24 Airway Anesthesia

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Key Messages

1. Proper psychological and pharmacological preparation of the patient by an empathetic anesthesiologist can go a long way in making airway anesthesia acceptable for all concerned.
2. The best anxiolytic is reassurance from a confident anesthesiologist, not midazolam.
3. Keep "Plan B" ready if you get your IV sedation wrong and the patient became apneic!
4. Lidocaine is available as various formulations ranging from regular solution, topical, viscous, gel, spray.
5. Topicalization is the easiest method for anesthetizing the airway; just gargle or spray lidocaine directly onto airway mucosa.
6. Adequate airway anesthesia is ensured by loss of pain, gag reflex, loss of swallowing sensation, and voice change.
7. Clinical features of toxicity with lidocaine can range from tingling, circumoral numbness, metallic taste, paranesthesia, and auditory changes to seizures, loss of consciousness, and complete cardiorespiratory collapse.

1 Introduction

General anesthesia (GA) is mostly used for endotracheal intubation. However, when the safety is threatened by induction of GA, awake intubation under airway anesthesia, with or without sedation is considered. Awake tracheal intubation has a good safety profile due to preservation of spontaneous ventilation and intrinsic airway muscle tone but can still fail in 1–2% of patients [1]. Fatal complications like complete loss of airway and myocardial infarction have also been reported. In an awake patient, good local anesthesia (LA) will produce minimal discomfort during airway manipulation and helps to minimize local and systemic effects such as coughing, bucking, laryngospasm, bronchospasm, tachycardia, and hypertension [2].

Airway anesthesia is produced by a combination of nerve blocks, topicalization, spray, and nebulization techniques. Objective is abolishing the gag and cough reflex. Success demands technical expertise as well as the anatomical and physiological knowledge of the airway [3].

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2 Indications, Contraindications, and Advantages

Specific indications (Table 24.1) for the use of airway anesthesia technique are vital for its success. A thorough knowledge of anatomy, the drugs used and complications of the various procedures will be beneficial in securing the airway safely and prevents patient discomfort.

Contraindications include uncooperative patient or patient refusal, coagulation abnormalities and anticoagulation therapy (for nerve blocks), distorted anatomy of the neck due to thyroid swelling, tumors, arteriovenous malformations, post-surgery and post burns contracture, allergy to local anesthetics and local infections.

Advantages of airway anesthesia include improved patient cooperation and comfort, reduced hemodynamic response without compromising airway patency.

Table 24.1 Indications for airway anesthesia

Awake airway procedure	Diagnostic airway procedure	Predictors of difficult airway/ Risk of aspiration
Awake fiberoptic intubation (AFOI)	Nasal endoscopy	Difficult laryngoscopy
Conventional direct laryngoscopy	Drug induced sleep endoscopy	Difficult mask ventilation (known or suspected)
Blind nasal intubation	Bronchoscopy	Trismus
Intubating laryngeal mask insertion		Cervical instability
Tracheostomy		Morbid obesity
Video laryngoscopy		Radiation therapy
Retrograde intubation		Cervical fusion surgeries

3 Drugs

3.1 Local Anesthetic Drugs

Lidocaine is the only LA used due to its rapid onset of action and low risk of systemic toxic effects [4]. Preparations used for airway topicalization include 10% spray, 4% topical, 2% viscous, 2% jelly, and 2% solution as shown in Fig. 24.1. The choice of type and concentration of the drug depends on the technique of topicalization, and the block that is planned.

Lidocaine 2–4% applied to mucous membranes produces superficial anesthesia in about 1 min. The peak effect occurs within 2–5 min and the duration of action is 30–45 min [5]. For regional blocks, the suggested maximum dose of lidocaine is 4 mg/kg and with epinephrine it is 7 mg/kg [5]. Higher doses of up to 9 mg/kg have been used by Woodall for airway topicalization since much of what is delivered is either swallowed or lost to the atmosphere and therefore not absorbed [6]. However, the danger of rapid rise of plasma levels after topical application of local anesthetic in the respiratory tract should be a limiting factor to use of such high doses of lidocaine [7]. The British Thoracic Society recommends that the total dose of lidocaine should be limited to 8.2 mg/kg in adults (approximately 29 mL of a 2% solution for a 70 kg patient) with extra care in the elderly or those with liver or cardiac impairment [8]. Maximum dose of local anesthetic based on patient body weight (lean body weight) should be estimated and this total volume is administered in all forms among different areas to be topicalized [9].

Fig. 24.1 Different formulations and preparations of lidocaine used for airway anesthesia

Table 24.2 Various adjuvant drugs used during airway anesthesia [10]

Medications	Dosage, route, timing	Actions	Reversal agent
Glycopyrrolate	0.2–0.4 mg IV 30 min prior the procedure	Antisialogogue, lack of central effects	None
Midazolam	0.02 mg/kg IV (titrate to effect)	Anxiolytic, sedative, amnesic, anti-seizure	Flumazenil (30–60 min duration of action [2])
Fentanyl	1 μg/kg IV or 25–50 μg IV (titrate to effect)	Analgesic, antitussive, sedative	Naloxone
Remifentanil	Loading dose 0.5–0.75 μg/kg Infusion 0.075μg/kg/min IV	Analgesic, sedative, ultra-short acting opioid	Naloxone (1–4 h duration of action [2])
Dexmedetomidine	0.5–1 μg/kg IV loading dose (titrate to effect)	Sedative, analgesic, anxiolytic, antisialogogue selective α2 agonist	Atipamezole
Propofol	0.5 mg/kg slow IV (titrate to effect)	Sedative	None
Ketamine	10–20 mg loading IV dose 0.2–0.4 mg/kg/h infusion	Sedative, analgesic	

The dosing regimen may need to be modified according to the current medical condition, physical status of the patient and stage of the procedure

3.2 Adjuvants Used During Airway Anesthesia

Pharmacological adjuvants are often administered in the preoperative holding area to ensure optimum action of these drugs prior to the procedure. The various medications used for sedation and analgesia and their dosages required during awake airway management [10] is given in Table 24.2.

