

Pre-shaped supraglottic airway devices offer an alternative to endotracheal intubation for airway management of postburn neck contracture: A case series

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Abstract

Background and Aims: Moderate to severe postburn contractures (PBCs) of the neck lead to multiple areas of difficulty in airway management. Awake flexible fiberscope guided intubation with cuffed endotracheal tube (ETT) is considered the “gold standard” for securing the airway in these cases. Supraglottic airway devices (SADs), if at all used, are used either as rescue devices or as conduits for ETT. This case series looks at the possibility of using SADs as a planned airway securing device in these cases.

Material and Methods: We managed 24 cases of moderate to severe PBC neck using six types of pre shaped SADs as the first choice airway device. These SADs were placed after either airway topicalization (19 cases) or general anesthesia (GA) (5 cases). Once SAD placement was confirmed, all the patients received GA and muscle relaxant. Tests for proper placement and function and fiberscopy (conducted in four cases) were performed at various times during the procedure. The SADs were removed once the patients were fully awake.

Results: SADs could be placed in one attempt in all the cases. The time taken to hand over the patients to surgeons was 12–20 min. SADs maintained their proper placement and function in spite of changing airway dimensions during contracture release. The patients tolerated the SADs well right until the time they were fully awake. The SADs could be successfully removed on the operation table in all the cases.

Conclusion: Pre shaped SADs secure the airway quickly and are free from the risk of intraoperative displacements and allow uneventful emergence in moderate and severe PBC neck cases and need to be considered as the first choice in these cases.

Keywords: Airway management, contracture neck, supraglottic airway devices


Introduction

Burns of the neck and face lead to postburn contractures (PBCs) of varying severity. Moderate to severe PBCs cause a wide variety of anatomical deformities of these areas. These include fibrotic scars distorting the mouth, nose, and neck, acutely angulated and reduced oropharyngeal space, compromised submandibular space length and compliance, and a scarred neck with limited extension. Due to the wrong position of the head on the neck during burn management and the pillow

under the head and not the shoulder, the chronic flexion contracture is often seen in deep extensive burns of the neck and this may be attributed to the flexion position taken by the patient to minimize the tension on the neck and hence decreasing the pain sensation.^[1] All these lead to multiple areas of difficulty in airway management.

Intubation with a cuffed endotracheal tube (ETT) is considered the “gold standard” for securing the airway for

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reconstructive procedures in these cases.^[2] Intubation is ideally achieved under flexible fiberoptic-guidance in an awake patient with airway topicalized, although many other methods have been reported.^[2,3] Supraglottic airway devices (SADs), if at all used, are used either as rescue devices or as conduits for ETT,^[3] although their use as definitive airway devices has also been mentioned.^[4]

There are several apprehensions regarding the use of SADs in such cases. These are: (i) pre-shaped SADs are difficult to introduce in cases of severe neck contracture,^[4] (ii) SAD placement is more likely to be improper because of acutely angulated and reduced oropharyngeal space and shorter submandibular space, (iii) machine ends of pre-shaped SADs will obstruct the surgical field, (iv) fixation of SADs after placement will be difficult and will come in the surgical site, (v) SADs will get displaced with changing neck length as will happen in these cases as the contracture is released, and (vi) even if not anatomically “displaced,” the functional characteristics of SADs will change for the worse. Our 24-case case series, where we used pre-shaped SADs as the first choice airway device, addresses all these apprehensions and offers these devices as an alternative to endotracheal intubation.

Case Series

We present 24 patients of moderate to severe PBC neck who underwent release of neck contracture over a period of more than 10 years. Most of our patients were young (median age 23.5 years) with a preponderance of females [Table 1]. The severity of neck contracture can be guessed from the fact that only seven of the patients had the neck range of motion (extreme flexion to extreme extension) of $>30^\circ$. Although the median mouth opening of our patients was 4.35 cm with the minimum mouth opening being 2.7 cm but the modified Mallampati class was mostly 4 [Table 1]. In all these cases our team used SADs electively as the definitive airway device. Six types of pre-shaped SADs were used with LMA® ProSeal™ Airway (Teleflex® India) (by introducer technique) leading the chart. Second generation SADs were used in all except two patients where Ambu® AuraOnce™ (Ambu® India) was used [Table 2].

