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Original Article

Indian Journal of Trauma and Emergency Pediatrics
Volume 4 Number 4, October - December 2012

Rapid Sequence Intubation: Current Practices in the Pediatric Emergency Department of a Tertiary Care Pediatric Teaching Hospital

Mohnish Bolli M.B.B.S, D.C.H; Radhika Raman, DCH, DNB

Abstract

Advanced airway management in the pediatric emergency department is the first line of management in a critically ill child. Clinical condition of the patient, skills of ER (emergency room) personnel, influence outcome of this procedure. This prospective study describes the success rates, immediate complications and the environmental, patient and physician factors that influence complication rates of rapid sequence intubation (RSI) in the Pediatric Emergency Department of a tertiary care Pediatric Hospital, over a period of 1year, Of the 64 intubations, 39% were in infants, 43.7% had pre-existing illness, 28% required bag and mask ventilation for preoxygenation. Most common complication was right bronchus intubation. Majority were intubated at the first attempt. Success at first attempt, and complications correlated with the experience of doctors.

Conclusion: ER doctors are highly competent in performing RSI with acceptable complication rates. The need for using bag valve mask during RSI is not uncommon. Every paediatrician should be trained in RSI for securing the airway of a critically ill child.

Keywords: Rapid sequence intubation; Intubation; Bag valve mask.

Introduction

Airway compromise is the most common cause of death and severe morbidity in acutely ill and injured children. Pediatric emergency endotracheal intubation (ETI) is a lifesaving technique which all emergency physicians should be familiar with. Poor airway visualization, distorted anatomy, limited pre-treatment, gastric distension, or cardiovascular instability may make ETI difficult and hazardous. Adverse effects of the intubation procedure itself include increased intracranial pressure (ICP), airway trauma, pain, bradycardia, tachycardia, gastric regurgitation, aspiration, hypoxemia, arrhythmias, and death. These adverse effects can be circumvented with the use of the rapid sequence intubation (RSI) technique. RSI is the administration of a potent intravenous induction agent followed immediately by a rapidly acting neuromuscular blocking agent to induce unconsciousness and motor paralysis for tracheal intubation.[1,2] By providing unparalleled access to the airway, and superior protection against adverse effects such as aspiration, RSI is the fastest and safest way of securing a definitive airway.[1] Advanced airway management in the pediatric emergency department is the first line of management in a critically ill child. A number of factors such as clinical condition of the patient, skills of the ER personnel and the ER set up influence the execution and outcome of this procedure

Aims and Objectives

1. To describe the current practice of RSI in the Pediatric Emergency department of a tertiary care Pediatric Hospital.
2. To determine the success rates, to quantify the immediate complications of

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RSI and to assess the contribution made by environmental, patient and physician factors to the overall complication rates

Materials and Methods

Study design

Prospective Observational Study

Inclusion criteria

Patients aged 1 month to 18 years, undergoing Rapid sequence intubation in the ED of Kanchi Kamakoti CHILDS Trust Hospital, Chennai between August 2009 and August 2010.

Exclusion criteria

Age less than 31 days.

Intubated patients received in emergency room.

Methodology

All doctors who intubated patients in the ED were adequately trained to perform the procedure. Decision regarding necessity for intubation was taken by the doctor on duty in ED. For each intubation, the intubation team consisted of 3 doctors (one for each of the following - airway/cricoid pressure/monitoring) and 2 nurses (one for arranging instruments and administering drugs and the other for suctioning).

All equipment and medications for advanced airway management are available at all times in our emergency room. A standardized form was completed by the intubating doctor before and immediately after confirmation of intubation. Vitals such as heart rate, perfusion, blood pressure, respiratory rate and SpO2 were recorded just prior to administration of premedication and immediately (within 15 mins) post endotracheal intubation. Medications used, complications, attempts at intubation, pre-existing illness, designation of intubating person etc. were documented.

Cervical spine precautions were taken wherever indicated. An attempt at intubation was defined as placement of a laryngoscope into the patient's airway followed by the insertion of an endotracheal tube through the glottic opening. Failed attempt was defined as inability to pass the endotracheal tube through the vocal cords. Difficult intubation for this study was defined as either an intubation requiring more than two attempts or requiring help by intensivist or anaesthesiologists or the usage of alternative intubation techniques. The methods for confirmation of endotracheal intubation were direct visualization of an endotracheal tube passing through the vocal cords, five-point auscultation and X-ray chest post-intubation. Carbon dioxide detecting devices were not available during the study period.

