using the SAD as an intubation conduit. Suboptimal or malpositioned SADs are 26 times more likely to be associated with gastric insufflation and subsequent aspiration.[8] According to the Fourth National Audit Project (NAP4), aspiration of gastric contents was involved in the majority (most frequently with first-generation SADs) of SAD-related complications, and a second-generation device would be preferable for prevention.[10 17 18]

Optimal anatomical fit for SADs leads to better function

From an anatomical perspective, optimal positioning of a correctly sized SAD should include the following: (i) the distal tip of the cuff rests against and blocks the upper oesophageal sphincter; (ii) the cuff occupies the entire hypopharynx and lies immediately behind the cricoid cartilage, anterior to the second to seventh cervical vertebrae; (iii) the sides of the cuff face the pyriform fossae; (iv) the epiglottis is flattened between the anterior surface of the proximal cuff (on which it rests on the outer side of the cuff) and the posterior surface of the pharyngeal portion of the tongue, with the tip of the epiglottis aligned with the rim of the proximal cuff; and (v) producing two adequate seals, with the gastrointestinal tract (distally with the oesophageal entrance) and with the respiratory tract (the glottis opening opposing the distal opening of the airway tube). The closer the match between the shape of the SAD cuff and the pharynx and larynx, the better the seal produced by the airway device.[2] The tongue might improve the seal—potentially closing the gap, preventing an air leak—by forming an effective plug above the epiglottis–proximal cuff junction, which can be evaluated during the withdrawal of the laryngoscope. From a functional perspective, a well-sealed SAD should result in the following: (i) a functional barrier from soiling by secretions from below and gas and secretions from above, preventing aspiration and gastric insufflation (barring second-generation SADs, as the gastric drain tube and oesophagus neatly align themselves with one another); (ii) adequate gas exchange, facilitating spontaneous breathing or mechanical ventilation; and (iii) no trauma to the airway. Poor anatomical positioning after blind SAD insertion leads to specific deficiencies in function, as there is a link between form and function. Anaesthetists can improve deficient function using video-guided insertion techniques.[7 19] We propose: (i) a grading system for SAD positions; and (ii) standardized manoeuvres to correct suboptimal positions.

Direct vision prevents or corrects suboptimal positions of SADs

Suboptimal positions of SADs occur for several reasons: cuff hyperinflation/hypoinflation, use of too small or too large SADs, too deep or too superficial insertion, downfolding of the epiglottis, rotation of the SAD cuff in a sagittal plane, glottis distortion, backward folding of SAD cuff, proximal SAD cuff misplacement, and SAD cuff folding that results in airway gas leaks. Van Zundert and colleagues[7] recently revealed, using direct viewing by videolaryngoscopy, that 71% of SADs were initially malpositioned (but soon corrected). All malpositions could be corrected by applying jaw thrust and lifting the chin. This improved insertion conditions by elevating the epiglottis from the insertion path and increased the anteroposterior diameter of the pharynx. These manoeuvres also corrected temporary ventilatory failure attributable to airway obstruction. The Difficult Airway Society (DAS) guidelines[10] on the management of unanticipated difficult intubation in adults considers 'blind' airway management techniques unreliable and associated with a high incidence of airway trauma. The advent of videolaryngoscopy[19 20] and other direct viewing methods[21] allows visual confirmation of the positioning of any airway device, including SADs.

Vision-guided grading system, corrective manoeuvres, and flow chart

We propose a grading system for use with video-guided insertion and standardized manoeuvres to correct identified suboptimal positioning, and provide a flow chart that summarizes suggested interventions for both first- and second-generation SADs.

There are three grades of SAD positions (Fig. 1) after insertion.[19] Grade I is a perfectly seated SAD of the correct size, with the epiglottis resting on the outside of the device, a normal capnogram, good air entry on auscultation of both lungs, and normal values for oropharyngeal leak pressure (OPLP >25 cm H_2O), intracuff pressure (40–60 cm H_2O), and haemoglobin oxygen saturation by oximetry [peripheral oxygen saturation (Spo_2) >95%]. Grade I is uncommon with blind insertion of SADs, with the majority showing a Grade II or III position, as discussed above.