Antisialogogues–Although antisialogogues is not mandatory prior to awake airway management, it offers several advantages like decreased production of secretions to improve fiberoptic visualization, increase in the effectiveness of topically applied local anesthetics by removing the barrier to mucosal contact and decreases drug dilution [11]. Glycopyrrolate 0.2 mg intravenous (IV) 20 min prior or 4 μg/kg intramuscular (IM) given 40–60 min prior is very effective, but has to be used cautiously in cardiac patients [12].

Aspiration prophylaxis with H_2 receptor blocker such as ranitidine, a prokinetic drug (metoclopramide) and in addition a non-particulate antacid (15 mL of 0.3 M sodium citrate solution) will reduce the risk and severity of aspiration [11].

Vasoconstrictors reduces the risk of bleeding, shrinks the nasal mucosa, and thus increases the size of nasal airway passages resulting in better visualization and more space for airway instrumentation [13]. Epinephrine 1:200,000 added to lidocaine is the most used drug which reduces bleeding as well as prolongs the duration of action of lidocaine [14]. Caution should be exercised in patients with hypertension, coronary artery disease, and cerebrovascular disease. Cara et al. demonstrated that analgesic efficacy was better with the combination of lidocaine 5% with phenylephrine 0.5% compared to cocaine for nasotracheal intubation [10, 15]. Oxymetazoline (0.05%), 4 drops in each nostril or phenylephrine 0.5–1% spray is quite effective and is commonly used [14].

Sedatives, when judiciously used during airway anesthesia, enhance patient comfort. Major challenge is ensuring a patent airway and maintaining spontaneous ventilation by avoiding excessive sedation. Ideal sedative agent should provide anxiolysis, amnesia, analgesia, suppression of gag and cough reflex, easy to titrate, minimal cardiorespiratory effects, and above all safe on the patient [16]. Oversedation is a dangerous complication, which may precipitate airway obstruction, and hence a balanced use of sedative drugs is necessary to prevent the crisis of worsening difficult airway scenario. Sedation should never be used as a substitute for inadequate topical airway anesthesia [17]. In the NAP4 report Cook emphasized the presence of a second anesthesiologist to titrate and monitor the effects of potential side effects caused by the sedative drugs [18].

Anxiolytic agent, diazepam was used initially in combination with opioids, which was gradually replaced with midazolam. Sidhu et al. used 5 mg of midazolam, premedicated with intramuscular morphine and topicalization with “spray as you go” (SAYGO) technique for awake tracheal intubation and concluded that high dose of midazolam does not compensate for inadequate topicalization or analgesia and could result in respiratory compromise [19]. However, midazolam produces sedation, amnesia and can help prevent seizure activity in the event of local anesthetic toxicity [5].

Opioids are administered for sedation and blunting of airway reflexes. They also have antitussive effects. Lack of anxiolytic and amnesic properties of opioids may require addition of titrated doses of anxiolytics such as midazolam in selected patients. It is essential to prevent potentially dangerous synergistic effects of excessive sedation at lower-than-expected doses. Caution should also be exercised with high doses of opioids due to the potential for upper airway collapse and apnea [20]. Fentanyl with its relative hemodynamic stability, low cost, and familiarity to most anesthesiologists, is frequently used. Remifentanil has the unique advantage of an ultrashort acting drug, can be given as bolus, bolus followed by infusions, set rate of infusions, and as target controlled infusion (TCI). It is easily titratable, provides profound analgesia, suppresses airway reflexes, and has minimal effect on cognitive function [21]. Remifentanil used as a primary agent or in conjunction with midazolam is considered safer for co-administration as both the drugs can be reversed [3].

Dexmedetomidine is a highly selective alpha 2 agonist and has the advantage of providing sedation (but easily arousable), hemodynamic stability, anxiolysis, and analgesia. The respiratory benefits include minimal respiratory depression even at higher doses and decreased salivary secretions [22]. Numerous studies have been done to study the efficacy of dexmedetomidine as a sedative agent and they concluded that it was a safe drug which provided optimal conditions for awake fiberoptic intubation [23, 24]. Bradycardia and hypotension are some of the potential problems with dexmedetomidine and can be seriously detrimental to patients with cardiac disease [12].