Table 1: Conditions precipitating the need for RSI (diagnosis at admission)

Variables	No. of patients	%
A) Medical Causes		
1. Status epilepticus	12	18.75%
2. Acute CNS infection/ Encephalopathy	7	10.93%
3. Pneumonia/Bronchiolitis	12	18.75%
4. Status Asthmaticus	3	4.68%
5. Septic shock	6	9.37%
6. Dengue shock	10	15.62%
7. Cardiac failure	2	3.12%
8. Miscellaneous	6	9.37%
B) Trauma	3	4.68%
C) Poisoning	2	3.12%
D) Foreign body aspiration	1	1.56%

Results

Sixty four patients aged between 37 days to 15 years who had complete documentation of RSI as per our study protocol were our study group.

Baseline characteristics

More than 50 % (n=35) of intubations were performed after 4 pm. Male to female ratio was 1.2:1. Thirty nine percent (n=25) of RSI were performed in the patients in the age 1 month to 1 year. Twenty eight patients (43.7%) had pre-existing illness like cerebral palsy, asthma, congenital heart disease (VSD) congenital hydrocephalus and others. Most common indication for RSI was respiratory failure, low Glasgow Coma Scale (GCS), shock and upper airway obstruction in one patient (Table 1). Majority of the intubations were done by senior post-graduates (Table 2).

Outcomes

Eighty four percent (n=54) were successfully intubated in the first attempt, 12.5 % (n=8) and 3.1% (n=2) in the second and third attempts, respectively. There were no failed attempts of intubation. No patient required emergency cricothyrodotomy or nasopharyngeal intubation. Success rate for first attempt at intubation by consultant, PICU fellow and registrar was 100%, and a success rate of 81%, 93%, 73% and 70% for a third year post-graduate, second year post-graduate, first year post-graduate and senior house officer respectively. Complication rate and intubation mishaps were more common during intubations by a first year postgraduate and a senior house officer (Table 2). Twenty eight percent (n=18) required bag and mask ventilation to pre-oxygenate. Sellicks manouver was always used. The pre-medication, sedative, induction agent and the neuromuscular blocking agents most commonly used for RSI in this study were atropine (52/64), midazolam (49/64), fentanyl (51/64) and vecuronium (59/64). The mean time from the decision making to successful tracheal intubation was 20 minutes. Atropine/ midazolam/ fentanyl /vecuronium were the most common combination used. Facilitated RSI (RSI without the use of neuromuscular blocking agent) was used in 6.2 % (n=4) patients. Bradycardia was observed when atropine was not used as a premedication in 1.6% of patients. Hypoxia was observed in three with difficult intubation (Table 3). It was not determined if a particular medication contributed to a particular complication as a combi-

Table 3: Complications during RSI

Events	Number (%)
Bradycardia	1 (1.6)
Cardiac arrest	2 (3.1)
Hypotension	2 (3.1)
Hypoxia(Desaturation)	4 (6.3)
Pneumothorax	0
Dental and Oral Trauma	2 (3.1)
Vomiting& aspiration	0
Right Bronchus	5 (7.8)
Oesophageal intubation	2 (3.1)
None	52 (81.3)

Table 2: Complication rate and difficulties in RSI according to level of experience of intubating doctor

Intubating Doctor	Number of intubations (n=64)	Number of occasions requiring more than one attempt	Success rate for intubation in first attempt	Complications	Intubation mishaps
Registrar	5 (7.8%)	0	100%	0	0
3rd year PG	21 (32.8%)	4	81%	0	3
2nd year PG	13 (20.3%)	0	93%	2	1
1st year PG	11 (17.2%)	3	73%	3	2
SHO	10 (15.6%)	3	70%	2	1
PICU Fellow	3 (4.7%)	0	100%	1	0
Consultant	1(1.6%)	0	100%	0	0

SHO, Senior health officer; PG, Post-graduate

nation of medications were used. Nasogastric tube was inserted in majority of the patients prior to intubation. None of the patients developed vomiting and aspiration during the procedure.

