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REVIEW ARTICLE

Rapid airway access

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Resumo

Objective: To review the steps involved in safe airway management in critically ill children.

Sources of data: Review of articles selected through Medline until April 2003 using the following key words: intubation, children, sedation.

Summary of the findings: Airway compromise is rare, but whenever it occurs, the situation depends on professionals trained to carry out safe, early, and rapid airway management, with no harm to the patient. The method currently advocated for airway management is rapid sequence intubation, which requires preparation, sedation and neuromuscular block. We observed that it is not possible to apply one single intubation protocol to all cases, since the selection of the most adequate procedure depends on indication and patient conditions. We defined the drug doses most commonly used in our setting, since little is know so far about the real effect of sedatives and analgesics. In most situations, the association of an opioid (fentanyl at 5-10 µg/kg) with a sedative (midazolam at 0.5 mg/kg) and a neuromuscular blocking agent are sufficient for tracheal intubation.

Conclusions: Training, knowledge, and skill in airway management are of fundamental importance for pediatric intensive caregivers and are vital for the adequate treatment of critically ill children. We present an objective and dynamic text aimed at offering a theoretical basis for the generation of new protocols, to be implemented according to the strengths and difficulties of each service.

J Pediatr (Rio J) 2003;79(Suppl 2):S127-S38: Intubation, airway obstruction, sedatives, narcotics.

Introduction

When evaluating a child in any emergency situation airway management is a priority and tracheal intubation is the definitive action for a safe airway. Intubation is a critical stage since it should be completed quickly and safely in patients with limited cardiocirculatory, pulmonary or cerebral reserves.[1] Securing the airway in an emergency can represent the difference between a satisfactory outcome and permanent sequelae or death, for which reason it should be performed by adequately trained professionals.[2]

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Among the indications for endotracheal intubation, in addition to apnea and hypoventilation are respiratory or cardiovascular insufficiency with the need for positive pressure, post-op after major surgery, thoracic alterations, upper airway obstruction and $paCO_2$ control.[3-5]

When intubation is indicated we must be conscious of the fact that occasionally we will be confronted by an airway which is difficult to secure, defined by the American Society of Anesthesiologists as a delay of more than 10 minutes for endotracheal tube insertion and/or when three or more attempts are made by an experienced anesthetist. Others define endotracheal intubation difficulties as the failure to achieve perfect laryngoscopy.[6]

Depending on the patient's indications and clinical condition, recognition of a difficult airway, the experience of the professional and the availability of material, there are a number of different techniques which are options for obtaining an airway. As this is an extreme situation it is recommended that each hospital develops its own protocol, including alternatives for securing an airway in the event of an intubation failure.

Three techniques for achieving an airway in emergency situations are recognized: intubation without medication; sedation without neuromuscular blockade and; rapid sequence intubation.

Intubation without medication is a method that is only acceptable with unconscious patients, as is the case with cardiorespiratory arrest. In any other situation the procedure must be performed with the aid of relaxants and sedatives.

Sedation without neuromuscular blockade can be used in some situations: a) when it is recognized that the airway is difficult and airway patency depends on the tone of the upper airway muscles, or the specific position. As examples of this situation the following can be cited: abscess of the upper airway, airway obstruction, micrognathia and facial burns, among others. Paralysis in these cases can lead to loss of the ability to maintain the airway pervious. b) when there is sufficient muscle relaxation, whether due to central involvement (coma from any etiology) or to peripheral alterations (Guillain Barre syndrome for example). Despite the existence of conflicting data in literature it is not uncommon for intubation to be performed without neuromuscular blockade in ICU environments, motivated for other reasons.

We believe that this practice occurs as a result of: a) a better pharmacological understanding of sedative drugs, which has enabled greater sedation and muscle relaxation even in the absence of neuromuscular blocking agent. The recommended doses of midazolam (0.1 to 0.5 mg/kg) fentanyl (1 to 5 µg/kg) ketamine (1 to 4 mg/kg), thiopental (1-5 mg/kg) have been easily surpassed[2,7,8]; b) that patients in an ICU environment frequently have sensory alterations or compromise (sepsis, asphyxia, etc.) and, consequentially reduced muscular tone.

Intubation with sedatives but without paralysis has been defended as a safe alternative (it maintains spontaneous breathing), but it can cause delayed intubation leading to greater risks,[2,3] since, in order to produce suitable intubation condition, the quantity of sedative employed generally exceeds the dose which would preserve the respiratory trigger, frequently leading to apnea. Higher doses of sedatives produce more hemodynamic side effects and have unpredictable pharmacological activity times. Once more we question the pharmacological understanding of such drugs, a fact which interferes with the construction of rigid tracheal intubation protocols. Studies comparing RSI and intubation with sedation, but without muscle relaxants demonstrate that RSI is a safer technique with fewer complications.[2,7-10]

In a multi-center observational study Sagarin et al. found that of 156 pediatric intubations, 81% were rapid sequence intubations, 13% were without medication and 6% used sedation without neuromuscular blockade.[11] These results are surprising since they are not the same as those found at our service (work in progress at two pediatric ICUs in Porto Alegre, shows a predominance of sedation without neuromuscular blocking agent).

Below we will describe the approach to critical patient airway management known as rapid sequence intubation.

