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

Blindly inserted supraglottic airway devices often fit poorly

Blind insertion of SAD often results in suboptimal positioning in the oropharynx/hypopharynx. Studies involving magnetic resonance imaging (MRI), computed tomography (CT) and lateral neck X-ray have shown that the epiglottis is deflected posteriorly in >80% of cases after blind insertion of SADs[1] reflecting several aberrant positions.[2 3] Fibreoptic visualization also reveals that the epiglottis is deflected to suboptimal positions in 50 - 80% of insertions and the epiglottis tip may be seen to lie 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 the patients, resulting in an increased work of breathing and potentially obstructing tracheal intubation via the SAD if needed. Supportive literature further suggests that a blind insertion technique 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, which recommended measuring OPLP and intracuff pressure[11] as these may not be valid if no information is provided about the position of the device.

Currently used procedures for checking position and function of blindly inserted SADs

Clinical signs of incorrect SAD position include: a) resistance to SAD insertion in the hypopharynx; b) SAD dislodgement during cuff insufflation; c) bite block malaligned with incisors; d) poor oropharyngeal airway seal (OPLP; intracuff pressure); e) ineffective gas exchange (by observation of thorax excursions and front of neck, inadequate tidal volume, low SaO_2, poor capnograph trace, high airway pressure, air leak); f) no drain tube patency; g) 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] and h) information from instrumentation (fibreoptic inspection through airway tube and gastric drain tube; (video)laryngoscopy); and if required the use of expensive radiological methods.

Malpositions of specific SADs

All types and brands of SADs can malposition during insertion. No particular SAD design guarantees a perfect position when inserted blindly into the hypopharynx. However, some SADs may be more prone to malposition than others, e.g. in our experience a non-reinforced tip of the distal cuff of a first generation SAD (LMA-Classic) may frequently result in folding over backwards, which is hardly ever seen with reinforced-tip SADs. A circular/tubular breathing tube, as opposed to a more elliptical design, is on first principles more likely to sit less firmly in the hypopharynx and between the teeth and may be dislocated more easily than an ellipsoid one, due to rotation in the sagittal plane. A bite block (ideally built in to SAD design) helps to secure 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: a) a safer airway reducing the risk of aspiration which is the commonest cause of anaesthesia-related death and brain damage; and b) a more efficacious airway with a much better position, providing a patent airway than 1st generation SADs without gastric access channel.[12-15] Even with 2nd generation devices, we advocate visual verification to exclude malpositioning and is the best way forward.

The mask of the I-gel is designed anatomically to fit the perilaryngeal and hypopharyngeal structures without the use of 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 MRI, 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 more the tongue thus increasing the risk of aspiration, glottis narrowing, and airway resistance and soft-tissue morbidity.[9]

Complications resulting from suboptimal positioned SAD

Reported complications of suboptimal positioned SADs include:[2 16] a) ventilatory failure including insufficient tidal volume, air leak and airway obstruction; b) airway or tissue trauma (sore throat, hoarseness, dysphagia, dysphonia, arytenoids dislocation); c) nerve injuries (hypoglossal, lingual nerves, bilateral vocal cord palsy); and d) 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 4th National Audit Project (NAP4), gastric content aspiration is involved in the majority of (most frequently with 1st generation) SAD-related complications and a 2nd generation device would be a more preferable and logical choice in prevention.[10 17 18]

Optimal anatomical fit for SADs leads to better function

Our opinion based on the foregoing lines of evidence, the following factors define optimal position of SADs: From an anatomical perspective, optimal position of a correct-size SAD should include the following: a) the distal tip of the cuff rests against and blocks the upper oesophageal sphincter; b) the cuff occupies the entire hypopharynx, and lies immediately behind the cricoid cartilage, anterior to the second to seventh cervical vertebrae; c) the sides of the cuff face the pyriform fossae; d) 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; e) producing two adequate seals, i.e. 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 functional perspective, a perfect sitting and well-sealed SAD should result in: a) a functional barrier from soiling due to secretions from below and gas and secretions from above, preventing aspiration and gastric insufflation (barring 2nd generation SADs as the gastric drain tube and oesophagus neatly align themselves with one another); b) adequate gas exchange facilitating spontaneous breathing or mechanical ventilation; and c) no trauma to the airway.

