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Supraglottic Airway Devices: the Search for the Best Insertion Technique or the Time to Change Our Point of View?

Supraglottik Havayolu Araçları: En İyi Cihaz Yerleştirme Tekniğini Araştırmak mı, Yoksa Bakış Açımızı Değiştirme Zamanı mı?

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In the crowded world of supraglottic airway devices (SADs), many papers compare the easiness of insertion based on the different end-points of an operator's satisfaction: first pass success, ventilation effectiveness, complications and morbidity. Proseal LMATM (Laryngeal Mask Airway, Teleflex Medical, Dublin, Ireland) has been extensively studied because on one hand it has a steeper learning curve and more complex insertion when compared with other SADs and on the other hand many alternative techniques are available to facilitate insertion. This research is part of a larger body of studies exploring the issue that some devices are more difficult to insert because of many features related to sizing, constructive material, airway conduit and cuff design, performance and last but not least experience. Nevertheless, the biggest question might be the search for a systematic categorization of insertion difficulty features and identification of criteria allowing the choice for the best device and consequently for the best insertion technique. Given that, as a result of many intrinsic characteristics of the device we are using, insertion might become the secondary issue to be considered only after we clearly identify what makes it difficult, and to be counterbalanced on the results we expect from the device, performance we can achieve and degree of airway protection it could grant. The aim of this narrative review is to consider which factors might affect or condition SAD insertion difficulty and to try identifying some criteria addressing physicians pertaining to the use of SADs in clinical practice.

Keywords: Supraglottic airway devices, laryngeal mask airway, sore throat, airway management

Kalabalık supraglottik havayolu araçları (SHA) dünyasında birçok çalışmada, cerrahın memnun olduğu farklı sonlanım noktalarına dayanarak bu araçların takılma kolaylığı karşılaştırılmaktadır: ilk geçiş başarısı, ventilasyon etkinliği, komplikasyonlar ve morbidite. Proseal LMATM (Laryngeal Mask Airway, Teleflex Medical, Dublin, İrlanda) kapsamlı bir şekilde çalışılmıştır. Çünkü diğer SHA'lar ile karşılaştırıldığında bir yandan daha dik bir öğrenme eğrisi ve daha kompleks yerleştirilme şekli varken diğer yandan takılmasını kolaylaştırmak için birçok alternatif teknik bulunmaktadır. Bu çalışma bazı cihazların ebatları, yapıldıkları madde, havayolu kanalı ve kaf dizaynı, performans ve sonuncu ama en önemlisi de deneyimden dolayı yerleştirilmesinin zorluğu konusunda yapılan çalışmalardan birisidir. Ancak, araştırılması gereken en önemli konu araçların yerleştirilme zorluklarının sistematik olarak sınıflandırılması ve en iyi cihaz seçimine ve en iyi yerleştirme tekniğine olanak sağlayacak kriterlerin belirlenmesi olmalıdır. Kullandığımız cihazın yapısal özelliklerinden dolayı cihazın yerleştirilmesi, ancak aracın yerleştirilmesinde zorluk çıkaran etkenler belirlendikten sonra ve cihazdan elde edeceğimiz sonuçlar, ulaşabileceğimiz performans ve havayolu koruma seviyesi konusunda beklentilerimiz dengelendikten sonra düşünülmesi gereken ikinci konu olabilir. Bu geleneksel derlemenin amacı SHA'nın yerleştirilmesini zorlaştıran faktörleri dikkate alarak klinik uygulamada SHA'ların kullanımıyla ilgili hekimlere yönelik bazı kriterler belirlemektir.

Anahtar sözcükler: Supraglottik havayolu araçları, laringeal maske havayolu, boğaz ağrısı, havayolu yönetimi

'You know my method. It is founded upon the observation of trifles'
Sherlock Holmes in *The Boscombe Valley Mystery* (Sir Arthur Conan Doyle)

In this issue of TJAR, Dhulkhed et al. (1) present a prospective randomized trial on the comparison of two ProSeal LMATM (PLMA; Teleflex Medical, Dublin, Ireland) insertion techniques in adults; this study comprised 120 patients and demonstrated that the 90° rotational technique results in a faster and more successful PLMA insertion when compared with the index technique using a methodologically correct approach.