Grade II is a marginally positioned SAD, clinically recognized by airway leak, abnormal capnogram of varying degree, diminished ability to access air entry in both lungs, and lower values for OPLP [there are differences in OPLP between first-generation SAD (i.e. within 20 cm H_2O) and second-generation SAD (i.e. within 25 cm H_2O)], intracuff pressure (<40 cm H_2O), and eventually, Spo_2 <95%. Even cuffless SADs can result in a leak because of malpositioning. There may be cuff folding over backwards, distortion of the cuff with foldings, choice of 'too small' a size of SAD, insertion too deep, or cuff hypoinflation. The actions to be taken include a change to a directly viewed reinsertion technique (e.g. videolaryngoscope) and use of corrective manoeuvres. These manoeuvres include the following: (i) jaw thrust to correct initial downfolding of the epiglottis; (ii) adjustment of the position of the distal oesophageal cuff; (iii) changing the SAD to a device with a reinforced tip configuration if the cuff folds over backwards persistently; (iv) using a different size, type, or brand of SAD; (v) using a larger size of SAD or reinflating the cuff to an intracuff pressure of 40–60 cm H_2O if cuff hypoinflation is observed; and (vi) change to a silicone-cuffed SAD, instead of a polyvinyl chloride one, when folding in the cuff is causing an air leak. Grade II obtained with blind insertion should be regarded as unacceptable, but if no improvement is possible even with directly viewed insertion, it might be reasonable to proceed with caution or use alternative airway management methods, such as tracheal intubation.

Grade III is clinically unacceptable. It is detected by a severe gas leak, airway obstruction, or both, with an abnormal, odd, or even absent capnogram, inadequate ventilation of both lungs, and low values for both intracuff pressure (<40 cm H_2O) and, eventually, Spo_2 (<92%). In patients where the SAD is too large, the device is too superficial, or the cuff is hyperinflated, the problem might be corrected by using a smaller SAD or deflation of the cuff to an intracuff pressure of 40–60 cm H_2O. If the epiglottis is completely downfolded in the bowl of the device or double folded sideways, a major leak or airway malobstruction will ensue, resulting in a very low OPLP, sometimes approaching zero,