After the written and informed consent of the patient or the guardian, the patients underwent reconstructive procedures. In 19 of the 20 adult patients, SADs were placed while

they were awake. These patients were counseled and were given a detailed explanation of the procedure and the need for their participation in it. Airway was topicalized using a combination of lidocaine nebulization, gargles, and spray. Nebulization was carried out in the preoperative hold area with 3–4 mL of 4% lidocaine. Once in the operation theater (OT), standard monitors were attached and IV line was placed. IV midazolam 0.5 mg and fentanyl 0.5 $\mu\text{g}/\text{kg}$ was given. Patients were made to gargle twice over 3–5 min with 5 mL of 2% lidocaine viscous in each go. After thorough gargling in the oral/pharyngeal cavities, the patients were asked to spit out the first dose but were asked to swallow the second dose. Thereafter, the oropharynx was sprayed with 5–10 puffs of 10% lidocaine spray. The patients were then handed over the chosen SAD that had been well lubricated with 2% lidocaine jelly and were asked to insert it gently along the hard and soft palate. The operator kept talking to the patients, encouraging them and simultaneously assisting them in the placement by lightly holding their hands. Once the placement was complete the SAD was connected to anesthesia circuit with 100% O_2 at 6–8 LPM and adequate chest and bag movements and square-wave capnogram were confirmed. General anesthesia (GA) was induced with IV propofol 2 mg/kg.

In one adult, who refused airway management under topicalization, and four children (8–12 years), GA was given before placing SAD. The adult patient received airway topicalization also. In all these patients IV line was placed and IV midazolam 0.5 mg and fentanyl 0.5 $\mu\text{g}/\text{kg}$ was given. Anesthesia was induced with IV propofol 1 mg/kg. Lubricated nasopharyngeal airway (NPA) was introduced through the more patent or right nostril and patients breathed 6% sevoflurane in O_2 (3 cases) or 2% isoflurane in O_2 (2 cases) by mask. Good bag movements were appreciated in all five cases and SAD was placed once the depth of anesthesia was deemed adequate. After successful placement, the SAD was connected to either Rees-Ayre circuit or closed circuit with 4% sevoflurane or 1.4% isoflurane in O_2 and adequate chest and bag movements and square-wave capnogram were confirmed.

Once SAD placement was satisfactory and GA had been induced (in the topicalization group), all the patients received neuromuscular blocking agent. Fentanyl 1.5 $\mu\text{g}/\text{kg}$ was administered IV at this time. All the SADs were fixed by a single tape running from zygoma to zygoma encircling

Table 1: Patient characteristics of our case series

Age (years) Mean (SD); Median (Range)	Gender (M/F)	Inter-incisor gap (cm) ($>3\text{ cm}/<3\text{ cm}/<2$) Mean (SD); Median	Modified Mallampati class (1/2/3/4)	Neck extension $<30^\circ/>30^\circ$
24 (10); 23.5 (8-45)	9/15	22/2/0 4.3 (0.6); 4.35	1/3/5/15	17/7

Table 2: Various supraglottic airway devices (SADs) used, their performance characteristics and other features