Discussion

This prospective observational study describes the demographic profile of the patient, common indications, drugs used, skills of intubating doctors and complications of 64 intubations.'

There are no published studies available describing Pediatric ED intubation practices in India. The extensive studies on RSI in western countries on adults have compared skills of anaesthesiologists with the emergency physicians and the benefits of RSI with sedation-only or awake intubations. This study helps us get a better understanding of current practice of rapid sequence intubation in pediatric ED's in India.

Demographic profile

A significant proportion (50%, n=35) of RSI in our study were done after 4 pm as sick patients are referred from distant towns and neighbouring states to our tertiary care centre. Similar observations have been reported in an observational survey of RSI in the ED.[3]

Most of the intubations (40%, n=25) were required in patients aged 1 month to 1 year, probably due to the unique anatomical characteristics of the airway, thorax and musculature with added poor functional residual capacity in this age group.[2-5] Pediatric population forms only 4.4%-5.9% in studies on RSI and data on RSI in infants is not available.[3,4,5] In our study of the 64 patients intubated, 43.7 % (n=28) had pre-existing illness like cerebral palsy, asthma, congenital heart disease (VSD), Congenital hydrocephalus etc.

There was no correlation between pre-existing illness and occurrence of complications as concluded by other studies[5], though hypoxemia has been reported in patients with pre-existing respiratory or cardiovascular conditions.[6] The most common indication for RSI was respiratory failure 40.6 %(n=26), low GCS 32.4% (n=22) and shock 23.4 %(n=15). This observation can be attributed to the fact that poor respiratory reserves and anatomical characteristic contribute to respiratory failure as final common path way to a wide array of critical illness in children. Our results are similar to findings reported previously in which the common indications for intubation were shock and poor GCS.[3,5] The most common diagnosis in children requiring RSI in our ED were status epilepticus in 18.7 % (n=12), respiratory conditions such as pneumonia and bronciolitis in 18.7 % (n=12) and dengue shock in 15.6% (n=10)(Table 1), while encephalopathy, respiratory conditions and septic shock have been reported by others.[4,6]

Of the 64 intubations 84.37 %(n=54) were successful in first attempt, while 12.5 %(n=8) and 3.1 % (n=2) were successfully performed on the second and third attempts, respectively. There were no failed attempts of intubation. No patients required emergency cricothyrotomy or nasopharyngeal intubation. This was similar to other observations.[5,6] Failed attempts for intubation were noted in 0.9% of intubations by sagarin *et al.*[7] The mean time for successful tracheal intubation was 20 minutes as reported by J M Butler *et al.*[3] Dufor *et al*, observed that the median time for successful intubation was 12 minutes, much lesser in comparison to our study.[8] Four children (6%) had difficult airway, who were successfully intubated by ED consultant (1/4) and PICU fellows (3/4). All these patients were less than 1 year of age. Gencorelli FJ *et al*[9] reported difficult intubation in only 1.7% because all the intubation in this study was done by anaesthesiologists.

In our study, the success rate for intubation at the first attempt was 73%, 93%, 81% by postgraduates in their first, second and third year of postgraduate course and 100% by registrars who had completed their post-graduation almost similar to other results.[7]

Bag and mask ventilation was required to pre-oxygenate 28% (n=18) of patients, due to

apnoea or bradypnoea at admission and/or had difficulty in maintaining adequate saturation with 100% oxygen. In all patients the Sellicks manoeuvre was used. Nasogastric tube was inserted and gastric contents emptied in most of patients (except in trauma) after premedication and sedation, prior to intubation, and none of the patients developed vomiting or aspiration during the procedure. It also helped prevention of gastric distension in children who needed BVM ventilation. Atropine was the most common pre-treatment drug used, midazolam was the most common sedative, fentanyl was the most common analgesic agent used and vecuronium was the only neuromuscular blocking agent used. Similar to other observations,[10] however etomidate and propofol and succinylcholine were commonly used by others.[11,12]

Facilitated RSI (RSI without the use of neuromuscular blocking agent) was used in 4 patients (6%) who at admission were apnoeic or developed apnoea on giving induction agents and those with some underlying neuromuscular disorder. The complication rate noted in our study was (25%) which is higher in comparison to the observations of S M Fathil *et al* (15%) and the S. Trakulsrichai *et al* (11%).