The paper by Dhulkhed et al. (1) offers interesting points of discussion: first, what is the reason underlying this search of the best PLMA insertion technique, second, which is the best technique, if any, and finally, the issue pertaining to the importance of supraglottic airways device (SAD) insertion.

PLMA was launched in the market in 2000 after extensive research by its inventor, Dr. Archie Brain, and by the precious support of the recently deceased Chandy Verghese (2). In the era of Classic LMATM (CLMA; Teleflex Medical, Dublin, Ireland), it introduced the revolutionary concept of a 'second seal' and gastric access. Since its first introduction, it was

considered a type of 'double mask' (2) providing separation of respiratory and gastric tracts, physically 'plugging' inside the upper esophageal sphincter (UES) and being the first SAD to offer a dedicated channel granting access to the gastric content. A specific feature of the design of PLMA is the presence of a second cuff on the mask backplate, connected to the main perilaryngeal cuff and aimed to increase oropharyngeal sealing by pushing the PLMA against the larynx from the posterior hypopharyngeal wall (Figure 1).

All these theoretical advantages were put into clinical practice under high sealing pressures (around 30 cm H₂O in the original Brain's study and up to 40 cm H₂O in Brimacombe's study) (2), which allowed the clinical use of PLMA in fields classically considered off-limits for SADs, such as laparoscopy (3), prone position (4), elective C-section (5), obesity (6) and airway rescue in full stomach after intubation failure (7).

PLMA clinical performance set the new benchmark for what NAP4 (8) officially baptized the *2nd generation SADs*, showing their potential role for increased airway protection and performance in either routine and rescue use. Nevertheless, this evolution resulted in important changes among SADs users, including the need for advanced skills and different approaches.

The insertion challenge

PLMA, and in a different proportion the other 2nd generation SADs, pay the due of being bulkier when compared to 1st generation SADs by often requiring better insertion skills (2).

For these reasons, it is not surprising that original PLMA packaging included a dedicated introducer tool meant to pre-curve PLMA, to stiffen the wire-reinforced silicon airway tube and to allow a no-finger-in-mouth insertion technique, similarly to LMA Fastrach™ (FLMA; Teleflex Medical, Dublin, Ireland). As a consequence, LMA Supreme™ (SLMA; Teleflex Medical, Dublin, Ireland), designed as a disposable PLMA, was made out of PVC in a pre-shaped curve, with a thinner cuff and a fixation tab designed to improve handling and ergonomics during insertion, as confirmed in difficult insertion conditions such as in edentulous patients (9).

As a general consideration, we might say that a pre-curved shape could result in easier insertion because of a normal anatomic profile of upper airways and because it reduces the need of SAD advancement in patients' airways owing to intrinsic rigidity. Angle of curvature might condition intubation success, which seems to be higher for devices with an airway conduit angle of less than 90°, such as FLMA and C-Trach™ (CtRLMA; Teleflex Medical, Dublin, Ireland); these devices are somehow oriented upwards towards an anteriorized larynx. Other devices with airway conduit angles measuring 90° or more, which were designed for intubation, seem to perform better in terms of ventilation and sealing but do not attain the same high success rate of blind intubation of FLMA or CtRLMA (10).

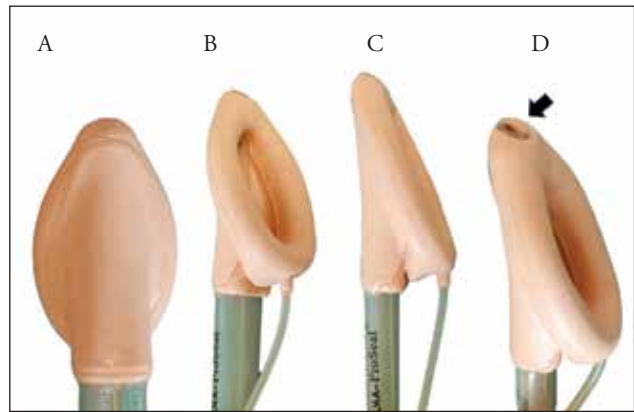


Figure 1. LMA ProSeal™ (Teleflex Medical, Dublin, Ireland): (A) back view; (B) lateral view; (C) profile view. Note: Double cuff design and (D-arrow) gastric access