SAD used (n)	PLMA (10)	SLMA (5)	AAO (2)	i-gel (5)	AAG (1)	BB (1)
Tests of Placement						
Smooth insertion and resistance in the end	10	5	2	5	1	1
Adequate length/orientation of airway tube outside	10	5	2	5	1	1
Outward movement of the device on cuff inflation	10	5	2	-	1	1
“Bubble” test negative	10	5	-	5	1	1
Suprasternal notch tap test positive	10	5	-	2	1	1
Smooth insertion/placement of gastric tube	10	5	-	5	1	1
Fiberscopy (conducted in 4 cases)	1	-	-	1	1	1
Tests of Function						
Adequate chest expansion on IPPV	10	5	2	5	1	1
Satisfactory compliance of the reservoir bag	10	5	2	5	1	1
Regular square capnography waveform	10	5	2	5	1	1
Absence of audible oropharyngeal/epigastric leak	10	5	2	5	1	1
Oropharyngeal leak pressure (Mean [SD]; Range-29 [7]; 16-40 cm H ₂ O)	10	5	2	5	1	1
Maximum volume ventilation test (done and passed in six cases)	2	1	-	1	1	1
Other features						
Time to hand over to surgical team (minutes)	Mean (SD)-15.8 (2.5); Median (Range)-15.5 (12-20)					
Duration of SAD use (minutes)	Mean (SD)-172 (22); Median (Range)-175 (138-210)					
Postoperative complications	Sore throat (mild)-2 cases Dysphonia, dysphagia or any nerve palsy-0					

PLMA=LMA® ProSeal™ Airway (Teleflex®, India) by introducer technique; SLMA=LMA® Supreme™ Airway (Teleflex®); AAO=Ambu® AuraOnce™ (Ambu, India); i-gel=i-gel® supraglottic airway (Intersurgical®, India); AAG=Ambu® AuraGain™ (Ambu®, India); BB=BlockBuster™ Laryngeal Mask (Tuoren®, China); OLP=Oropharyngeal leak pressure

the airway tube of the SADs just above the lips of the patient. Standard tests for SAD placement and function were conducted thereafter. Proper *placement* and *functioning* of SADs were confirmed in all 24 cases by various tests^[5] [Table 2]. The maximum volume ventilation test^[5] of *functioning* was conducted in the last 6 cases while fiberscopy was conducted in four cases of severe contracture soon after placement of SAD. It showed that SADs achieved good fiberoptic placement (fiberscopy score 3 or 4).^[6]

The time taken to hand over the patients to surgeons from the time the patients were shifted to the OT table was 12–20 min [Table 2]. The rest of the anesthetic management was as usual. Cuff pressure was monitored in all the cuffed devices and maintained at 25–30 cm H₂O. At the end of the surgery, the remaining effect of neuromuscular blocking agent was reversed and the patients were prompted to remove their SADs themselves when they were fully awake. SAD was removed successfully in all the patients on the OT table and the patients maintained their airway adequately after device removal.

At the beginning of surgery, 3–4 rings were needed under the patient’s head, depending upon the severity of contracture. These rings would be removed one by one as the contracture was released and the neck could be extended more and more. At each of these events, the placement and functioning of the SAD were retested by some of the tests that could be applied without disturbing the surgical field. The duration

of SAD use was 138–210 min (median—175 min). The patients were followed up on the first postoperative day for any postoperative complications due to SAD use. Only two patients complained of mild sore throat that responded to steam inhalation and analgesics that were advised for postoperative pain management. There was no incident of dysphonia, dysphagia, or any nerve palsy [Table 2].

Discussion

Accidents at workplace were the commonest causes of burns in our male patients and at home in children. Domestic violence and accidents in the kitchen caused burns in the female patients. That is why most of our patients were females (62.5%) and most (83.3%) were young adults (mean age of 20 adults—26.7 years).

Anesthetic management of moderate to severe PBC neck has always been considered challenging in terms of achieving safe airway access. The deformities caused by the scar over the face and neck can make mask ventilation and direct laryngoscopy difficult, and front of neck access difficult in milder and impossible in severe contractures. Here, the word “difficult” indicates a condition that is optimizable in the presence of appropriate resources.^[7] Most anesthesiologists prefer to achieve airway access with a cuffed ETT over a flexible videoendoscope (fiberscope) under topical anesthesia as these patients are mostly adults (as in our series as well) and thus easy to convince and consent for airway access under

topicalization. Typically, nasal route is used to introduce, although oral route too is used occasionally.^[3,8] Alternatively, some airway managers get the scar released under tumescent anesthesia or ketamine before proceeding with GA and oral/nasal intubation.^[2] There is a case report of resorting to tracheostomy also after scar release.^[9] Our 24-case series presents the option of using pre-shaped SADs as the definitive airway access and management device that is much simpler yet equally, if not more, effective than the prevailing methods for these patients.