The most common complication noted in our study was right bronchus intubation 7.8% (n=5) which contributed to an overall increase in the rate of complications and each patient could have had more than one complication. There was no association found between pre–existing illness and occurrence of complications. Hypoxemia and oesophageal intubation were commonly reported by others, the next common being hypotension.[13]

Limitations of our study

More number of cohorts and longer duration of study would have helped validate our conclusions. Duration of complications which would probably influence outcome like hypoxemia, hypotension etc. were not recorded. There was no blinding of data. It could not be ascertained if medications contributed to the complications as the procedure itself could contribute to complications like desaturation and bradycardia. Using other medications recommended in RSI, like morphine, etomidate, thiopentone and succinylcholine would probably have influenced our results in many ways.

Conclusion

- Requirement for Intubations in the ED can be anticipated more in critically ill children less than 1 year of age.
- ED doctors and personnel should be trained adequately in the technique of RSI as a good proportion of patients at tertiary level pediatric hospitals require RSI after 4 pm, when the number of skilled personnel is minimal.
- ED doctors have high competency levels in RSI with acceptable complication rates.
- Need for using the Bag valve mask during RSI is not uncommon.
- Intubation into the right bronchus is the most common complication in the pediatric ED.
- Pre- existing illness does not influence the occurrence of complications of RSI.

The lack of internationally accepted definitions of complications of RSI means that studies of emergency airway management (in any setting) cannot be compared on an equivalent basis. Standardised definitions would permit national and international comparisons in future.

Recommendations

Every paediatrician should be trained in RSI which will help in securing the airway of a critically ill child, under ideal intubating conditions. Every emergency department catering to pediatric patients should have monitoring facilities, medications, equipment, paramedical and medical personnel for RSI. Awake intubations should be avoided, unless other-

wise indicated.

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Review Article

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Emergency Management of the Pediatric Airway

Jhuma Sankar, MD

Abstract

Establishing a patent airway is one of the basic and most important components of basic and advanced life support. However, despite the availability of excellent guidelines/simulation training hypoxic arrests continue to occur in the emergency. This is because, most of the times the child may not be assessed properly in cases of mild to moderate distress at presentation and red flag signs are often missed. Simple measures like pacing a towel or ensuring sniffing position or position of comfort in case of breathing difficulty are not instituted in time eventually leading to a respiratory compromise. Use of appropriate sedatives, analgesics before using muscle relaxants is not ensured, resulting in pain and anxiety in the patient as well as in the care giver as ideal intubating conditions is not achieved in such cases. Use of bag and mask ventilation as a bridging measure in cases of failure of intubation may be life-saving and all health care providers involved in the care of critically ill children, should be skilled in this important procedure if they were to save the life of these patients. In this review, we have once again tried to reemphasize these important principles of airway management in a simple and comprehensive manner. Our emphasis is on simple measures to open the airway, use of airway adjuncts, technique of rapid sequence intubation with a simplified table on drugs commonly used during this important procedure and trouble shooting in an intubated patient. This review is targeted at all fellows in emergency medicine and intensive care and practising paediatricians involved in the care of critically ill/ injured child.

Keywords: Airway; Intubation; Rapid sequence intubation; Bag mask ventilation; RSI; Sedatives; Muscle relaxants; Analgesics.

Case study

A 4 year old child is admitted to the pediatric emergency with complaints of difficulty in breathing and fever of 4 days duration. You are the emergency resident on duty and are called in to evaluate the child. The vitals at admission are heart rate-156/min, peripheral pulses palpable, RR-67/minute, intercostal and subcostal retractions present, SpO_2 92% on rom air and capillary refill time of 2 seconds. Respiratory system examination reveals use of accessory muscles and bilateral crepitation in all areas of the lungs. Cardiovascular system examination is essentially normal. The child is drowsy but responding to commands.

What would be your next step? How will you manage this case? If during the course of management you find that the child has lost consciousness how can you maintain a patent airway without intubating the child if the child is breathing?