Rapid sequence intubation

Rapid sequence intubation (RSI) is the performance of intubation with anesthetics and neuromuscular blockade, with the objective of making the procedure quicker, easier and less traumatic.[2,7-9]

Patients that are candidates for RSI are all those who require intubation and have either full or partial consciousness, with any suspicion of a full stomach, convulsions, intracranial hypertension, pharmaceutical intoxication or trauma.[7]

The basic procedures of rapid sequence intubation can be remembered by the "6 Ps": Preparation, Preoxygenation, Pre-medication; Paralysis; Positioning (introduction) of the endotracheal tube and; Post-intubation. (Figure 1).[2,4,7,8,12]

Preparation

In patients with a potential for increased ICP, RSI minimizes the increases caused by laryngoscopy or coughing during endotracheal intubation.[4,7-9] Patients with respiratory dysfunctions (asthma, pneumonia and congestive cardiac insufficiency), with exogenous intoxication, with reduced airway protection reflexes and altered mental states, are rapidly intubated with few complications, with RSI.[7] Airway management of trauma victims is also facilitated by RSI.[9,13]

Rapid sequence intubation is also important in airway control with agitated patients that require profound sedation before treatment and diagnostic evaluation. Uncooperative

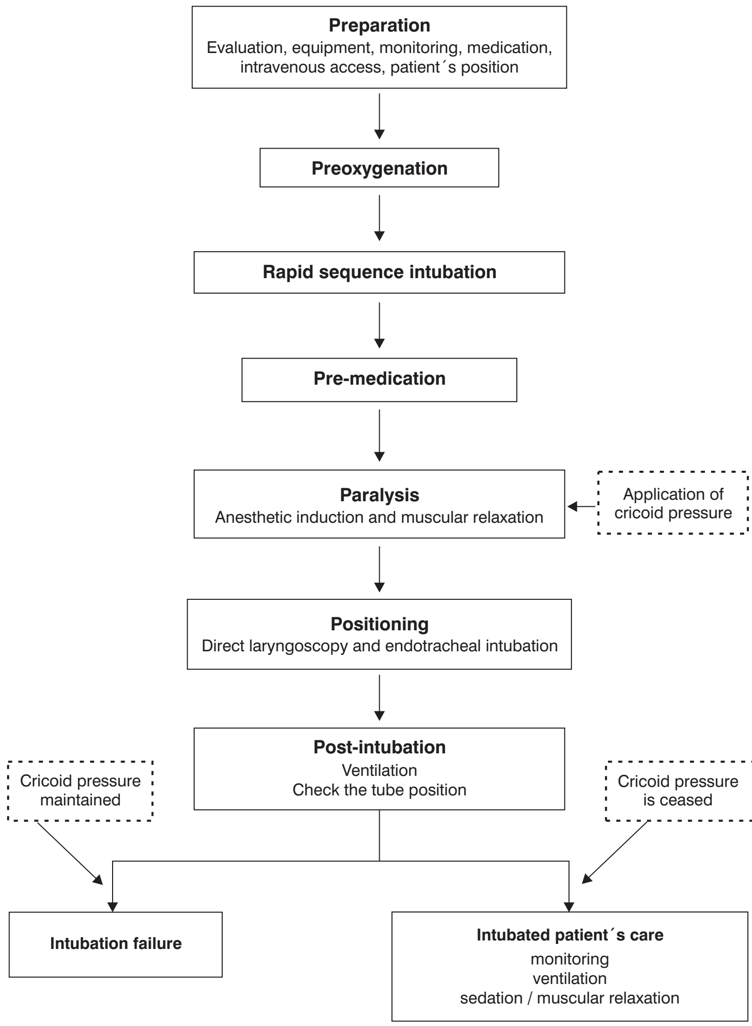

Figure 1 - Protocol of rapid sequence intubation
Adapted from McAllisten JD, Gnauck KA[2]

and agitated patients may be hypoxemic, hypoperfused, have metabolic disturbances or expansive lesions of the central nervous system.[7,8]

The use of RSI with patients who have spontaneous breathing in imminent danger of respiratory insufficiency allows an airway to be assured while the patient still has physiological reserves and can better tolerate the period of apnea while the endotracheal tube passes.[7]

Even in an urgent situation, rapid, directed anamnesis can be performed (history of allergy, use of medication, previous medical history particularly neuromuscular diseases and most recent meals). It is essential to evaluate the oral cavity, the size of the tongue, extension and flexibility of the neck and the distance between the mandible and the hyoid bone.[6,7,14,15]

In order to predict intubation difficulty, Mallampati created a point scale based on the ability to view the soft palate, the pillars and the uvula when the patient opens their mouth. In contrast, Cormack and Lehane, based their scale on the degree of difficulty in visualizing the glottis during laryngoscopy[5,6,14,15] (Figure 2). In laryngoscopy the mandibular space is limited by the arch of the mandible. When the mandibular space is large, greater compression of the tongue is possible with the laryngoscope blade, and consequentially a good view is obtained of the anterior larynx.[6,14]

Depending upon age, different techniques are used to align the oral, pharyngeal, and laryngeal axes. Smaller children have proportionally larger skulls in relation to body size and need a pillow under the subscapular region;