Figure 2. Different features of SAD cuffs and airway conduits: (A) iGel™ (Intersurgical, Wokingham, UK); (B) LarySeal™ (Flexicare, CA, USA); (C) LMA SureSeal™ (Teleflex Medical, Dublin, Ireland); (D) LMA Classic™ (Teleflex Medical, Dublin, Ireland); (E) LMA ProSeal™ (Teleflex Medical, Dublin, Ireland); (F) LMA Supreme™ (Teleflex Medical, Dublin, Ireland); (G) LMA Protector™ (Teleflex Medical, Dublin, Ireland); (H) AuraGain™ (Ambu A/S, Ballerup, Denmark)

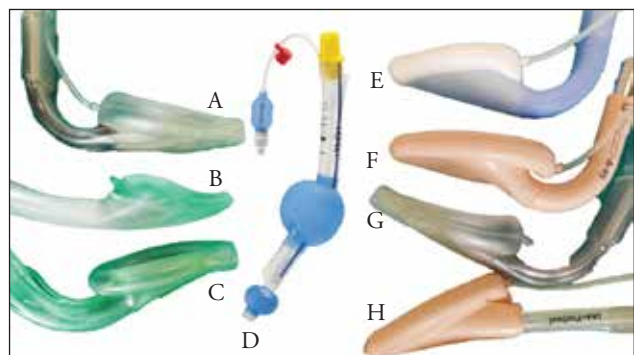


Figure 3. Thickness, curvature and constructive materials of different SADs: (A) LMA Supreme™ (Teleflex Medical, Dublin, Ireland); (B) iGel™ (Intersurgical, Wokingham, UK); (C) AuraGain™ (Ambu A/S, Ballerup, Denmark); (D) Laryngeal Tube Suction (VBM Medizintechnik GmbH, Sulz am Neckar, Germany) (E) LMA Protector™ (Teleflex Medical, Dublin, Ireland); (F) LMA Fastrach™ (Teleflex Medical, Dublin, Ireland); (G) LMA Supreme™ (Teleflex Medical, Dublin, Ireland); (H) LMA ProSeal™ (Teleflex Medical, Dublin, Ireland)

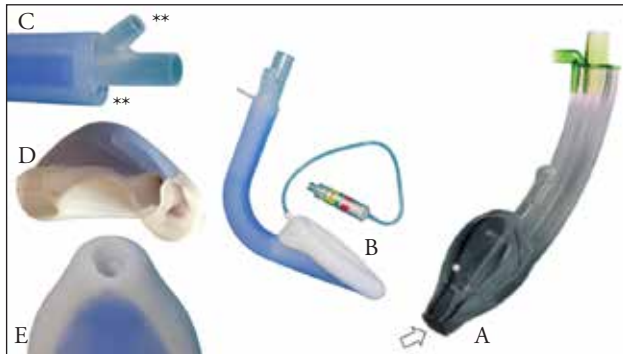


Figure 4. (A) Baska Mask™ (BVLM Pty Ltd, Strathfield, Australia); note: large bore gastric access (arrow) in direct connection with cuff reservoir (*); (B) LMA Protector™ (Teleflex Medical, Dublin, Ireland); note: (C) dual gastric access (**) for gastric tube and access to reservoir (D); (E) detail of gastric tube distal opening on entirely silicon cuff



Figure 5. (A) LMA-Gastro™ (Teleflex Medical, Dublin, Ireland); (B) Gastro-Laryngeal Tube™ (VBM Medizintechnik GmbH, Sulz am Neckar, Germany)

As a matter of fact, it is not simply dimensions

Some 2nd generation SADs might also require more or less dedicated position-check tests (such as drain tube leak test or suprasternal notch test for PLMA), and important implications pertaining to insertion might arise from constructive material, in which silicon cuffs, such as PLMA or the new LMA Protector™ (PrLMA; Teleflex Medical, Dublin, Ireland) or Aura 40™ (Ambu A/S, Ballerup, Denmark), express a higher friction coefficient against oropharyngeal mucosa when compared with PVC-made devices such as LMA Unique™ (ULMA; Teleflex Medical, Dublin, Ireland), SLMA or Aura-I™ and AuraGain™ (Ambu A/S, Ballerup, Denmark), LarySeal™ LMA (Flexicare, CA, USA), new generation self-inflatable AirQ™ (Mercury Medical, Clearwater, FL, USA) or thermoplastic polymer such as iGel™ (Intersurgical Ltd, Wokingham, UK) (Figure 2).