Anesthetic agents are also used for conscious sedation and they supplement the psychological support. Anxiolytics and analgesics used as adjuncts to local anesthetic prevent adverse cardiorespiratory events [16]. Depending on the clinical demand and urgency of the situation the sedative agents should be chosen based on their significant action, optimizing the safety of the procedure and the patient outcome. It is important to avoid over sedation as it may cause the patient to lose protective airway reflexes, obstruction of the airway, regurgitation of gastric contents or unable to cooperate for the procedure [12]. However, care should be executed when sedation is administered in a known case of obstructed airway [25]. Propofol has the advantage of blunting neurally mediated airway reflexes and bronchodilation. It can be administered as intermittent boluses (0.5–1 mg/kg) or as an infusion at the rate of 1 mg/kg/h [26]. Both techniques have been shown to be safe and well tolerated by patients. TCI of propofol in combination with fentanyl, remifentanil, and dexmedetomidine and topicalization using SAYGO technique have been extensively studied in various trials [24, 27]. The dose range for infusion was not clearly defined, but the risk of oversedation was increased when effect site concentration was higher than 3–3.5μg/mL. They also concluded that propofol sedation is inadequate for awake airway manipulation if laryngeal topicalization is not used. Concomitant use of opioids such as fentanyl, remifentanil, and benzodiazepines along with propofol will improve the TCI efficacy and also minimizes the side effects [28]. Propofol requires careful titration to avoid airway obstruction and loss of verbal communication with the patient because of its narrow window between sedation and general anesthesia. Ketamine can provide analgesia and sedation for awake intubation. Unlike opioids, ketamine does not cause significant impact on the respiratory drive and there is preservation of upper airway patency and muscular coordination [29]. The undesirable effects of ketamine that hinders awake airway management includes increased secretions in the airway, nausea, cardio stimulation, and drug induced delirium [30]. Sinha et al. combined low dose ketamine (20 mg/h) with dexmedetomidine (bolus dose of 1 μg/kg over 10 min followed by 0.5 μg/kg/h of infusion) and concluded that sedation quality and intubating conditions were better with the combination and hemodynamic stability was achieved by counteracting the effects of each of these drugs [31].

Emergency drugs—adrenaline, atropine, and lipid emulsion must be readily available for use in case of emergency.

4 Equipment

4.1 Drug Delivery Devices

1. Short-beveled needles of 22-gauge to 25-gauge sizes, 25-gauge spinal needle
2. 2, 5, and 10 mL syringe
3. Nebulizer or atomizer
4. Tongue depressor
5. Right-angled forceps
6. Oxygen source and face mask or cannula
7. Suction catheter and apparatus

4.2 Monitors

Routine monitoring devices such as pulse oximeter, non-invasive blood pressure apparatus, and electrocardiogram.

4.3 Yankauer Suction Device

This rigid and hollow suction tip made of steel or plastic helps to clear secretions or blood without damaging the surrounding delicate laryngeal tissue.

4.4 Airway cart

1. Oropharyngeal and nasopharyngeal airways
2. Self-inflating bag with reservoir bag and oxygen tubing
3. Endotracheal tubes of various sizes
4. Laryngeal mask airways (including LMA-Classic, Intubating-LMA, and ProSeal-LMA)
5. Different types of laryngoscope blades/handles
6. Lighted stylet, rigid/flexible fiberoptic laryngoscopes, malleable stylets, tube exchangers
7. Surgical airway kit*This list is by no means exhaustive, as individual centers and anesthesiologist can and will add airway equipment of their choice to the cart.*

5 Preparation of the Patient

5.1 General Preparation

A detailed preoperative anesthetic evaluation of the patient is necessary prior to administration of airway anesthesia. Appropriate laboratory results must be reconfirmed, and intravenous access has to be obtained prior to any intervention. If any pharmacological preparation must be done in the pre-induction room, presence of an intravenous access, Indian Society of Anesthesiologists (ISA) recommended monitors and resuscitation equipment is essential [32]. Supplemental oxygen is administered at 3–5 L/min using Hudson mask.

5.2 Psychological Preparation

Proper patient counseling regarding the procedure, its advantages, associated adverse reactions of the drugs and complications should be explained to the patient in a language that is best understood by the patient and informed written consent has to be obtained [5]. Reassurance and explanation of the procedure makes the patient more cooperative and conduct of procedure pleasant and successful. Communication with the patient throughout the procedure is of vital importance.

6 Various Methods of Providing Airway Anesthesia

The main aim of providing airway anesthesia is to inhibit the otherwise protective reflexes (Table 24.3) of the airway. The stimulation of these reflexes during awake airway management can cause multiple systemic and local side effects which could be life threatening. Various methods of providing local anesthesia into the airway include topicalization of the airway by non-invasive techniques and injection techniques of blocking the nerves as given in Table 24.4.

Topicalization is the simplest, non-invasive, and safest method for anesthetizing the airway. This technique lessens the hemodynamic response to instrumentation, acts as a supplement to sedation and analgesia, reduces coughing and bucking response, and decreases the occurrence of laryngospasm during extubation [33]. Topicalization of the airway is the spreading of local anesthetic over a region of mucosa to facilitate local anesthetic uptake and neural blockade of that particular area. The various methods of topicalization of the airway are mentioned in Table 24.5 and each technique will be discussed later. However, no

Table 24.3 Airway reflexes

Reflexes	Nerves involved and blocked
Gag reflex	Glossopharyngeal nerve
Glottic closure reflex	Superior laryngeal nerve
Cough reflex	Recurrent laryngeal nerve

Table 24.4 Various methods of airway anesthesia

Spraying techniques (provides 10–15 min of effective topicalization)	Direct application	Regional blocks
Nebulization	Pledgets, swab sticks	Glossopharyngeal block
Atomization	Gargling	Superior laryngeal block
	Transtracheal injection	
	Spray as you go	

sufficient evidence exists to suggest individual technique like mucosal atomization, spray-as-you-go or nebulization is superior when compared with each other [17]. Wilson and Smith have suggested that topical airway anesthesia is safe during awake videolaryngoscopy and in patients with cardiovascular disease, adequate topicalization of the airway will prevent the hemodynamic variations associated with general anesthesia [34].