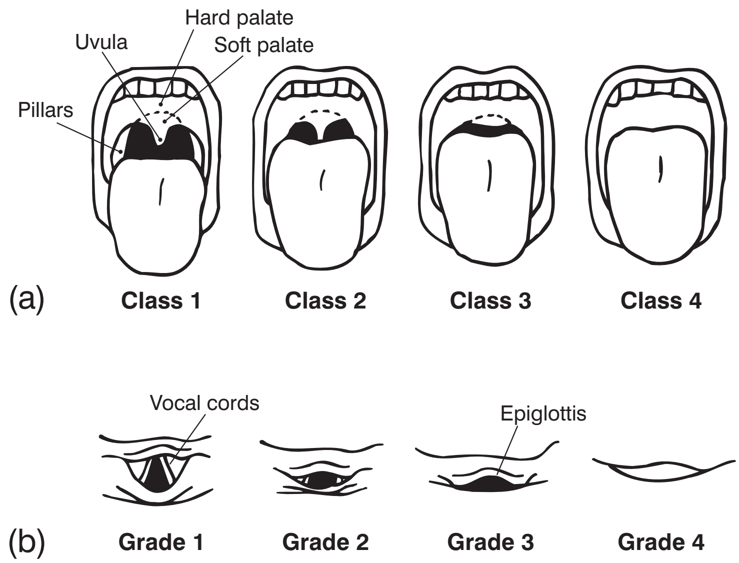

Figure 2 - **a)** Mallampati classification modified by Samsoon and Young: Class 1 - visualization of the soft palate, Class 2 - complete visualization of uvula, Class 3 - visualization of the base of the uvula, Class 4 - soft palate is not visible at all; **b)** Laryngoscopy according to the classification of Cormack and Lehane: Grade I - most of the glottis visible, Grade II - only the posterior extremity of the glottis visible, Grade IV - not even the epiglottis visible[6]

while larger children require the pillow in the occipital area, for better alignment of the three axes and visualization of the airway through the laryngoscope.[3,5,14]

Unstable and critically ill patients have a greater risk of gastric aspiration during intubation, since gastric drainage may be retarded by the disease or due to medication.[9,14] The presence of gastrointestinal bleeding, enteral nutrition probes or recently ingested food, may increase gastric volume and the chance of aspiration.[14] Infants and small children arte the most susceptible, due to increased air deglutition while crying, because of their diaphragmatic breathing and because they have a short esophagus.[9] Patients at risk of pre-intubation aspiration should receive treatment to reduce gastric volume and to neutralize gastric secretions, if time permits. The use of rapid sequence intubation can prevent passive reflux of gastric content to the pharynx.[9,14]

Equipment and medication

The material needed for intubation should be prepared and organized in advance.[6,7] Rapid sequence intubation should only be begun when all the equipment is available and functioning correctly (suction, oxygen, laryngoscope, endotracheal tube, stylets and bag-valve mask, duly prepared medication, heart monitor, oxygen saturation monitor, blood pressure monitor and expired CO_2 monitor and also equipment for alternative airway access in case of intubation failure: laryngeal mask, transtracheal jet ventilation and cricothyrotomy equipment).[2,7-9]

Endotracheal tubes without balloons are recommended for children less than eight years old, since by between 8 and 9 years of age, the airway is similar to that of an adult except for size. The limiting factor to endotracheal tube insertion with children is the funnel shape that the airway assumes created by the stricture at the level of the cricoid cartilage. The use of tubes without balloons reduces the risk of complications related to permeability of the airway, such as edema and subglottic stenosis.[3,8,15-19]

A variety of different formulas exist for selecting the most suitable tube for endotracheal intubation in children. One alternative for choosing the appropriate tube for pediatric patients (above 2 years) is based on internal diameter, which can be estimated by the formula: *tube diameter = age (years)/4 +4.* Tubes should be kept available one size above and one size below that estimated by calculation since the final choice of tube will be made at the point of laryngoscopy. Consulting tables can also facilitate our choice of endotracheal tube (Table 1).[8,9,17] Another practical, quick and simple method of selecting the endotracheal tube is by comparing the middle phalanx of the fifth finger with the internal diameter of the tube.[17]

The correct distance (depth) in centimeters for tube insertion can be obtained for children older than two by adding twelve to half the patient's age: *age (years)/2 +12*. Another method for estimating insertion depth (in centimeters) can be calculated by multiplying the internal diameter by three.[5,17]

There are two types of laryngoscope blades available for pediatric patients: the straight blade (Miller) and the curved slide (Macintosh). Straight slides are used with pediatric patients, primarily those less than three years old, because of the more forward and cephalic position of the larynx. Curved slides are used with larger children and adults because their bases are wider making it easier to maneuver the tongue and view the vocal chords (positioned behind the epiglottis).[2,5,17,18]

Table 1 - Guide for selecting the internal diameter of endotracheal tube, suction cannula and laryngoscope blade in infants and children

Age group	Internal diameter of endotracheal tube	Suction cannula	Laryngoscope blade
Preterm	2.5-3.0	4-5 fr	0
Newborm	3.0	6 fr	0
1-6 months	3.5	6	0
6-12 months	3.5-4.0	6	1
12-24 months	4.0-4.5	8	1-2
3-4 years	4.5-5.0	10	2
5-6 years	5.0-5.5	10	2
7-8 years	5.5-6.0	10	2-3
9-10 years	6.0-6.5	10	3
11-12 years	6.5-7.0	10	3