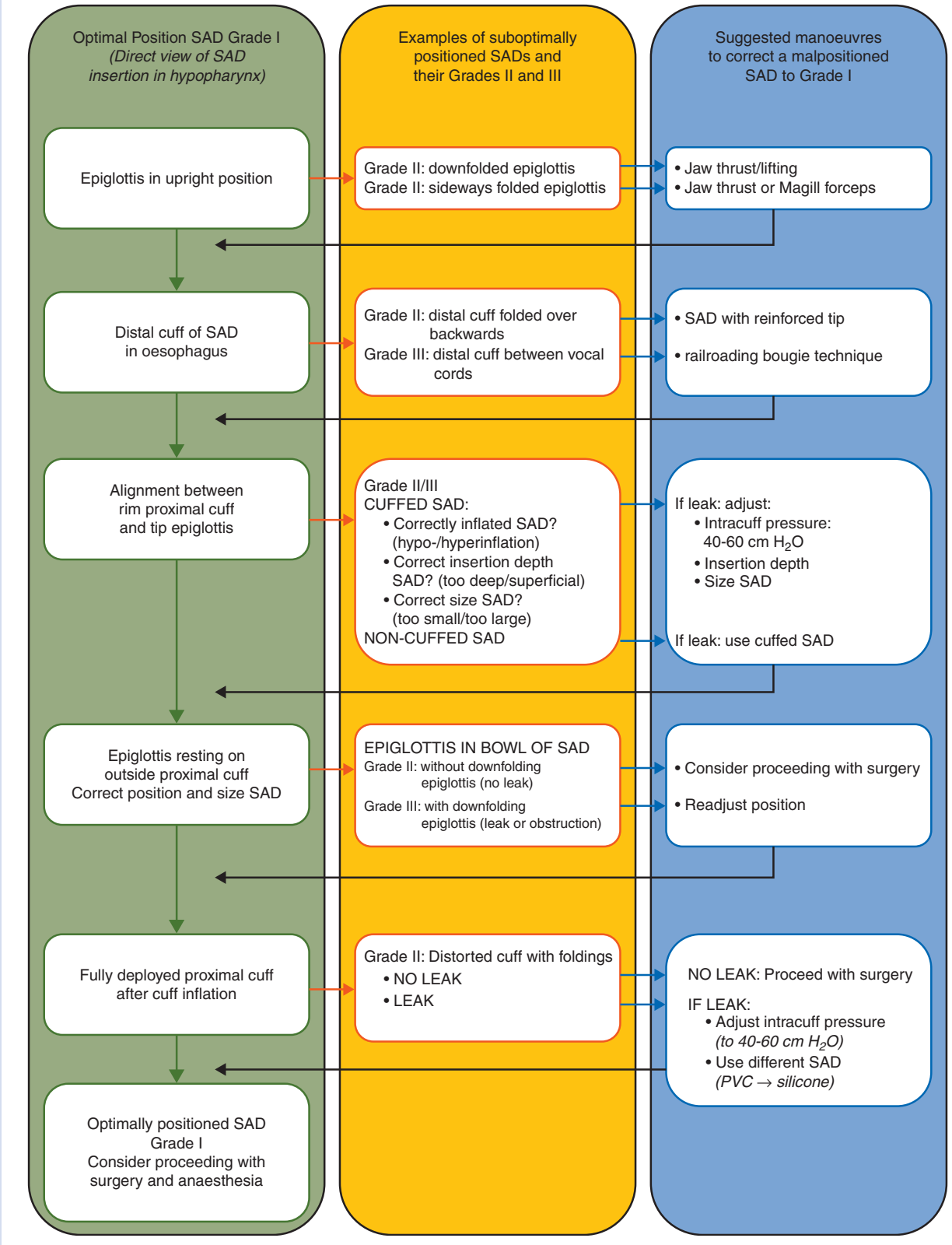

Fig 1 Flow chart for adjusting suboptimally positioned SADs, using routine direct or indirect viewing. The left column shows the situation that results in optimal SAD positioning (green arrows indicate 'yes'). Malpositioning (red arrows indicate 'no'), as in the middle column, can be relieved using appropriate manoeuvres (blue arrows), shown in the right column. Manoeuvres are specific for Grade II or III, and should be repeated or changed sequentially as suggested in the right-hand column until the left column, optimal position, has been achieved. SAD, supraglottic airway device.

requiring corrective manoeuvres such as jaw thrust. If jaw thrust does not correct the malposition, a railroad technique (e.g. using a gum elastic bougie, an Aintree intubation catheter, or Frova tube-changer)[2] or repositioning using Magill forceps might correct the malposition. In the event that the distal cuff of the device lies between and across the vocal cords, a major leak will result, with an OPLP of 0 cm H_2O. Jaw thrust should be applied with the aim of relocating the tip of the SAD.

If the epiglottis lies within the bowl of the SAD but does not result in a leak or the leak is minimal, there is minimal or no airway obstruction, and the epiglottis is in the upright position and not downfolded, the function of the SAD is usually adequate, which allows us to proceed with surgery (Grade I). If the videolaryngoscope demonstrates that the epiglottis is positioned in the bowl of the device, one cannot readily differentiate between an epiglottis in the upright, partly downfolded, or completely downfolded position. The only way to exclude downfolding or otherwise of the epiglottis in the bowl of the SAD is by inserting a fibreoptic scope through the ventilating channel of the SAD. Grade III needs immediate correction. In reality, most, if not all, Grade II and III malpositions should be corrected promptly even if there is no immediate adverse clinical outcome. A Grade III-positioned SAD is extremely likely to result in an adverse outcome (e.g. airway obstruction), which precludes continuing with surgery and can be considered as a 'failed' SAD. Further studies should elaborate on specific incidences and causes of malpositioning across a broader range of SADs.

Conclusions

Anaesthetists should aspire to improving the quality of SAD insertions; it is unacceptable to have patients breathing noisily, partly obstructed via a misplaced SAD, or SAD cuff inflation pressures that are dangerously high (or unmeasured). Poor fits should not be accepted. Blind insertion results in a poor fit, whereas direct vision improves placement with videolaryngoscopy, facilitating functional and anatomical optimization. Any placement Grade of II or III should be regarded as a misplaced or 'failed' SAD. As the way forward is direct viewing, manufacturers are encouraged to develop SAD-specific viewing tools to facilitate correct insertion. Until such a time, videolaryngoscopy is the tool of choice. More than 40 yr ago, Brain[22] suggested the use of a laryngoscope to view and adjust the position of his then newly invented laryngeal mask airway. However, using a Macintosh laryngoscope has historically been regarded as defeating part of the purpose of using a SAD, which is to avoid the adverse haemodynamic effects of laryngoscopy. Videolaryngoscopes offer a fresh alternative,[20] and the time is ripe to follow Brain's early advice to check and correct malpositioned SADs by direct viewing.