Or suppose, you find the child not responding to your treatment and not maintaining saturation what would be your next step? What is rapid sequence intubation? Can you use RSI in this child? If so what are the pre-requisites? What are the alternatives to endotracheal intubation?

In this review we shall try to answer the above pertinent questions related to airway management in such cases.

Introduction

Establishing a patent airway is one of the

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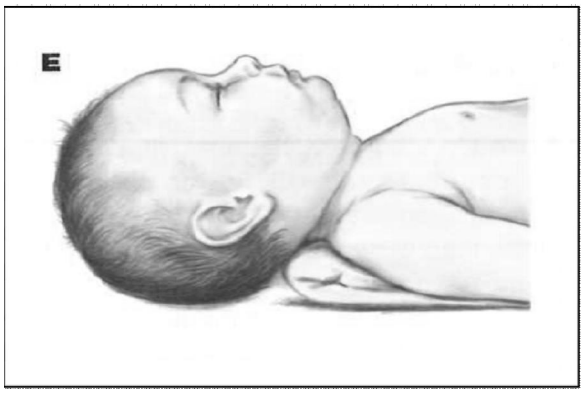
Figure 1: A folded towel is placed beneath the shoulder to open the airway in an infant



basic and most important components of basic and advanced life support. Airway management depends on a brisk assessment of the patient's breathing and knowledge of the likely progression of the airway problem, that is, deterioration versus improving function. In virtually any setting where respiratory difficulty is suspected, oxygen should be administered until the specific abnormality can be identified and adequately treated.[1,2]

If the patient is breathing spontaneously, attention is directed first to signs of upper airway obstruction, including absence of audible or palpable air flow, stridor, or rocking chest and abdominal motion rather than the normal, smooth rise and fall that should occur with inspiration and expiration.[1,2]

Assessment of airway

It is essential to determine whether airway

Figure 2. The towel is placed beneath the occiput in an older child to open the airway

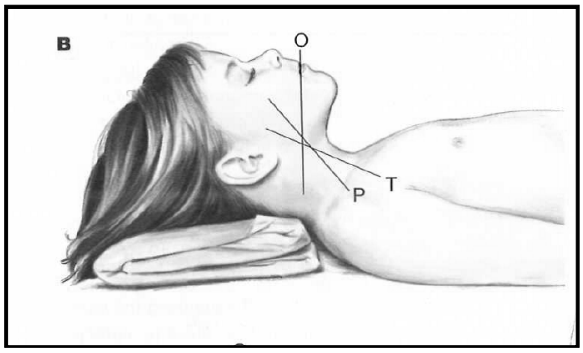
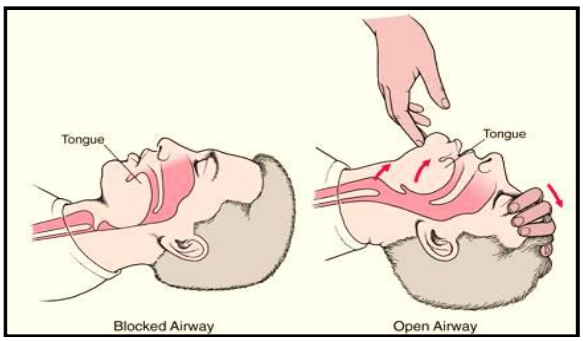


Figure 3: Head-tilt-chin-lift maneuver to open the airway



is patent or not. This can be done by observing the movement of chest or abdomen, by listening for breath sounds and by feeling for movement of air at the nose and mouth. We must also establish if upper airway is clear, whether it is maintainable or not or maintainable by simple measures such as placing a towel (Figure 1 & 2) or head-tilt-chin-lift maneuver.[1]

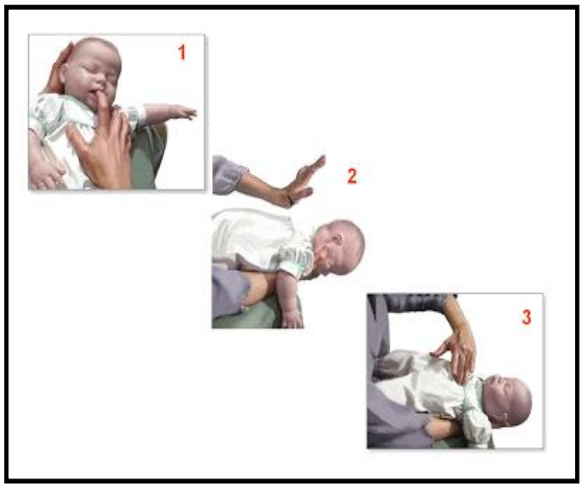
Measures to restore upper airway patency