One aid in difficult intubations is to use a metallic guide, a flexible, but rigid stylet which can be inserted into the endotracheal tube before intubation to give the tube the desired configuration. In order to avoid trauma during the intubation, the point of the stylet must not pass the distal portion of the endotracheal tube and should be positioned one centimeter from the distal extremity of the tracheal cannula. Even with this precaution there is a greater risk of trauma (bleeding, laceration), and stylets should be used with caution.[5,9,17]

Ventilation and oxygenation can be maintained safely and effectively by means of self inflating (AMBU) bag equipped with a reservoir bag and connected to an oxygen supply (15 l/min flow rate).[2,5,9,17,18]

It is generally necessary to suction secretions such as blood or vomit from the oropharynx, nasopharynx or trachea in order to be able to view the airway. Vacuum suction systems or portable aspiration apparatus may be used. Flexible suction catheters are useful to remove the final secretions from the mouth nasopharynx and trachea. Thick, rigid suction cannulae are more efficient for aspiration of the pharynx and are useful to remove thick secretions and for particles. For suction, flexible aspiration probes are preferable, sizes no. 4 to 10. The suction pressure should be effective and should not cause damage to the mucosa, being no greater than 120 mmHg with infants and children. Aspiration should not last longer than 5 seconds and should be pre-oxygenated at 100% in order to reduce hypoxemia. Heart rate and saturation should be monitored during aspiration.[2,9,17]

Monitoring

Ideally every serious child case should have heart monitoring, pulse oximetry and arterial pressure readings before and during RSI, however in emergency situation the procedure should not be delayed for lack of electronic monitoring. There should be great vigilance for tachycardia since this is the first manifestation of hypoxemia and hypoxia, while bradycardia is a later sign demanding immediate measures aimed at improving oxygenation (e.g.: suspend laryngoscopy and restart ventilation with bag and oxygen).[2,7,8,21]

Pre-oxygenation

Preoxygenation aims at increasing hemoglobin oxygen saturation and is performed with an oxygen supply at 100% with a mask and with the patient breathing spontaneously for a period of three minutes. Preoxygenation causes nitrogen to be eliminated, creating an oxygen reserve in the lungs. This reserve permits 3 to 4 of apnea, eliminating the need for positive pressure ventilation, associated with an increased risk of aspiration before endotracheal intubation.[2,7-9,15]

If spontaneous respiration is inadequate or apnea occurs, the patient should be preoxygenated manually using positive pressure ventilation for 1 to 2 minutes. This procedure can lead to gastric distension and should only be performed in conjunction with cricoid pressure (Sellick's maneuver)[2,7-9,15] (Figure 3).

Pre-medication

The laryngoscopy and endotracheal tube can trigger a variety of physiological responses. Coughing and the vomit reflex may lead to tachycardia, systemic arterial hypertension, tissue hypoxia and increased intracranial and intraocular pressure. Certain drugs administered before the procedure can reduce these effects.[7,8,15] Here we will follow the LOAD mnemonic (Lidocaine, Opioid, Atropine and Defasiculation drug).[1]

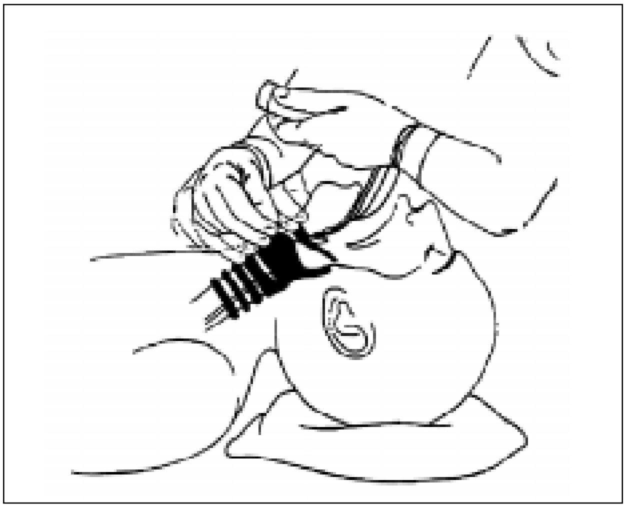

Figure 3 - Oral endotracheal intubation with a curved blade[6]

Lidocaine attenuates adrenergic responses during laryngoscopy and endotracheal tube insertion. Intravenous lidocaine reduces hypertension and tachycardia and also reduces the increase of intracranial and intraocular pressure associated with intubation. The recommended dose for lidocaine is from 1.5 to 3 mg/kg IV 2 to 5 minutes before laryngoscopy. Maximum effect is achieved at between 3 and 5 minutes after the intravenous injection.[2,7-9] Lidocaine also has a topical anesthetic effect which can help to reduce the reactions to intubation. There is conflicting data on whether the use of intratracheal lidocaine is effective in reducing reactions to the passage of the endotracheal tube. Notwithstanding, the introduction of this substance to the trachea can produce foreign-body type reactions.[2,7,8] An alternative would be to use nebulization with lidocaine, although this has not been definitively proven.[7]