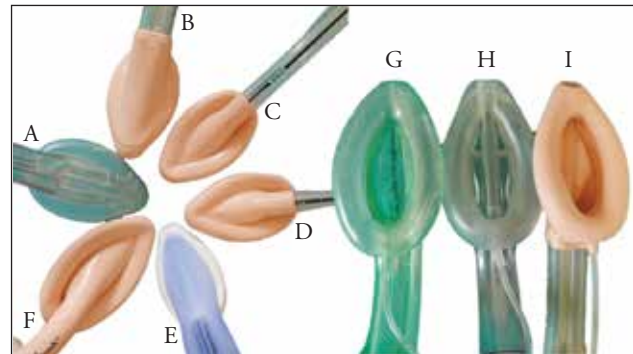


Figure 6. Different SAD cuff materials and shapes potentially influencing depth of penetration in upper oesophageal sphincter. (A) and (H) LMA Supreme™ (Teleflex Medical, Dublin, Ireland); (B) and (I) LMA ProSeal™ (Teleflex Medical, Dublin, Ireland); (C) LMA Classic™ (Teleflex Medical, Dublin, Ireland); (D) LMA Flexible™ (Teleflex Medical, Dublin, Ireland); (E) LMA Protector™ (Teleflex Medical, Dublin, Ireland); (F) LMA Fastrach™ (Teleflex Medical, Dublin, Ireland); (G) AuraGain™ (Ambu A/S, Ballerup, Denmark)

If we compare the ‘Combitube-like’ SADs, such as Cobra-PLA™ (Engineered Medical Systems, Indianapolis, IN, USA), Easytube™ (Teleflex Medical, Dublin, Ireland) or Laryngeal tube™ (VBM Medizintechnik GmbH, Sulz am Neckar, Germany), we might assume that these devices when compared with ‘LMA-like’ SADs are easier to insert (11-13) due to their linear shape, lower profile and increased stiffness; on other hand they show a different performance with respect to sealing pressures, advanced manoeuvres (such as fiberoptic combined use) and gastric access, which is limited only to newer generation devices such as Intubation-LTS™ (VBM Medizintechnik GmbH, Sulz am Neckar, Germany) (14).

Many papers, including that by Dhulkhed and coworkers (1), exploring the performance of different PLMA insertion techniques and comparing them based on different endpoints of insertion time, success rate, operator satisfaction, presence of blood staining on cuff or postoperative complications such as sore throat or dysphagia have been published.

Different available options that have been described to facilitate PLMA insertion are the original introducer tool (2), the *rotational* technique (1, 15-18), the lightwand technique (19), the laryngoscope- (20) or videolaryngoscope-assisted (21) technique, the combination with stylet (22, 23), Gum Elastic Bougie (GEB) (24-26) or introducer (27), and the gastric tube-driven insertion (28) or suction catheter-driven insertion (29).

Looking at different studies and approaches, the highest success rate has been observed with the 90° rotational technique, whereas PLMA manufacturer’s introducer, laryngoscope/ videolaryngoscope-assisted or ‘catheter-assisted’ techniques are mostly described as rescue manoeuvres in cases of failed conventional insertion.

In front of this large body of research, the real issue, probably, is not whether we have a best insertion technique but why we might be in need of an alternative or 'simplified' insertion technique.

CLMA and other 1st generation devices are notoriously easier to insert (30); nevertheless, there is still ongoing research aimed to determine a better insertion technique or adjuncts (31).

At the same time, many papers show that some devices such as iGelTM are faster and easier to insert when compared with other SADs (32); independent of study methods and any possible bias or limitation, the point is that we have clear evidence that some SADs are easy to insert and immediately become operational, whereas others may require more time or effort for perfect insertion, thus requiring a search for facilitating manoeuvres.

So, facing the huge amount of available SADs, and the continuous availability of newer devices from the market, we could try to identify some features facilitating ease of insertion and need for advanced techniques, postponing the search of the best insertion techniques if necessary.