A) Basic measures

1. Allow child to assume a position of comfort.
2. Use head tilt-chin lift (*Figure 3*) to open the airway unless cervical spine injury is suspected. The tongue is the most common cause of airway obstruction in unconscious pediatric victim. Hence manoeuvres like head tilt – chin lift or jaw thrust are used to open the airway
3. If cervical injury is suspected, open the

Figure 4: Jaw thrust maneuver in case of cervical spine injury

Figure 5: Back slaps and chest thrusts in an infant with foreign body airway obstruction



airway using a jaw thrust without neck extension. When a head or neck injury is suspected, use the Jaw – thrust manoeuvre, with spinal immobilization instead of head tilt – chin lift. *Procedure*: Place 2 or 3 fingers under each side of the lower jaw at its angle and lift the jaw upward and outward. This moves the jaw and tongue forward and opens the airway without bending the neck.

4. In a patient with cervical spine injury if jaw thrust does not open the airway then use *head tilt chin lift* or *jaw thrust with neck extension* as opening airway is a priority !
5. Suction the nose and oropharynx.
6. *Technique of suctioning:* connect suction

Figure 6: Oropharyngeal airways

Figure 7: Nasopharyngeal airways of different sizes

apparatus to wall suction or pump suction and maintain a continuous pressure of less than 120 mmHg. Give 100% oxygen before suctioning. Open the mouth and sweep the suction tip across the oral cavity. Limit the suction time to less than 10 seconds per attempt. Reoxygenate the child in between the attempts. While suctioning the trachea reduce the pressure to less than 100 mmHg.

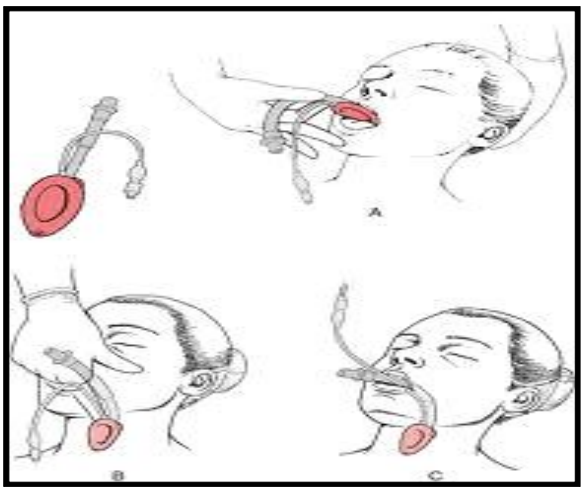
Precautions during suctioning

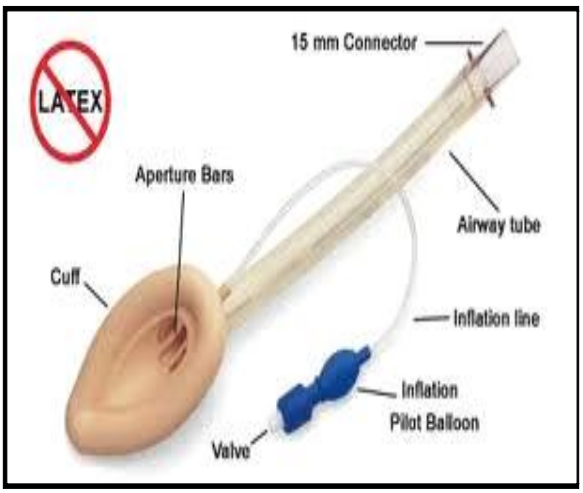
- Avoid deep Yaunker suction in awake patients to prevent gagging, vomiting or laryngospasm
- Avoid nasogastric tubes in facial / cranial trauma
- Exercise caution when placing orogastric tubes in suspected laryngeal, penetrating neck, or esophageal injury

7. Perform foreign body airway obstruction relief techniques if the child is responsive. This includes backslaps and chest thrusts for infants below 1 year of age and abdominal thrusts for older children (*Figure 5*). Once the child becomes unresponsive start cardiopulmonary resuscitation.