The use of opioids is useful for conscious sedation of patients with spontaneous breathing. They promote sedation and analgesia, producing apnea only at high doses. During RSI they not only provide analgesia and sedation but also hemodynamic stabilization in the presence or absence of harmful stimulants.[7] Fentanyl is a reversible short action synthetic opioid analgesic and is useful for sedation in RSI. It provides rapid analgesia and unconsciousness at intravenous dosages of 5-10 µg/kg, with an effect duration of 30 minutes. It blocks the adrenergic sympathomimetic responses during intubation and has a minimal effect on the cardiovascular system. Newborns and infants appear to be more sensitive to this drug and smaller doses should be used with these patients and administration should be slow, particularly when the dose is above 5 µg/kg. There are descriptions of variable effects on intracranial pressure and cerebral blood flow.[2,7,8,12]

In children the vagal response is more pronounced than in adults and may be caused by hypoxia, the laryngoscopy or succinylcholine. These responses can be minimized by pre-treatment with Atropine. Atropine also reduces the production of secretions within the airway allowing a good view during intubation.[7-9] Atropine is indicated for children younger than one year old (provided they have not had tachycardia), for children between 1 and 5 years old who are on succinylcholine, adolescents and adults who receive a second dose of succinylcholine, and for patients with bradycardia before intubation. The dose for Atropine is 0.02 mg/kg (maximum 1mg, minimum initial dose 0.1mg) 1 to 2 minutes before intubation.[2,3,7-9]

Succinylcholine is a myorelaxant often used for RSI, which produces muscle fasciculations and neuromuscular paralysis. In order to prevent fasciculation, which can cause increased intracranial pressure, employ 10% of the normal dose of a nondepolarizing muscle relaxant, such as pancuronium (0.01 mg/kg), rocuronium (0.01 mg/kg) or vecuronium (0.01 mg/kg), administrated 1 to 3 minutes before the paralyzing succinylcholine dose.[7,22] The administration of defasciculating drugs is recommended for patients with an increased risk of presenting fasciculations (e.g.: children over five).[2,7-9]

Cricoid pressure (Sellick's maneuver)

The Sellick maneuver or rearward dislocation of the larynx is produced by continuous pressure on the cricoid cartilage. This pressure performs a dual function, first the movement backwards of the larynx allows visualization of the vocal chords and eases the passage of the endotracheal tube, and, second, this pressure obstructs the esophagus (an effect which has not been sufficiently demonstrated), preventing reflux of the contents of the stomach to the oropharynx. Theoretically, the occlusion of the esophagus would reduce the entry of air into the stomach, reducing gastric distension and allowing more air to enter the larynx and lungs during positive pressure ventilation, however, passive regurgitation and aspiration may occur.[2,7,8]

Other drugs that are useful in pre-medication

Rapid sequence intubation presupposes the use of sufficient sedation to eliminate the sensation of paralysis and reduce sympathetic tone. Sedatives should be administered a few minutes before the paralytic agent. The ideal sedative is one that will rapidly induce unconsciousness, has a short duration and minimum side effects. The selection of sedative should be performed for each patient taking into account associated morbidity (hypovolemia, hypotension, or intracranial hypertension), age and co-existing conditions.[5,7,15]

Midazolam, a rapid-acting benzodiazepines has a potent amnestic(anterograde) property. When compared with other sedatives used for RSI, it has a relatively late start of activity. The sedative effect is related to the dosage (0.3 to 0.5 mg/kg), the speed of infusion, the presence of other sedative drugs and age. Midazolam has a moderate effect on cerebral blood flow.[7,9,23] Despite being well known it is frequently used in subdoses (average 0.08 mg/kg $\pm$ 0.04) according to Sagarin et al.[24] We have used midazolam for sedation because of its sedative and amnestic properties. However, for conscious patients it is suggested that a more potent sedative be used in association (fentanyl, ketamine or thiopental).

Thiopental is a short duration barbiturate, with rapid onset and which reduces intracranial pressure and metabolic oxygen demand, producing an effect that is protective of the central nervous system (important with patients with cranial-encephalic trauma, convulsive states and meningitis). It has the disadvantage of inducing hypotension by vasodilation and myocardial depression. These effects depend on dose and speed of infusion and can be divided (1 to 3 mg/kg) and used in a slow infusion. For conscious patients, the total dose oscillates between 2 and 5 mg/kg. In the presence of hypotension, hypovolemia or suspected shock, thiopental should be avoided or used at reduced dosages.[7,9,12]

Ketamine, a derivative of phencyclidine, is a dissociative anesthetic, characterized by rapid sedation, amnesia, analgesia, the maintenance of reflexes and cardiorespiratory stability. The dose is 2-4 mg/kg IV and 5-10 mg/kg intramuscular. It improves ventilation and reduces bronchospasm in patients with severe asthma, probably by catecholamine liberation. It can cause myocardial depression in patients with chronic diseases with catecholamine depletion. It is relatively contraindicated in patients with hypertension, cerebral lesions, psychiatric problems or glaucoma. It produces excessive secretions in the airways and should be used with an atropine pre-treatment.[1,2,7-9]

Propofol is an anesthetic inductor and a sedative, highly lipophilic, which is rapidly distributed throughout the brain, has rapid onset and short duration (10-15 minutes) and is a good option for patients subjected to RSI. Propofol reduces intracranial pressure and cerebral metabolism. In common with thiopental, it significantly reduces average arterial pressure. When inducing anesthesia in conscious patients with a view to intubation, the dose is between 1.5 and 3.5 mg/kg, and is recommended for children over 3 years old.[7,8]