SAD design

Two design factors, thickness and shape (particularly that of the cuff), mostly affect insertion. As we know based on clinical experience and literature (10), FLMA and CtrLMA (33) are considered 'easy' to insert because of a low profile cuff (same as CLMA), a stiff and rounded airway conduit provided with handle and less than a 90° angle between the airway conduit and cuff. This shape mimics upper airway anatomy, resulting in low resistance and allowing 'anatomical' insertion. SLMA is PVC made. The angle of its airway conduit is a little larger than 90° but its cuff thickness is very low, with a very favourable inflated/deflated ratio; thus, it seems to be easier to insert than PLMA and as easy to insert as AuraGainTM or CLMA but less easier to insert than iGelTM (32) (Figure 3). As a general perception based on literature data (13, 30), pre-curved, stiffer, non-silicone and low profile 2nd generation devices (such as iGelTM, SLMA and AirQTM) seem to be easier to insert when compared with the other devices. This difference might be explained with simple observations: PLMA has thicker (double) cuff, it is silicon made (resulting in higher friction against tongue and palatal and hypopharyngeal mucosa) and it comes with silicon-based wire-reinforced flexible airway conduit, which reduces the amount of force transmission from point of application (bite-block or tube) to the tip. This last issue might also explain the steeper learning curve observed for Flexible LMATM (FLMA; Teleflex Medical, Dublin, Ireland) and Aura-flexTM (Ambu A/S, Ballerup, Denmark) when compared with other SADs (34). Similar conclusions might arise for devices hosting a larger cuff or a reservoir for further protection from gastric content regurgitation (Figure 4), such as Baska MaskTM (35) (BVLMT Pty Ltd, Strathfield, Australia) and PrLMA, or for SADs designed for specific endoscopic proce-

dures, such as LMA GastroTM (36) (GLMA; Teleflex Medical, Dublin, Ireland) and Gastro-Laryngeal TubeTM (37) (VBM Medizintechnik GmbH, Sulz am Neckar, Germany) provided with an embedded endoscope-dedicated channel (Figure 5). In conditions of similar shapes or material, also length of SADs cuff's tip entering the UES might affect device performance (including misplacement possibility and theoretical protection against regurgitation) (38), ease of insertion and possible side effects as sore throat or dysphagia (32) (Figure 6).

Anesthetic plan

Not so many papers comparing insertion, performance and side effects of different SADs included (or considered its absence like bias) (39) the depth of anaesthesia monitoring threshold for insertion, maintenance or removal of different devices, despite it seems logical to admit a potential interference. Albeit SAD insertion is performed mainly in anesthetized patient; if we do not measure the depth of anaesthesia or establish a clinical/temporal criteria to proceed with insertion (40), including choice of different hypnotic drugs or dosing (41) and using or not using neuromuscular blockers (42), we might falsely judge an even thinner device positioned in a less anaesthetized patient difficult to insert. Similarly, we could claim a higher sore throat incidence not taking into account that a superficial patient or an arousal reaction might evoke swallowing reflex and UES contractions resulting in a relatively increased transmucosal pressure exerted by a certain SAD cuff with a consequent more probable sore throat. Not forgetting the clinical evidence that anaesthetic requirement is different according to not only patient characteristics but also to the chosen SAD (43) because of the aforementioned specific constructive and design features.

Not rarely, specific characteristics facilitating an increased insertion difficulty (and need for a deeper anaesthetic plan) do variably affect devices with advanced performance (i.e. high sealing pressures), opportunities to access the gastric content with a large bore channel, opportunities to perform position control tests and last but not least intubation possibilities (44).

Size choice

In clinical practice, it is common to use dedicated formulas to calculate the endotracheal tube size in paediatric patients, as we know the narrowest point of pediatric airways is the cricoideal transverse diameter, which we can't directly observe. Similarly, we might need to rely on some formula or algorithm to determine the correct size of our SAD, because also in this case we cannot observe directly the hypopharyngeal space where they will be seating. We are conventionally basing our SADs sizing on manufacturer's recommendations, classically referring to patient's weight, often suggesting a size-related cuff inflation volume (for inflatable cuff SADs), not taking account of inter-individual anatomical variability and of SAD specific design.

Consequently, this method might start to look a little bit anachronistic and definitively not realistic; however, clinical experience (and simple logic) has taught us that a 1.50 cm and 100 kg female patient will not require SAD of a size same

as that required by a 1.90 cm and 100 kg male patient; we also must not forget other papers showing that insertion of PLMA of the same size could be affected by elevating the head to the same level on the operation bed (45).