When use of simple measures does not help in maintaining the airway then one should consider the use of advanced measures such as oropharyngeal and nasopharyngeal

Figure 8. Technique of insertion of laryngeal mask airway





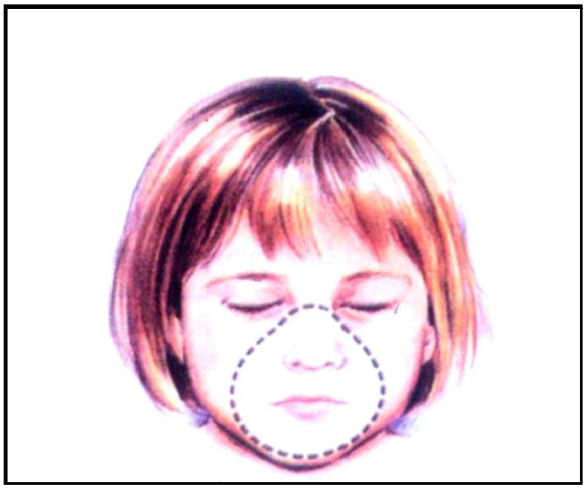
airways, laryngeal mask airway and finally intubation.[1-3]

B) Advanced measures

a) *Oropharyngeal airways* help maintain an open airway by displacing the tongue or soft palate from the pharyngeal air passages. Oropharyngeal airways (*Figure 6*) are used in unresponsive victims who do not have a gag reflex. Make sure to select the correct size. An oropharyngeal airway that is too small may push the base of the tongue farther into the airway while one that is too large may obstruct the airway.[1]

b) *Nasopharyngeal airways* can be used in semi-conscious children with an intact gag reflex. Pay careful attention to proper diameter and length. A nasopharyngeal airway (*Figure 7*) that is too short may not maintain an open airway, while one that is too long may obstruct it. A small-diameter nasopharyngeal airway may be obstructed easily by secretions. It may therefore require frequent suctioning.[1]

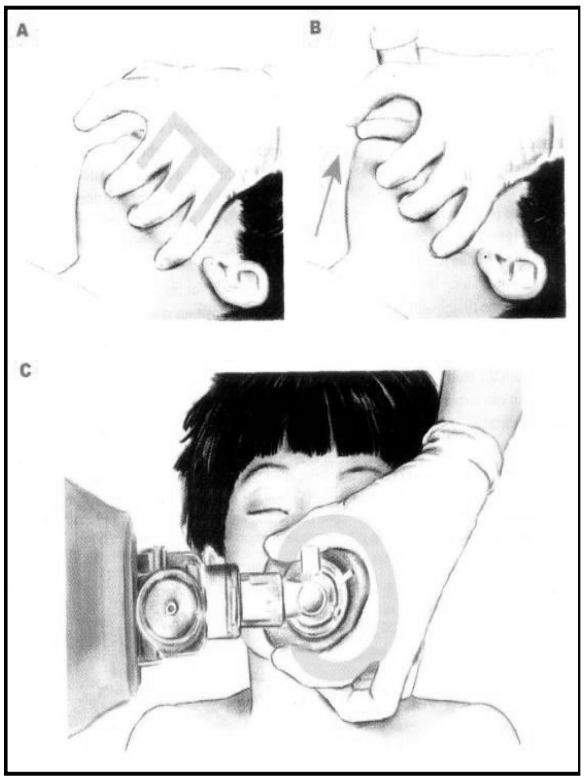
Figure 9: Method of applying the mask



c) *Laryngeal mask airway (LMA):* When bag-mask ventilation is unsuccessful and when endotracheal intubation is not possible, the LMA is acceptable when used by experienced providers to provide a patent airway and support ventilation. LMA insertion is associated with a higher incidence of complications in young children compared with older children and adults.[4]

d) *Endotracheal intubation:* The pediatric intensivist is frequently called on to intubate critically ill patients when brief ventilation with bag and mask is inadequate to reverse the underlying disorder. This requires special training and skills and should be performed only by a person trained in advanced airway management or a person with the necessary skills. One should be skilled in the procedure of bag and mask ventilation before intubation as in cases of failure of intubation it is a life-saving procedure. Here we would briefly recapitulate the technique/steps of bag and mask ventilation.[1-3]

Figure 10: E-C Clamp technique for bag and mask ventilation



Bag and mask ventilation (BMV)

It serves as the initial method to maintain ventilation and the method of choice if endotracheal intubation is unsuccessful. BMV should be started for all patients who have apnea / bradypnea or inadequate respiratory effort.