This editorial highlights how poor anatomically positioning after blind SAD insertion leads to specific deficiencies in function, as there is a link between form and function. In turn we emphasise how anaesthetists can improve deficient function using video-guided insertion techniques.[7 19] We propose: a) a grading system for SAD positions to assist in this process; and b) standardised manoeuvres to correct suboptimal positions.

Direct vision prevents/corrects suboptimal positions of SADs

Given the above definition of what constitutes optimal SAD position, we can specify that suboptimal positions of SADs may occur due to several reasons: cuff hyperinflation/ hypoinflation, use of too small-/too large-sized SAD, too deep/or too superficial insertion of SADs, downfolding of 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 resulting in leakage of airway gases. Van Zundert et al.[7] recently discovered that direct visualization using videolaryngoscopy revealed 71% of SADs (of 206 insertions) were in fact initially malpositioned (but soon corrected). Suboptimal position of the SADs included: a) downfolding of the epiglottis (71%) at introduction; b) sideways downfolding of the epiglottis (5%); c) distal cuff folding over backwards (1%); d) distal cuff touching the vocal cords (4%); e) the use of inadequate cuff inflation, incorrectly insertion depth or inadequate size, either too small (4%), or too large (5%) SADs; and f) PVC cuff distortion causing air leaks (8%). All malpositions could be restored to effective optimal position of SADs by applying jaw thrust and lifting the chin. This improved insertion

conditions, by elevating the epiglottis from the insertion path, and increased the antero-posterior diameter of the pharynx. Incidentally these manoeuvres also corrected any temporary ventilatory failure due to airway obstructions.

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 higher incidence of airway trauma. The advent of videolaryngoscopy[19 20] or other direct visualization methods[21] indeed provide opportunity for visual confirmation of any airway device including SAD positioning. Tracheal intubation is rarely undertaken blind; on the other hand SAD insertion is rarely performed under direct vision such as videolaryngoscope or other methods of direct visualization may be easily available, fast and reliable.

Vision-guided grading system, corrective manoeuvres & flow chart

We now propose: a) a grading system for use with video-guided insertion; b) the use of standardised manoeuvres to correct any suboptimal position; and c) a flow chart (which applies to both 1st and 2nd generation SADs) that summarizes the suggested interventions. A videolaryngoscope (C-MAC™, Karl Storz®, Tuttlingen, Germany) was used for the insertion of all SADS and its view was used to describe the positions. There are 3 possible grades of SAD positions (Fig. 1) after insertion and the images were published recently in this journal.[19]

A **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_20) and haemoglobin oxygen saturation by oximetry (SpO_2 >95%). A Grade I is uncommon with blind insertion of SADs, with the majority showing a Grade II or III position, as discussed above. Nevertheless, a Grade I requires no further action at this point and surgery can proceed.

A **Grade II** is a marginally-positioned SAD, clinically recognised by an airway leak, an abnormal capnogram of varying degree, diminished ability to assess for air entry in both lungs and lower values

for OPLP (there are differences in OPLP between 1st generation, i.e. ± 20 cm H_20; and 2nd generation SAD, i.e. ± 25 cm H_20), intracuff pressure (<40 cm H_20) and (a late sign) SpO_2 (<95%). Even cuffless SADs may result in a leak due to malalignment and malpositioning. There may be cuff folding over backwards, distortion of cuff with foldings, choice of a 'too small' size SAD, insertion too deep or cuff hypoinflation. The actions to be taken include change to a visualised re-insertion technique (e.g. videolaryngoscope) and use of corrective manoeuvres: a) jaw thrust to correct initial downfolding of the epiglottis; b) adjustment of the position of the distal oesophageal cuff; c) changing the SAD to a device with a reinforced tip configuration if cuff folds over backwards persistently; d) using a different size, type or brand of SAD; e) using a larger-size SAD or reinflating the cuff to an intracuff pressure of 40-60 cm H_20 if cuff hypoinflation is observed; and f) change to a silicone cuffed SAD, instead of a PVC one, when foldings in the cuff of the SAD are observed to be causing an air leak. A grade 2, if obtained with blind insertion, should be regarded as unacceptable. If it is the best that can be obtained, even with directly visualised insertion, then it may be reasonable to proceed with caution and a robust plan B. Depending upon circumstance it would be entirely reasonable to employ alternative airway management methods such as tracheal intubation.