Etomidate is a short-acting nonbarbiturate hypnotic sedative. The dose is 0.2-0.4 mg/kg. It causes less cardiovascular depression than barbiturates or propofol. There are few studies to demonstrate its efficacy and effectiveness for endotracheal intubation and it has been approved for children over ten years old. As with other inductive agents, etomidate reduces intracranial pressure, and diminishes cerebral blood flow and cerebral metabolism. It has a minimal effect on arterial pressure and there are studies which demonstrate a transitory suppression of cortisol and aldosterone synthesis.[1,2,7,8]

As we can see, there is no ideal sedative that is applicable in all RSI situations and drugs must be selected case by case. After intubation, long-acting sedatives should be chosen (bolus of lorazepam, diazepam and phenobarbital may be used).[2,7]

Paralysis: muscle relaxants

Muscular paralysis generally allows easier intubation and ventilation. The ideal paralytic agent should have a fast onset, short duration and minimum side effects and be reversible; unfortunately none of the available relaxants satisfy all of these criteria. They can be divided into two categories: depolarizing and nondepolarizing.[2,7,8]

Depolarizing relaxants, represented by succinylcholine, connect to post-synaptic receptors, resulting in depolarization, leading to period of repeated excitation, resulting in transitory muscle fasciculations. These are followed by neuromuscular transmission blockade and flaccid paralysis.[2,3] Clinically succinylcholine produces fasciculations with asynchronous contractions of the muscle fibers which cease with the onset of paralysis. Hyperkalemia and increased intracranial pressure are two side effects secondary to the increase in muscular activity. The increase in potassium is generally negligible except in children with pre-existing renal conditions.[2,7-9] Bradycardia can also be caused by succinylcholine and is preventable with atropine and should be taken into account for all children under five years old.[2,7,8]

Succinylcholine, the preferred muscle relaxant for rapid sequence intubation, has an extremely quick onset (paralysis in less than 1 minute) and a duration of 5 to 10 minutes. The dose is between 1 and 2 mg/kg/dose.[1,2,4,20]

Malignant hyperthermia is a potentially fatal metabolic reaction that has been described with the use of succinylcholine and other anesthetic agents. Characterized by an increase in temperature to above 43° C, disseminated intravascular coagulation, metabolic acidosis, rhabdomyolysis and other physiological problems related to the heat. Therapy is based on aggressive heat-reducing therapies and dantrolene. It is important to check the temperatures of children undergoing RSI approximately 10 minutes after the administration of succinylcholine.[2,7,9]

Nondepolarizing neuromuscular blocking agents compete with acetylcholine for the post-synaptic receptors, but without activating them and so without inducing fasciculations. They generally have a slower onset and a longer duration of effect than succinylcholine. We would highlight three nondepolarizing neuromuscular blocking agents for use in intubation: rocuronium, atracurium and vecuronium.[2,7,8]

Rocuronium, an intermediate duration relaxant, is as effective as succinylcholine and should be used when the latter is contraindicated. It provokes muscle relaxation in 30-45 seconds at a dosage of 0.6-1.2 mg/kg intravenously (it can also be used intramuscularly), however it has a duration of 30 to 45 minutes (longer in patients under 10 months). It can cause tachycardia and, is antagonized by neostigmine and atropine.[1,2,7,9,25]

Atracurium is also an intermediate duration neuromuscular blocking agent with the advantage that the neuromuscular blockade is not prolonged by large or repeated doses, however atracurium is associated with histamine liberation. The dose is 0.4-0.6 mg/kg.[7,8,20]

Vecuronium has also come to be used as an alternative to succinylcholine for RSI, since it presents minimum cardiovascular effects and does not cause histamine liberation. The dose is 0.15-0.2 mg/kg, onset is at 30-90 s, however duration is 90-120 minutes. It had been considered efficacious and without side effects for pediatric patients. Recent studies have demonstrated an association between the use of vecuronium and myopathy in sever cases where children receive high doses of steroids, but the mechanism has not yet been explained. It should be used with caution with children who have been treated with steroids.[2,7-9]

Pancuronium is a muscle relaxant which presents a long duration (around an hour) and is often used in pediatric intensive care, especially for maintenance during mechanical ventilation, during transportation and while examinations are performed[20]. It will not be discussed at present as it is rarely used during rapid intubation.

Table 2 lists the most commonly used drugs at our service for the intubation of children in the pediatric ICU and emergency.

Intubation techniques

The oral endotracheal route is the most rapidly achieved route and the one that requires the least experience,[17] however the choice of the route to be used (nasotracheal or oral endotracheal) is usually individual to the treating doctor. Despite the preference for oral endotracheal intubation recommended by Pediatric Advanced Life Support[18] there is no evidence in literature to demonstrate the superiority of one route over another, which would definitively support its choice. Therefore a trained intensive care/emergency service professional should have the knowledge and practical experience necessary to realize both techniques allowing the choice of which to use to be determined by individual circumstances.

Oral endotracheal route (Figure 3)

- The appropriate material is selected based on the anatomical characteristics and primary condition of the patient.
- Appropriate positioning (alignment of the oral, pharyngeal, and laryngeal axes).
- Preoxygenation at 100% (3-5 minutes).
- Administration of sedatives/muscle relaxants.
- Opening of the oral cavity and introduction of the laryngoscope on the right-hand side of the mouth.
- Tongue moved to left.