There is no single nerve that can be blocked to produce complete anesthesia of the airway. Invasive techniques like the superior laryngeal nerve and glossopharyngeal nerve blocks are associated with higher risk of local anesthetic systemic toxicity (LAST) and patient discomfort [35, 36]. The combination of nerve blocks, application of local anesthetic drugs and atomization techniques as given in Table 24.4 is effective in providing sufficient degree of airway anesthesia.

Table 24.5 Topicalization techniques

Different techniques of topicalization
1. Cotton pledgets applicator/ribbon gauze soaked in local anesthetic solution
2. Mucosal atomization device (MAD)
3. McKenzie technique
4. Nebulization of local anesthetic drug
5. Local anesthetic spray
6. Drummond's toothpaste method
7. Pacey's paste
8. Gargling of local anesthetic drug
9. Serial insertion of nasopharyngeal airways
10. SAYGO technique

1. Application of cotton swabs or pledgets [37] soaked in the anesthetic solution (lidocaine 4% with epinephrine 1:200,000 or a 3:1 mixture of lidocaine 4% and phenylephrine 1% in the nares) [2] over the nasal mucosa bilaterally provides adequate anesthesia of the nasal cavity. When nasal intubation is the choice, one cotton pledget is placed at a 45° angle to the hard palate to anesthetize the sphenopalatine ganglion [11]. Another pledget is placed along the superior turbinate, resting against the cribriform plate and posterior nasopharyngeal wall, to anesthetize the anterior ethmoidal nerve and branches of the sphenopalatine ganglion [2, 38]. The pledgets are left in place for 5 min. Additionally, nasal airways in increasing sizes lubricated with lidocaine 2% jelly are passed into the nostril being intubated for additional anesthesia and to check the patency of the nostril [39]. A 32 F nasopharyngeal airway inserted into the nostril allows for easy passage of 7.0 mm cuffed ETT. The various requirements for application of anesthetic drug soaked pledgets are as shown in Fig. 24.2.

Fig. 24.2 Nasal pledgets and cotton applicators

2. Atomization—local anesthetic (1–2 mL of 2% lidocaine) is dispersed via an atomizer device into a fine mist and directly sprayed into each nostril. Mucosal atomizer device (MADgic) is a malleable atomizer (shown in Fig. 24.3) which provides a combination of direct application and nebulized delivery of the drug coordinated with patients deep inspiratory efforts [33]. Atomized droplets are smaller than nebulized droplets; with better penetration into mucosa [8]. They provide 10–15 min of effective topicalization. However, the lack of control over drug delivery is a major disadvantage with this technique.
3. Mackenzie technique—20-gauge intravenous cannula is connected to an oxygen source via three ways stopcock extension, and oxygen flow is set to 2–4 L/min. As the local anesthetic is slowly administered via a 5 mL syringe attached to the port of the three ways stop-cock as shown in Fig. 24.4, a jet like spray effect is seen, which greatly increases the surface area of topicalization [40, 41].
4. Nebulization of lidocaine 4% [42] via facemask or oral nebulizer as shown in Fig. 24.4 for 15–30 min can achieve highly effective anesthesia of the nasal cavity and trachea for intubation [2]. The patient has to be instructed to breathe through the nose with a facemask. Shallow breaths are advised to topicalize the proximal airway and slow deep breaths for distal airway anesthesia. This process may need repeating to ensure adequate anesthesia. The disadvantages of this technique are that

Fig. 24.3 Atomization devices

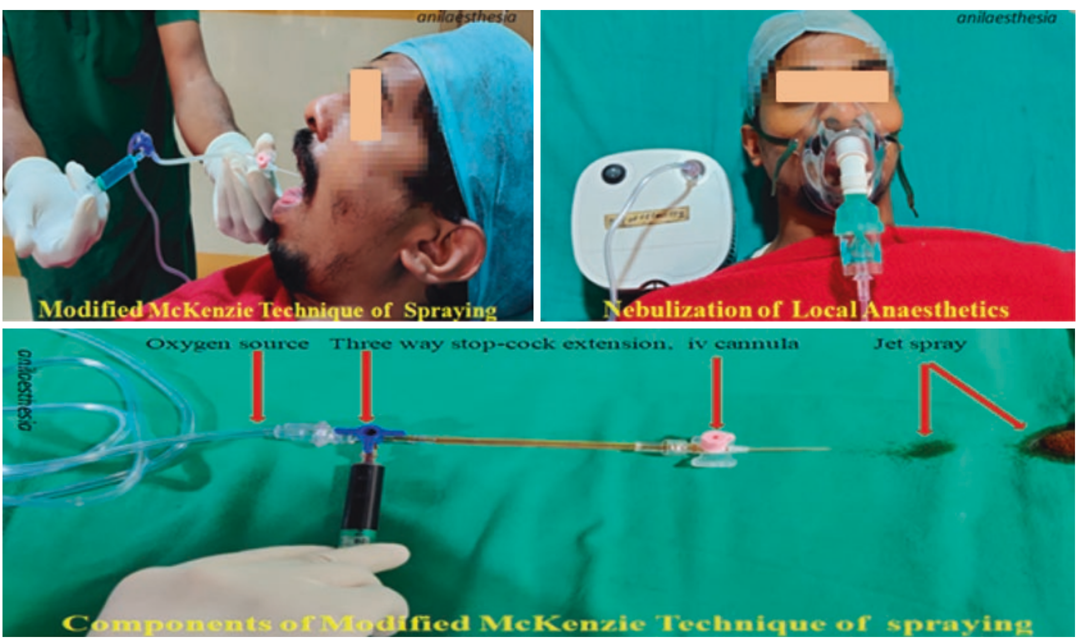

Fig. 24.4 MacKenzie technique and nebulization of anesthetic drugs

the block may be uneven and less dense and may occasionally cause central nervous system depression. The larger size of the drug limits the spread to the distal part of the trachea [20] Additionally, the technique requires the patient to inhale deeply which may not be conducive to all patients.