Our group also used to get these cases done under fiberscope-guided nasal or oral intubation. In the absence of fiberscope, we would use intubating laryngeal mask airway (ILMA) and blind intubation through it.^[3] In one such case where the blind intubation through the ILMA was particularly difficult and somewhat traumatic, we decided to keep the ILMA in place along with the ETT throughout the surgery. After intubation and ascertaining equal air entry on both sides of the chest, we first fixed the reinforced ETT to the airway tube of ILMA and then fixed the ILMA in place, ensuring that the base of its handle was padded to prevent injury to patient's face. And to our surprise, the surgical team could easily tuck the machine end of the ILMA under the drapes. This gave us the idea of trying to get these surgeries conducted by using pre-shaped SADs as the sole and definitive airway devices. The inherent stiffness of pre-shaped SADs allowed us to introduce these without introducing our finger into patients' mouth, which may be difficult in cases of severe contracture.

It is thought that pre-shaped SADs are difficult to introduce in cases of severe neck contracture. The reasons being reduced mouth opening^[10] and reduced sterno-mental space.^[3] Although the inter-incisor gap (IIG) is almost always adequate in these cases,^[8] [Figure 1a] sometimes the upper lip gets pulled down over the upper incisors to give a false sense of reduced mouth opening and IIG [Figure 1b]. Once that is understood and the distorted upper lip is pulled out of the way, the adequate IIG can be appreciated [Figure 1c and Table 1]. On the other hand, because of the reduced sterno-mental space, the machine ends of preformed SADs get stuck against the anterior chest as the mask of SAD is being introduced into the patient's mouth. In case this happens, lateral (along the cheek) or upside-down approach^[3] allows initial introduction. And except for ILMA and ProSeal LMA loaded on its introducer, the introduction of other pre-shaped SADs can be facilitated by straightening their airway tube somewhat by applying gentle pressure on its curved portion.

When we first proposed using SADs as definitive airway devices for the release of moderate to severe PBC to the



Figure 1: (a-c; clockwise from upper left) The inter-incisor gap (IIG) is almost always adequate in cases of postburn neck contractures—(a). Sometimes the upper lip covers the upper incisors to give a false sense of reduced IIG—(b). Once the distorted upper lip is pulled out of the way, the underlying adequate IIG can be appreciated—(c)

plastic surgeon (PB), both parties were a bit worried about the likelihood of the machine ends of pre-shaped SADs obstructing the surgical field and we began with the premise that the surgical team will have to “tolerate” that handicap. To our surprise, once the connection between the SAD and the anesthetic circuit was secured and surgical draping was complete, the drapes on the chin easily covered and kept the SAD out of the surgical field and the surgical team hardly noticed the slight bump. Thereafter, as the contracture was partially released in the first 5–10 min and the neck extended by surgical assistant's retraction over the submandibular area, even this bump moved away from the surgical field [Figure 2].

Recent studies have shown retrospectively^[11] and prospectively^[12] that TMD <6 cm and reduced neck range of motion (NROM) are two of the strongest predictors of difficult SAD use. That would make patients with moderate to severe PBC neck, who have a remarkably short TMD [Figure 3a] and reduced NROM, especially vulnerable to problems with SAD placement and/or functioning. Moreover, contracture neck leads to acutely angulated and reduced oropharyngeal space and shorter submandibular space. These also should theoretically affect SAD placement adversely. However, our series does not support any of these findings and assumptions. The reasons, we feel, are that the pre-shaped SADs are stiff enough to negotiate these acute angles and reduced oropharyngeal space; and although the SAD shaft-mask angulation might be altered by these anatomical variations, these would not alter their functioning [Figure 3b and c]. It may be possible that the reduced TMD and NROM in patients *without* neck contracture are associated with anatomical changes inside that confound proper placement of



Figure 2: Once the connection between the supraglottic airway device (SAD) and the anesthetic circuit is secured and the surgical draping is complete, the SAD is almost out of the surgical field. And as the contracture is released and the submandibular area retracted by the surgical assistant (seen on the right of the picture), the SAD is moved totally away from the surgical field

SADs, rather than just pulling down of the chin as happens in most patients with contracture neck.