Table 2 - Drugs used at our services for the intubation of children in the pediatric ICU and emergency

Drugs	Dose	Comments
Pre-medication		
Lidocaine	1.5 mg/kg IV	CET, acute asthma
Fentanyl	5 - 10 µg/kg IV	CET
Atropine	0.02 mg/kg IV	Prevents bradycardia
Defasciculating drugs (Pan/Vecuronium)	0.01 mg/kg IV	↓ 5 years/20 kg: never ↑ 5 years/20 kg: CET
Inductive agents		
Midazolam	0.3 - 0.5 mg/kg IV	Hypotension: ↓ dose
Thiopental	3 - 5 mg/kg IV	↓ Perfusion: do not use or ↓ dose: 1 mg/kg IV
Ketamine	1 - 4 mg/kg IV or 4 mg/kg IM	Acute asthma
Propofol	2-3 mg/kg	> 3 years
Paralytic agent		
Succinylcholine	2 mg/kg IV	Pre-treatment with Atropine

CET: cranial-encephalic trauma /IV: intravenous; IM: intramuscular

- If a straight blade is used: after introduction remove slowly until the vocal chords are visible (elevate the epiglottis with the blade).
- If a curved blade is used: gradual introduction until the epiglottis is visible and the slide is inserted into the vallecula (traction the epiglottis with blade).
- Smooth pressure at the cricoid level may be necessary (Sellick's maneuver) to facilitate visibility and reduce the risk of aspiration.
- It is important to maintain traction along the length of the laryngoscope body (without moving the hand and support on the upper lip).
- Insertion of the tube to the right of the blade (without obstructing the blade's concavity).
- Appropriate positioning.
- Fixing.

Complications: more difficult to fix (accidental extubation), more difficulty with the oropharynx secretion towel, obstruction of ventilation by dental occlusion.

Contraindications: occlusion of the temporomandibular joint, obstructive processes within oral cavity

Nasotracheal

- The appropriate material is selected based on the anatomical characteristics and primary condition of the patient.
- Appropriate positioning.
- Towel and nasal suction.
- Preoxygenation at 100% (3-5 minutes).
- Administration of sedatives/muscle relaxants.
- Lubrication of tube.
- Pass through the nostril to the rear pharynx.
- Opening of the oral cavity and introduction of the laryngoscope on the right-hand side of the mouth.
- Tongue moved to left.
- If a straight blade is used: after introduction remove slowly until the vocal chords are visible (elevate the epiglottis with the blade).
- If a curved blade is used: gradual introduction until the epiglottis is visible and the slide is inserted into the vallecula (traction the epiglottis with blade).
- Smooth pressure at the cricoid level may be necessary (Sellick's maneuver) to facilitate visibility and reduce the risk of aspiration.
- With the laryngoscope in position and the larynx visible, the tip of the tube at the pharynx is guided with the aid of Magill forceps.
- Insertion can be facilitated by an assistant via the nostril.
- Appropriate positioning of the cannula.
- Fixing.
- Certain variations in technique can be employed, using prior oral endotracheal intubation to secure the airway with a subsequent change of cannula as soon as the tube inserted nasally is visualized at the rear pharynx.

Complications: epistaxis, necrosis of the nostrils, acute otitis media, sinusitis.

Contraindications: cribiform plate fracture, coagulation disorders, obstruction of the passage of the tube by nasal deformity of compression.

Post-intubation: confirmation of tracheal intubation

A clear view of the tube passing the larynx is the best way to confirm intubation. Care should be taken when moving the cervical region after intubation, since the tube can be dislocated in just 2.5 cm.[2]

After intubation, the location of the endotracheal tube should be confirmed by physical examination (symmetrical expansion and thoracic auscultation at the midaxillary line), pulse oximetry and $ETCO_2$ monitoring. Continuous capnometry is sensible and gives an early warning of accidental extubation and can also be used to measure cardiac output and predict the return of spontaneous circulation. In many cases $ETCO_2$ has a correlation with $PaCO_2$ making serial gasometric analysis unnecessary.[2,14,21] Final confirmation is provided by chest X-ray.[2,16]

Special intubation techniques

There are other tracheal intubation techniques, such as intubation with optical fibers, intubation guided by a light source, retrograde intubation, etc, however we will draw attention to two of them for their applicability at emergency and pediatric intensive care units.

Laryngeal mask

This consists of a silicon plastic tube connected at a thirty-degree angle to an oval-shaped mask with an inflatable rubber cuff (Figure 4).[2,8,26,27] After fitting, the mask is inflated using a pilot balloon providing a seal above the laryngeal opening. The oval mask will lodge with its distal extremity blocking covering the superior esophageal sphincter, the dorsal in contact with the posterior wall of the hypopharynx, the sides in contact with the pyriform fossa and the upper edge against the tongue.[2,8,18,26,28,29] It therefore forms a chamber with the mask as its ceiling and the only exit the laryngeal orifice.