A **Grade III** is totally clinically unacceptable. It is detected by severe gas leak and/or airway obstruction with an abnormal, odd or even absent capnogram, clinically inadequate ventilation of both lungs and low values for both intracuff pressure (<40 cm H_20) and (a late sign but one which may arise promptly if there has been no pre-oxygenation) SpO_2 (<92%). In cases where a too large SAD is chosen, the device is inserted too superficially or the cuff is hyperinflated, the problem could be corrected by using a smaller size SAD and further deflation of the cuff till an intracuff pressure between 40 and 60 cm H_2O is obtained. 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, 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 or gastric tube)[2] or repositioning using a Magill forceps may 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 and an OPLP of 0 cm H_20 is observed. 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 is not downfolded, the placement should be classified as Grade II, as the function of the SAD is usually adequate, which allows us to proceed with surgery. 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/breathing channel of the SAD. A Grade III should be considered to be a wrongly-positioned SAD which 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 and corrective measures should be taken if the situation is deteriorating. 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 – in the line with 'failed intubation' – as 'failed' SAD.

Improved checking of adequacy of insertion, using either routine videolaryngoscopy-guided initial insertion of SADs or other suitable visualisation method under direct vision into and past the hypopharynx, by identifying the incidence of the optimal and malpositions of SADs and by offering corrective options for SAD malposition using the proposed flow chart (Fig. 1) can greatly improve. Further studies should elaborate on specific incidences and causes of malpositioning across a broader range of SADs.

Conclusions

Most importantly, the anaesthetic community needs to aspire to improving the quality of SAD insertion: no longer should it be deemed acceptable to have patients breathing noisily, partially obstructed via a

misplaced SAD, or SAD cuff inflation pressures that are dangerously high (or unmeasured) through long hours of surgery. Poor fits should no longer be accepted. Blind insertion results in poor fit, while direct vision improves placement with videolaryngoscopy facilitating functional and anatomical optimisation.

In our proposed scheme, any placement Grade of II or III should be regarded as a misplaced, 'failed' SAD. Since the way forward is direct visualisation, manufacturers are encouraged to develop SAD-specific visualisation tools which help to make a correct insertion. Until such a time videolaryngoscopy is the tool of choice, and this in turn increases further the scope of use for videolaryngoscopes. Over 40 years ago Brain suggested the use of a laryngoscope to visualise and adjust the position of his then-newly invented LMA.[22] 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. Now, videolaryngoscopes offer a fresh alternative (e.g. even proposed as a means of awake intubation).[20] The time is ripe to follow Brain's early advice to check and correct malpositioned SADs by direct visualization.

Author's contributions

All authors approved the final manuscript and attest to the integrity of the original data and its subequent analysis.