5. Local anesthetic can be sprayed directly onto the nasal mucosa using a 10 mL syringe filled with lidocaine 2–4% and sprayed via a small-bore single or multi perforated catheter or the working channel of the fiberoptic bronchoscope, approximately about 1 mL per nostril [2].
6. Serial insertion of larger nasopharyngeal airways coated with lidocaine 2% gel anesthetizes, lubricates, and ensures nasal patency [42].
7. Gargling of 4 mL of 4% lidocaine or 2% viscous lidocaine by the patient for 30 s followed by deep inspiration is beneficial. Repeat this cycle for a period of 4 min and expectorate the remaining solution. This targets the glossopharyngeal nerve and is extremely useful in suppressing the gag reflex. Gargling often does not cover the larynx or trachea adequately [39].
8. Drummond's toothpaste method—Topical anesthesia can also be carried out using 3–4 mL of 5% lidocaine ointment placed on the end of a tongue depressor blade, instructing the patient to place the blade as far posteriorly in the mouth as possible. Patient should then gently bite on the blade and avoid sucking, letting the paste liquefy on airway structures for about 10 min [43].
9. "Pacey's Paste"—A 50:50 mixture of 2% lidocaine solution with 2% lidocaine jelly is filled in a syringe with the use of a three-way stopcock. The resulting mixture which is a sticky, viscous fluid is dribbled onto the back of the tongue [44].
10. SAYGO technique—The vocal cords can also be topicalized with a local anesthetic using the spray-as-you-go (SAYGO) technique. Here, the distal end of a 16-gauge epidural catheter, cut up to 3 cm is fed through the working channel of a bronchoscope. That tip of the catheter should be just visible in the distal part of the bronchoscope and the proximal end is attached to a 5 mL syringe with 4% lidocaine. Placing the bronchoscope along with the catheter in front of glottis, the local anesthetic is then sprayed onto the vocal cords and the bronchoscope is advanced in the airway after a gap of 30–60 s after spraying [5]. This technique can be used to anesthetize the postnasal space, posterior pharyngeal wall and epiglottis. Alternatively, local anesthetic can be directly injected through the working channel of scope without epidural catheter, by aiming the tip of the scope at the structure to be blocked.

The nerves blocked during airway anesthesia are glossopharyngeal nerve, superior laryngeal nerve, and recurrent laryngeal nerve. The glossopharyngeal and superior laryngeal can be blocked by direct application of anesthetic soaked pledgets or by injection technique, either by intraoral or extraoral approach. The recurrent laryngeal nerve is blocked by translaryngeal/transtracheal deposition of the drug.

11. Glossopharyngeal nerve block

    Drugs—2% lidocaine 5 mL

    Approach—intraoral or extraoral (peri styloid)

    Area anesthetized—posterior third of the tongue, vallecula, anterior surface of the epiglottis, and oropharynx (wall of the pharynx and the tonsils) [45]. This block abolishes the gag reflex, but is insufficient to provide complete airway anesthesia.

    Gargling of 2% lidocaine will anesthetize most of the area supplied by the glossopharyngeal nerve [11].

    Intraoral approach

    Position—sitting or supine with mouth open

    Technique—After adequate topical anesthesia of tongue and oral cavity, introduce the tongue blade with the non-dominant hand. Identify the posterior tonsillar pillar, and displace the tongue medially creating a gutter between the tongue and the teeth. A 25-gauge spinal needle is inserted into the mucus membrane near the floor of the mouth at the caudal aspect of the posterior tonsillar pillar where it crosses the palatoglossal arch. After negative aspiration for blood and air, 2–4 mL of 1% lidocaine is injected [39]. Alternatively, the block can be achieved using direct mucosal application via pledgets soaked with local anesthetic (4% lidocaine) [46], or even by spraying topical anesthetic onto the above-mentioned region.

Extraoral approach (peri styloid approach)

Position—supine position with head in neutral position

Technique–Identify the styloid process at the midpoint of a line drawn from angle of the mandible to the tip of the mastoid process. Locate it with deep pressure; insert the block needle perpendicular to the skin, directing at the styloid process. After locating the styloid process at the depth of 1–2 cm deep, redirect the needle posteriorly to walk off the styloid process, inject 5 mL of 2% lidocaine after negative aspiration, and repeat the block on other side [45].

> If blood is aspirated redirect the needle more medially, if air is aspirated needle has passed through and through the mucosal membrane.

12. Superior laryngeal nerve (SLN) block

    Drugs—2% lidocaine—6 mL

    Approach—internal and external approach

    Position—supine with neck extension

    Area anesthetized—mucosa above the vocal cords (including secretomotor innervations), tongue base, the posterior surface of the epiglottis, the aryepiglottic folds, and the arytenoids [45]

    External approach

    Technique—The greater cornua of the hyoid bone is palpated transversally with the thumb and the index finger on the side of the neck. Displace the hyoid bone towards the side to be blocked as shown in Fig. 24.5. A 25 mm, 25 gauge needle is walked off the greater cornua of the hyoid bone inferiorly and after confirming negative aspiration for blood and air, 2 mL of the drug is injected. Additional 1 mL is injected as the needle is withdrawn. Repeat the block on the other side [46]. If it is difficult to identify the hyoid bone, first locate the thyroid notch, which is the most prominent structure in the midline, trace the superior edge of the thyroid cartilage posteriorly until the superior horn is palpated as a round structure. The needle is directed towards the superior horn of the thyroid cartilage and then redirected upwards where the greater cornu of the hyoid bone is situated [42].