It is indicated in situations when the airway is difficult, whether previously known or not (it is an indispensable piece of equipment in any emergency room), for cardiorespiratory arrest when attended by health workers without intubation skills,[17] for surgical procedures such as on the oral cavity, diagnostic imaging procedures and fibrobronchoscopy. It is used in ICUs for temporary airway control until a secure route is obtained. Recent studies have demonstrated that, with trained personnel, its fitting may be quicker than the laryngoscopy tube.[6,9,14,26,29] This technique should be taught as part of medical emergency training.[5,6,8,27]

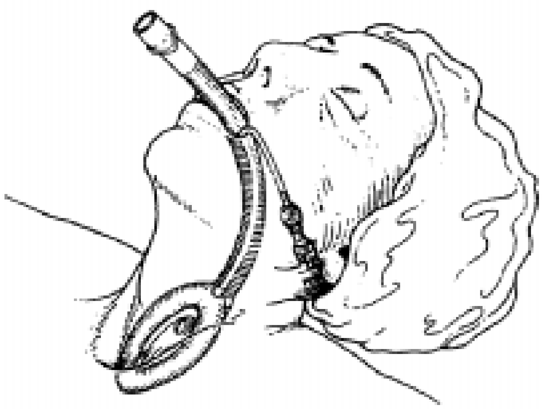

Figure 4 - Laryngeal mask

The laryngeal mask can be fitted having previously given induction agents such as midazolam, fentanyl, propofol and thiopental.[27] The mask should be completely deflated before fitting and lubricant only applied to the rear of the mask because of the risk of inhalation causing airway obstruction or coughing. The patient should be placed in the "sniffing position", and should be maintained in this position at the moment of inserting the mask. The mandible is tractioned downwards and the mask is introduced to the oral cavity until it meets the hard palate using the index finger of the right hand. The mask should be guided around the curvature of the rear pharynx and within the hypopharynx, maintaining pressure upwards until the characteristic resistance is felt at the end of the mask corresponding to the superior esophageal sphincter. The cuff is inflated with an appropriate volume of air depending upon size (Table 3). With the cuff inflated, the mask can advance beyond the limit of the mouth by about 1 cm. The black line which runs the length of the tube should be aligned with the middle of the upper lip and the space between the two central incisors.[2,8,28,30,31]

The most common reasons for insertion to be difficult are: insufficient anesthesia, inadequate muscular relaxation (pharyngeal muscle spasms or laryngeal spasms), failure to obtain sufficient neck flexibility or an incorrect choice of mask size. A bite protector is usually employed to avoid damage to equipment or obstruction of the airway.[8,26,28,29]

It is contraindicated primarily for patients with a high risk of aspiration (after manual ventilation, digestive hemorrhage, obesity) and also when high inspiratory pressure is necessary.[18,27,29]

Complications are rare (0.15% in a series of 11,000 patients), and include gastric aspiration, local irritation, trauma to upper airway structures and broncho-constriction.[27]

Transtracheal jet ventilation

This consists of puncturing the cricothyroid membrane and inserting a large caliber venous catheter in the direction

Table 3 - Description of different sizes of laryngeal mask

Size	Weight (Kg)	Internal diameter (mm)	Lenght (cm)	Cuff volume (ml)	Biggest tracheal tube (mm)
1	< 6.5	5.25	10	2 to 5	3.5
2	6.5 to 20	7.0	11.5	7 to 10	4.5
2.5	20 to 30	8.4	12.5	14	5.0
3	30 to 60	10	19	15 to 20	6.0 (s/cuff)
4	60 to 80	12	19	25 to 30	6.5 (s/cuff)
5	> 80	14	19	30 to 40	7.0 (s/cuff)

of the trachea in order to allow oxygen to be supplied temporarily until a definitive airway is achieved[2,17,18] (Figure 5).

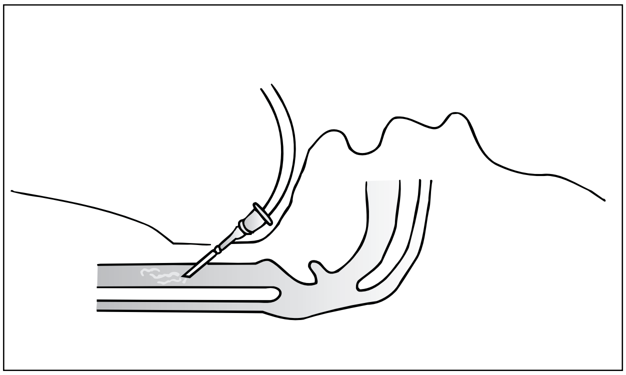

Figure 5 - Jet ventilation

This is also a technique which should be taught to doctors who work in emergency and pediatric ICUs, to be used when it is not possible to intubate or ventilate the patient. It can be performed more quickly than a tracheostomy, and generally provides adequate oxygenation and ventilation until a definitive airway can be established.[14,18]

A no. 14 or 16 abocath needle is inserted via the cricothyroid membrane and advanced to the trachea. Care should be taken when ventilation is performed at high pressure if the catheter is in an extratracheal location since a cervical subcutaneous can result, provoking distortion of the cervical anatomy. After passing and fixing the catheter it is connected to an oxygen supply and ventilation begun. Ventilation will be effective and oxygenation occur only if oxygen is supplied at high pressure. It can also be connected to an auto-inflating bag.[8,14] There are reports of 30% complications.[8,14]

Finally, we would like to point out that the airway can be maintained in the majority of cases with a valve-bag mask when conditions are adverse,[32] however in a hospital environment it is imperative that a conducive environment and a trained professional are available to make securing the airway the least traumatic and most effective possible.

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