Declaration of interest

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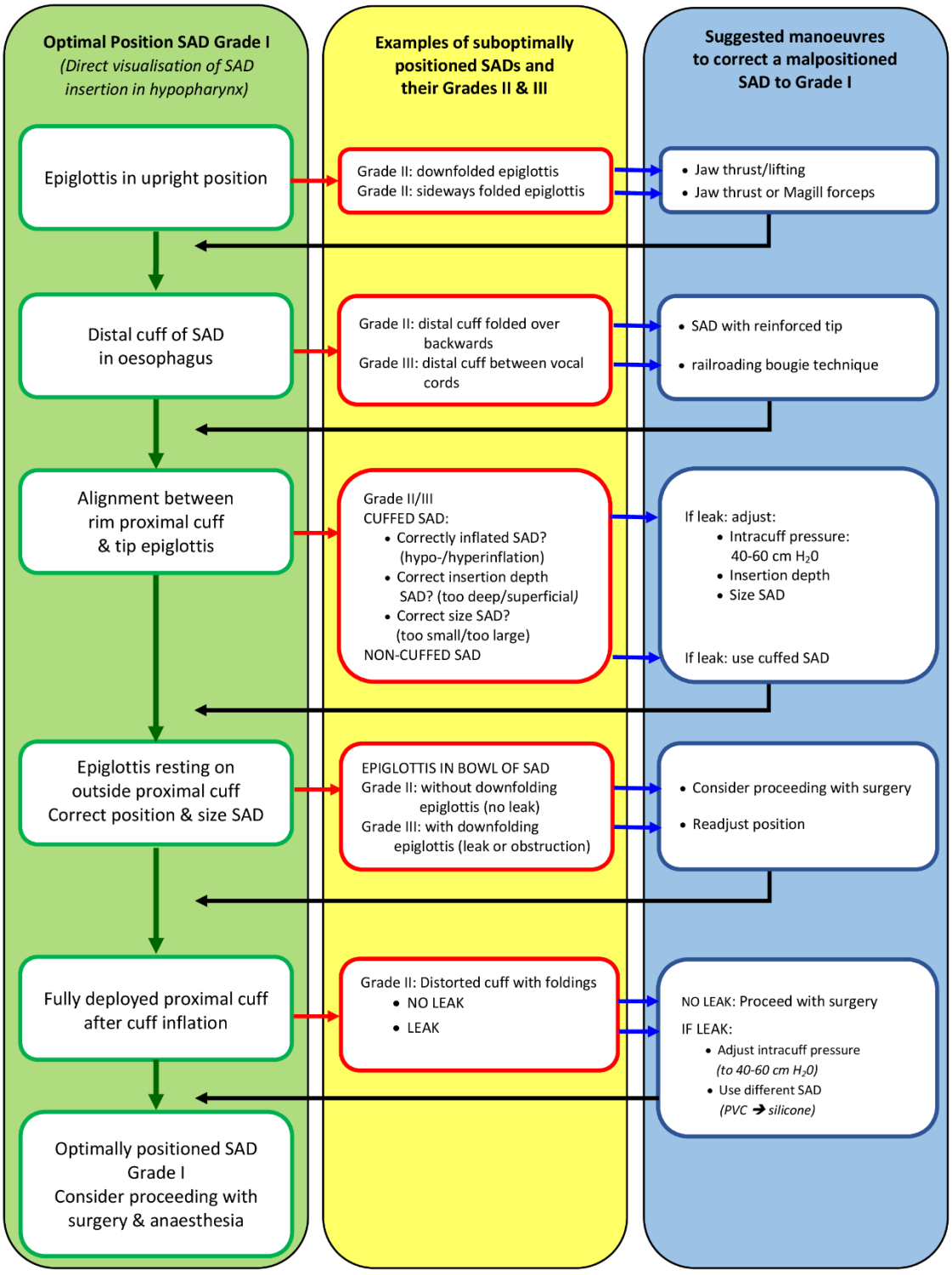
Legend for Figure 1

Corrective Flow Chart for adjusting suboptimally-positioned supraglottic airway devices, using routinely any means of visualisation (direct or indirect, e.g. videolaryngoscopy-guided insertion or another suitable visualisation method). The left column shows the situation which results in optimal positioning of SADs (green arrows indicate “YES”). Any 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 the Grade II or III situation, and should be repeated or changed sequentially as suggested in the right hand column until the left column, optimal position has been achieved.


Optimal Position SAD Grade I
(Direct visualisation of SAD insertion in hypopharynx)
Examples of suboptimally positioned SADs and their Grades II & III
Suggested manoeuvres to correct a malpositioned SAD to Grade I
Epiglottis in upright position
Grade II: downfolded epiglottis
Grade II: sideways folded epiglottis
• Jaw thrust/lifting
• Jaw thrust or Magill forceps
Distal cuff of SAD in oesophagus
Grade II: distal cuff folded over backwards
Grade III: distal cuff between vocal cords
• SAD with reinforced tip
• railroading bougie technique
Alignment between rim proximal cuff & tip epiglottis
Grade II/III
CUFFED SAD:
• Correctly inflated SAD? (hypo-/hyperinflation)
• Correct insertion depth SAD? (too deep/superficial)
• Correct size SAD? (too small/too large)
NON-CUFFED SAD
If leak: adjust:
• Intracuff pressure: 40-60 cm H20
• Insertion depth
• Size SAD
If leak: use cuffed SAD
Epiglottis resting on outside proximal cuff Correct position & size SAD
EPIGLOTTIS IN BOWL OF SAD
Grade II: without downfolding epiglottis (no leak)
Grade III: with downfolding epiglottis (leak or obstruction)
• Consider proceeding with surgery
• Readjust position
Fully deployed proximal cuff after cuff inflation
Grade II: Distorted cuff with foldings
• NO LEAK
• LEAK
NO LEAK: Proceed with surgery
IF LEAK:
• Adjust intracuff pressure (to 40-60 cm H20)
• Use different SAD (PVC → silicone)
Optimally positioned SAD Grade I
Consider proceeding with surgery & anaesthesia