The skeptics among us predicted that even if the SAD gets placed well, it would either get displaced anatomically or its functional characteristics will get worse as the neck length increases with the release of contracture. However, none of that happened as shown by the tests of placement and functions at various times before, during, and at the end of surgery [Table 2]. Out of these tests, we started doing the maximum ventilation test^[5] only after November 2015 and did it in all six cases conducted after that. We also documented it fiberoptically in four cases of severe contracture. Herway and Benumof documented that the upper airway and trachea (upper incisor to tracheal carina distance; UI-CA) expand like an accordion on extending the neck, but the maximum change in length (90% of UI-CA distance increase) happens in the vocal cord-sternal notch zone while the incisor-cricoid (I-C) length remains relatively stable.^[13] As SADs occupy the I-C space their position remains stable. The minimal change in the I-C space probably indicates that during full neck flexion to full extension, the only change is the “opening up” of the posterior oropharynx. This probably results in just the corresponding opening up of the acutely bent airway tube of SADs as the neck extends [Figure 3b and c] that has no clinically relevant effect on its functioning. Interestingly, an appropriately placed ETT occupies the vulnerable vocal cord-sternal notch zone with the tip at mid-trachea (sternal notch). It is thus an ETT that is much more likely to get displaced during surgery^[14] and most experienced anesthesiologists tend to push the ETT 1–2 cm beyond the depth marker to compensate for this expected increase in tracheal length during surgery.



Figure 3: (a-c; clockwise from top) Moderate to severe contracture causes a remarkable reduction in thyromental distance and neck range of motion. (a) With the machine end of the SAD (Ambu AuraGain in this case) fixed at the lip (marked by a tape) and the tip of the SAD cuff at the level of upper esophageal sphincter (cricoid cartilage), the extreme flexion (b) to extension (c) of the neck results in only opening up of the acutely bent airway tube of the SAD in the oropharynx without affecting the performance characteristics of the SAD

Airway topicalization was achieved by a combination of techniques but care was taken not to exceed the maximum dose of lidocaine (9 mg/kg).^[15] Although the Difficult Airway Society guidelines for awake tracheal intubation 2020 (DAS ATI)^[15] recommends the use of 30–40 puffs or even more of 10% lidocaine, we distributed the allowable dose of lignocaine for nebulization (120–160 mg), gargles (200 mg), lubricating the SAD (40–60 mg), and puffs (50–60 mg). Thus we used only 5–10 puffs. We also made our patients slowly swallow the second dose of lignocaine gargles to anesthetize the area of the laryngopharynx better. We feel that this makes it easier to place the SAD in its final position with the tip at the upper esophageal sphincter. Our awake patients tolerated the SAD introduction very well with this technique.

We added a novel element to counseling during SAD placement in awake patients by allowing patient participation in the actual airway access. As mentioned, the patients introduced the SAD themselves while we just counseled and helped them along. Success of any airway intervention under topicalization is dependent on good counseling and judiciously dosed sedation that allow the patient to remain cooperative and calm yet not affecting the airways, breathing, and hemodynamics adversely. Lately, the DAS ATI guidelines 2020 label this level of sedation as “minimal sedation” and define it as “drug-induced state during which the patient responds normally to verbal commands, while the airway, spontaneous ventilation, and cardiovascular function are unaffected.”^[15] Our choice of agents and the dosage for minimal sedation were guided by the drug availability and the same principles as suggested by these guidelines.