> Caution: Do not insert needle into the thyroid cartilage, since injection at the level of cords may cause laryngeal edema and airway obstruction. If air is aspirated, suspect breach in the laryngeal mucosa and immediately withdraw the needle. If blood is aspirated, redirect the needle anteriorly.

Fig. 24.5 Superior laryngeal nerve block

Internal approach

The block can be achieved by direct mucosal application of pledgets soaked with the local anesthetic (2–4% lidocaine) solution for 5–10 min using Kraus or Jackson forceps, [11] or even by spraying topical anesthetic drug onto the pyriform fossa. This is performed only when the external approach is not feasible or has failed.

13. Transtracheal block

Drugs—4 mL of 4% lidocaine

Nerves blocked—recurrent laryngeal nerve

Position—supine with extended neck

Area anesthetized—vocal cords and trachea below the level of vocal cords

Relative contraindications for this procedure are difficult anatomy in patients with scars, tumors, inflammation, injuries in the neck, history of surgery or radiotherapy in the neck, limited neck extension, large neck circumference [46].

Stabilize the larynx by placing the thumb and third finger of the non-dominant hand on either side of the thyroid cartilage. Identify the midline to palpate for the cricothyroid membrane. The landmark of the translaryngeal approach is as shown in Fig. 24.6. A 5 mL syringe containing 4 mL of 4% lidocaine mounted on a 20- or 22-gauge intravenous catheter or needle is introduced into the trachea through the cricothyroid membrane [39]. Sudden loss of resistance and aspiration of air confirms the correct placement of the catheter, and the rigid stylet is removed. At the end of the expiratory effort, 4 mL of local anesthetic solution is rapidly injected into the trachea.

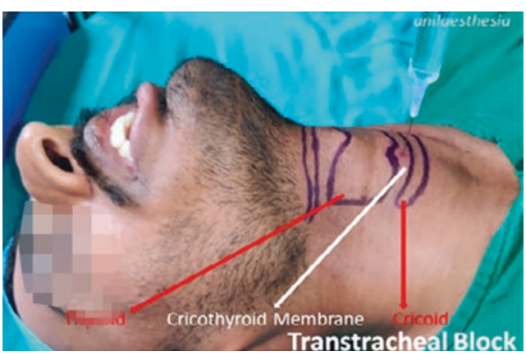

Fig. 24.6 Transtracheal approach

Direct recurrent laryngeal nerve blocks can result in bilateral vocal cord paralysis and airway obstruction [2], as both the motor and the sensory fibers run together. Therefore, this nerve is blocked using the transtracheal approach.

Direct recurrent laryngeal nerve blocks can result in bilateral vocal cord paralysis and airway obstruction [2], as both the motor and the sensory fibers run together. Therefore, this nerve is blocked using the transtracheal approach.

- Tip: If a cannula is used, it can be left in place so that injections may be repeated if needed. It can also be used for rescue oxygenation [46] and can provide a conduit for the passage of a guide wire facilitating Seldinger tracheostomy in cases of failed intubation or airway obstruction. Injection at the end of expiration will cause patient to first inhale and then forcefully cough, spreading the lidocaine over the trachea and above the cords, making distal airway anesthesia more predictable.
- Caution: Prior to the procedure, inform the patient about the likelihood of coughing after the injection. Patient should not talk, swallow, or cough DURING the injection.

7 Anesthesia of Nasal Cavity and Nasopharynx

The nerves that need to be blocked for nasal anesthesia are anterior ethmoidal nerve, greater and lesser palatine nerves, maxillary branch of trigeminal nerve (sphenopalatine ganglion). Drugs used are 10% lidocaine spray, 4% lidocaine, lidocaine with adrenaline, 2% lidocaine jelly, and 0.05% phenylephrine. Patient is placed in 45^0 propped up position. One or a combination of the following techniques can be used for effective anesthesia of the nasal airway:

1. Local application of anesthetic soaked cotton pledgets
2. Atomization
3. Mackenzie technique
4. Nebulization of local anesthetic drugs
5. Local anesthetic spray
6. Serial insertion of nasopharyngeal airways.

Successful block is indicated by patient's tolerance to nasopharyngeal airways placed 1–2 min before attempt of intubation [47]. Complications include epistaxis and loss of laryngeal reflex by posteriorly trickled anesthetic solution.

> Asking the patient to sniff while spraying the nasopharynx can aid in the distribution of local anesthetic drug.

8 Anesthesia of Mouth, Oropharynx, and Base of the Tongue

The nerves that are required to be blocked in the oral cavity are lingual, pharyngeal, tonsillar branch of glossopharyngeal nerve, and superior laryngeal nerve. The local anesthetic drugs needed are 10% lidocaine spray, 4% lidocaine solution, 2% viscous lidocaine or 2% gel. Patient is placed in sitting position. Both invasive and non-invasive techniques and their combinations have to be adopted to achieve successful oral anesthesia which include:

1. Gargling.
2. Nebulization is an excellent technique allowing the topicalization of patients with limited mouth opening. In resource poor settings it can be used as a sole technique to provide adequate anesthesia.
3. Atomization allows for effective topicalization of the tongue and posterior pharynx with an atomizer.
4. Drummond's toothpaste method helps in anesthetizing the base of the tongue.
5. Lidocaine spray 10% can be sprayed on the posterior third of the tongue and posterior pharyngeal wall after depressing the tongue with a tongue depressor. One puff of spray delivers about 10 mg of lidocaine [11]. Alternatively, 4% lidocaine taken in a 10 mL syringe can be sprayed directly through a small, bored needle.
6. Pacey's paste, the viscous fluid is dribbled into the base of the tongue.
7. Simple 2% lidocaine gel can be placed on a tongue blade and the patient is advised sucks on it for several minutes. Typically, peak onset of action is within 15 min.
8. Non-invasive and invasive needle-based techniques to block the glossopharyngeal and superior laryngeal nerve.