As a personal experience using the new PrLMA (unpublished), which is silicon made, an important determinant for correct size choice could be represented by patient's height before (or together with) their weight. These concepts might also explain possible different performances, especially in *borderline* (edentulous, restricted mouth opening, etc.) patients, of silicon (more adaptable) and PVC (stiffer) cuffs of inflatable (more adjustable) rather than non-inflatable or self-inflatable (not or partially adjustable) SADs.

With such premises, the point of difficult insertion, unless not corrected for a precise sizing policy, remains affected by a serious bias, whereas different techniques like tongue dimension-based sizing (46) show interesting but not definitive results, and further research is aiming to find out specific criteria for prediction of difficult SGAs positioning and ventilation (47).

Experience and learning curve

Precise data are missing for definition of a (specific) SAD learning curve despite clear evidence that SAD insertion is easier and performance is faster to achieve when compared to standard airway control techniques such as facemask ventilation or intubation (30). A recent study explored performance improvement for PLMA insertion after 40 attempts, with difficulty in establishing a clear cut-off for learning curve in inexperienced first year residents (48). A reasonable conclusion might be that a) the learning curve of SADs is faster than effective facemask ventilation or successful intubation, b) proficiency in SADs use is clearly experience dependent, c) a biphasic proficiency curve could be drawn, with the first peak being 'basic' users, with probably less than 100 insertions, and the second expertise peak being 'advanced' users requiring much more than 100 insertions or up to 750 for PLMA according to Brimacombe (49).

Albeit an obvious learning curve, SADs are not obvious devices, and high performance might be expected and reached only after a certain experience in the field has been developed. This must be clearly taken into account whenever designing any research comparing insertion performance because either operators' inexperience or too much experience might represent an important bias on study endpoints (39).

The need to shift point of view

It is now clear that the answer for the best SAD or for the easier to insert one is far to be reached and that the same search of a better insertion technique for a specific SAD might be purely speculative. Above all, any comparison between techniques might be unfair in light of what we considered; thus, no results could be considered totally reliable and could address our choices. It could be much more helpful when using these devices with a certain criticism and trying to understand how the specific features of each device might interfere

with our insertion performance and develop our target-based (*what I could do with what*) SAD classification, always keeping in mind the only evidence-based available rigorous separation between 1st and 2nd generation SADs (50).

This way, ease of insertion, depending on constructive material and device features conditioning stiffness, bulkiness, friction coefficients and ergonomics apart from operator's experience, becomes secondary and assumes a different meaning.

Placing a normal endotracheal tube is easier than correctly positioning a double lumen tube, but we cannot ask a normal tube to provide a controlled one lung ventilation. Similarly, we will probably have easier to insert SADs (whichever the reason) and more difficult to insert SADs, keeping in mind that there is always a reason for this difference and there could be often a parallel difference in performance to be counterbalanced on our expectations. How much is the ease of insertion important when compared with a certain advantage that we might have from an advanced, although more difficult to insert, SAD?

We should probably focus more on other critical issues such as sizing, real aspiration protection and cuff pressure monitoring (51) as factors potentially affecting performance, outcome and side effects.

Whatever is the device and the study, we need to be absolutely rigorous with methods to reduce biases and maximize reproducibility of results.

Conclusion

Since Archie Brain introduced LMA Classic™ in clinical practice in early 90's, we witnessed an unstoppable evolution and widespread diffusion of SADs; thus, today probably more than 40 different devices have been available in worldwide market (30), and, hard to think differently, any anaesthesiologist in the world knows or has used at least one device.

With slightly different meanings, indications or preferences, any international airway management guideline lists SADs between mandatory devices in emergency airway cart, with critical and clearly recognized role for airway rescue (52).

The same concept of SAD has changed over time, starting from a rescue device for the cannot ventilate the patient, becoming a routine anaesthesia management device with many theoretical advantages over tracheal tube (53, 54), for which it represents a reasonable and nowadays clinically accepted alternative in different surgical procedures, including non-operating room anaesthesia and last but not least as a tool for protected extubation in selected conditions and patients (55).

In the end, when we choose to use a SAD in our patient, we should probably address our choice not (simply) on insertion easiness but on procedure, expectations and patient's peculiarity.

Using SADs regularly in critical practice will have many benefits, climbing (and understanding) a learning curve, developing skills, improving our decisional criteria and resulting in the final message that we might not have the best SAD but the better performing one in a certain setting and in a certain patient provided we know it and we know how to use it proficiently.

Difference, as Sherlock Holmes used to say, is in details.

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