Even in the five patients who were administered GA before placing SAD, we used only minimal dosage of sedation followed by 1 mg/kg propofol. Thereafter, we placed NPA in every case and then deepened the anesthesia with volatile agent in O₂ and placed SAD. This way we ensured that none of the patients had apnea, significant respiratory depression, or airway obstruction and good oxygenation was maintained at all times. Thus, in both our airway management plans (airway access before or after GA); we could bypass all three areas of difficulty (mask ventilation, direct laryngoscopy, and front of neck access)—similar to what is achieved during awake fiberscope-guided intubation. Mask during GA was used only to deliver anesthetic vapors over patients' open airway (with NPA) to deepen anesthesia and not for ventilation. In case this plan (Plan A) were to fail, it would not lead to any airway emergency and we could choose to either perform flexible videoendoscopic (fiberscopic) guided oral or nasal intubation (fiberscope was always on standby) while continuing paraoxygenation through NPA (Plan B). At any other center that does not have fiberscope, the patient can be easily allowed to wake up and plan for another day or another center (Plan B).

Using these techniques of topicalization (other than nebulization, which happened in the preoperative hold area), sedation, counseling, and patient participation in patients where SAD was introduced awake and in those where it was done after GA, we were able to hand over the patients to the surgical team in 12–20 min after they were shifted to the OT table. This is much less than the usual time taken for most other methods of securing the airway in these patients.

The duration of SAD in-situ was 138–210 min (median—175 min), which is much more than the usual “spoken about” duration of <120 min. However, there is neither any evidence that longer durations of SAD use lead to increased risk of complications nor a maximal duration of SAD use has been determined.^[16] If prolonged SAD use is contemplated, a second-generation device is recommended to decrease gastric insufflation and it is suggested that the cuff pressure should be monitored continuously and kept as low as possible.^[17] Case reports have also described safe SAD use for over 9 h.^[18] We used second-generation SADs in all but two cases and we monitored the cuff pressure in all the cases and kept it at around 25 cm H₂O. We followed up the patients for SAD-induced postoperative morbidity, and it was found to be minimal.

Although it appears that the emergence will be easy once the contracture is fully released, but in reality, it is not so because of the dressing that the plastic surgeons put over the neck that almost impinges on the lower lip [Figure 4]. However, we were



Figure 4: The large dressing applied over the neck by the plastic surgeons at the end of contracture neck surgery makes the process of extubation or SAD removal challenging

able to successfully remove the SAD in all the patients on the OT table itself. This was possible because of two important reasons: one, like at the beginning, we prompted the fully awake patients to remove their SAD themselves; two, as we had conducted our cases with SADs, we were confident that we would be able to reintroduce these, if needed.

There are very few reports of SAD use in contracture neck and most are as an emergency option^[10] or as a conduit for ETT.^[3,8] There is a study where LMA and i-gel have been compared as definitive devices in cases of neck contracture but the study design, methodology, discussion, and conclusions are rather ambiguous. The study does not describe the severity of contracture or airway characteristics of the patients and seems focused on highlighting the attributes of i-gel.^[4] Apparently, the patients had less severe contracture than our series as it not only included patients undergoing release of PBC but also those undergoing debridement, split skin grafting, and change of dressing.

During the course of this case series, we felt that there is a need for an anesthesia-related severity scoring system for neck contractures that should be based on NROM rather than the classifications given by surgeons.^[19] We suggest that if NROM is >60°, the contracture should be termed *mild*, if it is 30–60° it should be termed *moderate*, and if it is <30° it should be termed *severe*. Once this is done, investigators can compare their work and also document the issues related to each grade, and draw strategies for future use.

Our case series demonstrates that pre-shaped SADs are effective definitive airway devices in moderate and severe PBC neck cases and need to be considered as the first choice in these cases as they secure the airway quickly and effectively throughout these surgeries in spite of changes

in airway dimensions, are free from risk of intraoperative displacement and extubation, allow uneventful emergence, and cause minimal postoperative airway morbidity if used with intraoperative cuff pressure monitoring.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients/ their guardians have given their consent for their/ their wards' images and other clinical information to be reported in the journal. The patients/ their guardians understand that their/ their wards' names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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