Block is effective when laryngoscopy or intubation attempts are well tolerated.

9 Anesthesia of the Hypopharynx, Larynx, and Trachea

The combination of non-invasive and invasive techniques is imperative to block the larynx, vocal cords, and the subglottic region. This includes:

1. Superior laryngeal nerve block
2. Recurrent laryngeal nerve block by the transtracheal approach
3. Atomization with 2 mL of 4 or 2% lidocaine sprayed into the larynx and trachea using MADgic laryngo-tracheal mucosal atomizer under laryngoscopic guidance.
4. Nebulization of local anesthetics is not as effective as airway blocks in providing better quality of lower airway anesthesia as assessed by patient recall of procedure, coughing/gagging episodes, ease of intubation, vocal cord visibility, and time taken to intubate [48].
5. SAYGO technique.

   Block assessment is evaluated by blunting of airway reflexes such as coughing, gagging, diminished pain, and cardiovascular responses to instrumentation of the airway.

10 Recent Developments

10.1 Airway Anesthesia During COVID-19

Topicalization of the airway in times of COVID-19 infection is undertaken with all precautions to minimize aerozolization. Hence, Phipps et al. used a combination of Pacey's paste to be applied on the posterior tongue, lidocaine 10% spray on the oropharynx, lidocaine 4%-via a mucosal atomizer device, and superior laryngeal nerve block with 4% lidocaine-soaked gauze [49].

10.2 Use of Ultrasound in Airway Anesthesia

With the use of ultrasonography (USG), airway anesthesia has gained new momentum making it more reliable and safer especially when anatomic landmarks are difficult to identify [50]. Superior laryngeal nerve block and transtracheal block can be performed with USG.

10.2.1 Ultrasound Guided Superior Laryngeal Nerve Block

High frequency linear probe must be used. The structures to be identified are hyoid bone, thyroid cartilage, greater cornua of hyoid, thyrohyoid membrane, superior laryngeal artery, and superior laryngeal nerve. Place the probe transversely in the upper part of the neck; identify the hyoid bone, which appears as a hyperechoic, bright, curved structure in the midline (Fig. 24.8). If the probe is moved laterally, the greater cornua of the hyoid bone can be seen as a bright structure medial to the superior laryngeal artery. The internal branch of the superior laryngeal nerve runs along with the superior laryngeal artery just below the level of the greater cornu of the hyoid bone. Using an in-plane technique, a needle is passed aiming just below the greater cornu of the hyoid bone. 1–2 mL of local anesthetic is injected after negative aspiration [51, 52].

10.2.2 Ultrasound Guided Transtracheal Nerve Block

High frequency linear probe is used with the depth of 2 cm. Structures to be identified are the tracheal rings, cricoid cartilage, thyroid cartilage, and cricothyroid membrane. Difficulty is observed in patients with previous neck radiation, neck obesity, enlarged thyroid gland, and lateral tracheal displacements [12] Place the probe in the midline, longitudinally in the lower part of the neck to identify tracheal rings as shown in Fig. 24.7. Delineate the cricothyroid membrane between the lower border of the thyroid and the upper border of the cricoid cartilage as shown in Fig. 24.8. Mark the location of the cricothyroid membrane on the skin using a marker pen. Transtracheal injection is performed at the marked site [42].

The block can also be performed by direct vision of the needle using the ultrasound. Keeping the cricoid cartilage in view and simply tilting the probe from the midline to a parasagittal position, the needle entry point should be just cranial to the cricoid cartilage and seen on the ultrasound monitor [42].