Authors' contributions

All authors approved the final manuscript and attest to the integrity of the original data and their subsequent analysis.

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Critical airways, critical language

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The contribution of human factors to adverse outcomes during emergency airway management is well established.[1] Effective communication is a core non-technical skill that contributes to minimizing such error.[2] The language used must aid rather than hinder communication.

The term 'critical language' refers to standardized communication in which specific terms or phrases have a clear, mutually agreed meaning.[3 4] It is employed in healthcare and other high reliability industries to avoid ambiguity, flatten hierarchies and improve team situation awareness.[3–6] Its use has typically involved phrases invoking a halt to activity and a mandate to consider any party's concerns,[3–5] but the concept can be extended to include any standardized language that improves clarity of communication and reduces teamwork errors by facilitating a shared mental model. Critical language used in emergency settings should be precisely defined, consistently used, memorable, easy to articulate and readily understood by all team members. Ideally it should not only improve clarity of communication but also trigger cognitive links to key priorities and actions required. Phrases including 'cardiac arrest', 'no output', 'shockable rhythm' and 'stand clear' are examples of de facto critical language that are embedded in cardiac arrest management and familiar to most clinicians. In contrast, such consistent clear vocabulary has not developed in emergency airway management, which is encumbered with multiple terms and a lack of definitions for many essential concepts, devices and procedures. This creates the preconditions for confusion and misunderstanding between team members with the potential to impair performance, particularly in a crisis setting. Here, we describe specific areas of concern and discuss the need to consolidate these terms to create a universally accepted lexicon for airway management.

Communicating 'can't intubate, can't oxygenate'

The can't intubate, can't oxygenate (CICO) situation occurs when 'oxygenation' cannot be achieved using the anatomical conduits of the upper airway. The shift to CICO from the previous 'can't intubate, can't ventilate (CICV) terminology, initiated by Heard,[7] has been applauded for creating a focus on the priority of maintaining patient oxygenation. The expectation is that this could diminish fixation on tracheal intubation and attempting to establish normal minute ventilation, which is known to have jeopardized oxygen delivery and contributed to adverse airway outcomes.[1 8] Adoption of the term CICO has not been universal, however, and it is conceivable that the co-existence of the similar terms CICV and CICO to describe the same situation could lead some clinicians to wrongly conclude that they are intended to distinguish between slightly different circumstances. If a declaration of CICV is not understood to be synonymous with one of CICO, this could compromise team situation awareness that the trigger for abandoning attempts at the upper airway techniques of face mask, supraglottic airway and tracheal intubation has been reached. The move from 'ventilate' to 'oxygenate' has also introduced some issues that affect the potential utility of the new term as a form of critical language for emergency airway management.

Firstly, it has impacted on the abbreviated forms, converting the initialism CICV (which must be spelt out when verbalized) into the acronym CICO (which can be spoken as a word). This alteration is a double-edged sword: on one hand, the CICO acronym creates a distinct term that can be easily verbalized during a crisis. In addition to facilitating team situation awareness, this has the potential to generate a 'brand' that not only helps promote CICO itself, but link it to related concepts such as CICO training, CICO kit, CICO pathway,[9] CICO status[10] and CICO rescue.[10] On the other hand, however, the acronym converts the descriptive phrase 'can't intubate, can't oxygenate' into an incomprehensible neologism. This creates the potentially dangerous situation of having a term that may not be understood by all clinicians in a team. This risk is likely to vary with geography, institution and discipline, according to the cultural tendency to use the abbreviated form—indeed we have observed differences between Australia (where the spoken abbreviation is commonplace) and the UK (where voicing the abbreviation is not the norm). Even in environments where the abbreviated form is in common use, a lack of consistency in how it is verbalized may still lead to confusion. Variations include ky-koh, kic-koh, see-koh, cheek-koh, sic-koh, psy-koh and spelling out C-I-C-O. While this diversity may seem comical, the lack of standardization in a