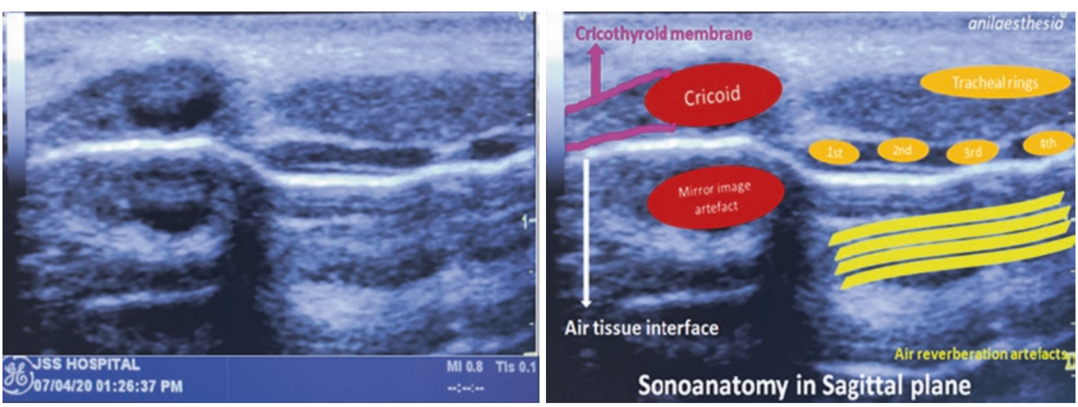

Fig. 24.7 Probe position for translaryngeal block

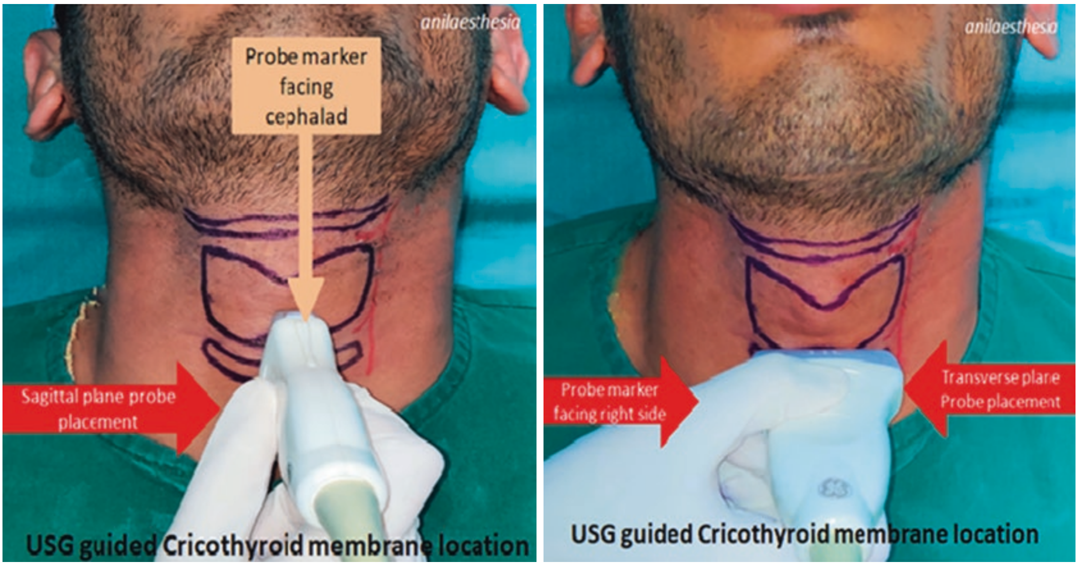

Fig. 24.8 Sonoanatomy of cricothyroid membrane

11 Complications of Airway Anesthesia

1. Local anesthetic systemic toxicity (LAST): Anesthetic drugs applied topically can enter the circulation more rapidly than when injected into the tissues, and can be absorbed from the respiratory and gastrointestinal tracts. Local anesthetics must be carefully measured with a syringe to monitor the dosages the patient is receiving. Consider dilute concentrations when using sprays or other such preparations. Also, intravascular injection due to the proximity to the internal carotid artery (during intraoral approach of glossopharyngeal nerve) and internal jugular vein (during peri styloid approach of glossopharyngeal nerve) can occur.
2. Hematoma formation can result from a puncture during needle placement for injection or damage to vascular structures. Maintain pressure long enough to prevent hematoma or continued bleeding.
3. Airway obstruction has been reported in several cases of local anesthetic administration [53, 54]. Peristyloid approach is associated with an increased risk of upper airway obstruction, related to the concomitant block of the hypoglossal nerve and the vagal nerve proximal to the origin of the recurrent laryngeal nerve [45]. Airway collapse can occur after topical airway anesthesia due to loss of muscle tone and reflexes causing reduction in dynamic air flow [55]. On the contrary, inadequate airway anesthesia can precipitate laryngospasm or acute airway obstruction during airway manipulation [56].
4. Hoarseness and swallowing difficulty in bilateral peri styloid blocks present a logical and unacceptable risk due to its proximity to the vagal nerve [45].
5. Risk of coughing is more during transtracheal block, which should be considered in patients for whom coughing is undesirable or contraindicated in cases like unstable cervical spine and ischemic heart disease.
6. Structural injuries of the surrounding structures, including the posterior tracheal wall and vocal cords can be damaged, especially if the needle is not stabilized during injection of the local anesthetic or not removed immediately. Hyoid bone fracture can occur during superior laryngeal nerve block [2].
7. Aspiration is a possibility which can happen due to oversedation and because of the loss of protective airway reflexes commonly observed in emergency situations [2].

8. Vagal responses like bradycardia and hypotension can occur, especially in young anxious patients.
9. Subcutaneous emphysema following translaryngeal injections [46] due to a rent in the laryngeal wall and seepage of air into the subcutaneous planes can occur.
10. Nerve damage due to direct injection into the nerve fibers can be a possibility.
11. Methemoglobinemia is a complication seen with the use of benzocaine.

Author's Techniques for Airway Anesthesia

- Two sprays of oxymetazoline/xylometazoline into each nostril.
- Nose and nasopharynx—packing of nostrils with ribbon gauze soaked in homemade solution of lidocaine 4% (120 mg) plus 1:100,000 adrenaline 3 mL
- Oropharynx and tongue—gargling 4 mL of 2% viscous lidocaine for 4 min and expectorating the remaining solution (80–60 = 20 mg)
- Bilateral superior laryngeal block using 6 mL of 1% lidocaine (60 mg)
- Translaryngeal injection—2 mL of 4% lidocaine (80 mg).

Currently available data does not allow for a conclusion on the ideal method for local airway of anesthesia. Knowledge about the different methods, advantages, and disadvantages can be weighed and the anesthesiologist should find the right way to anesthetize the airway according to the individual situation.

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