Equipment

A) Ventilation mask: A ventilation mask consists of a rubber (or) plastic body, a standardized 15 mm / 22 mm connecting port and a rim or face seal. The mask should be transparent to observe the color of child's lip and condensation to detect exhalation. They are available in various sizes. The mask should extend from the bridge of the nose to the cleft of the chin, enveloping the nose and mouth and avoiding compression of the eyes (*Figure 9*). It should provide an air tight seal around the area covered.

B) Manual resuscitator: (self- inflating or flow inflating) It is designed to re-inflate automatically after being compressed and released during BMV. (It is available in size 1 liter suitable for entire pediatric age range).

Technique

Performing BMV in an infant or child begins with positioning the child (as described above) opening and clearing the airway. Select the appropriate mask that completely covers the nose and mouth. Select a 1 liter bag. Connect the bag to source of oxygen. Apply the mask to the face with the non-dominant hand while positioning the head and neck optimally to maintain airway. With the help of the index finger and thumb gently compress the mask on the face (C-grip), and place the long, ring and small fingers on the angle of the jaw, forming an "E" (*Figure 10*). The entire hand placement for BMV is called "E-C Clamp". The fingers on the jaw should pull the patients chin into the mask, creating a good mask seal. Once the mask is properly applied to the face we need to compress the resuscitation bag with the dominant hand at an age – appropriate rate. Squeeze the bag just until chest rise is adequate. When 2 persons are available for BMV one person uses both hands to apply the mask using the "E-C Clamp" technique and the other compresses the bag (*Figure 10)*. Place a nasogastric tube to relieve the inflation of stomach caused during BMV. Carefully monitor the patient at all times while performing BMV. Monitor heart rate, chest rise, SPO_2 on pulse oximetry to ensure that the procedure is being properly performed. Bradycardia, hypoxia and hypercapnia are all possible indications of poor technique. If O_2 is not available BMV can be done with room air.

Complications: Aspiration of gastric contents or pneumothorax due to barotrauma and/or eye injury due to compression with mask may occur.

As mentioned earlier bag and mask is only used in the intervening period before intubation and one cannot replace intubation with this technique. Therefore arrangements

Table 1: Characteristics of drugs commonly used during rapid sequence intubation

Drugs	Dosage	Properties	Onset time	Offset time	Remarks
Sedatives					
Midazolam/ Lorazepam	0.1–0.3 mg/kg IV	Amnestic, sedative	30-60 seconds	30-45 minutes	• Often combined with Fentanyl • May cause hypotension
Thiopental	1-6 mg/kg (depends on build of patient)	Amnestic, Sedative	60-90 seconds	5-10 minutes	• Good for ICP but bad for hemodynamics • May cause respiratory depression
Etomidate	0.3 mg/kg IV	Amnestic, sedative	30-60 seconds	3-5 minutes	• Clonic activity, clinically significant adrenal suppression • Good for hemodynamics but not recommended for children with septic shock
Propofol	1–3.5 mg/kg IV	Amnestic, sedative	60 seconds	5-10 minutes	• Good for ICP but *bad* for hemodynamics • Patients wake up clear headed as compared to thiopental
Sedatives /Analgesics					
Fentanyl	2–4 mcg/kg IV	Amnestic, analgesic, sedative	30-60 seconds	30-60 minutes	• Good for hemodynamics • May cause occasional chest wall rigidity
Morphine	0.1–0.3 mg/kg IV	Amnestic, analgesic	15-30 minutes	2-4 hour	• Bad for hemodynamics • Occasional respiratory depression
Ketamine	1-2 mg/kg IV	Amnestic, sedative, analgesic	60-90 seconds	60-90 seconds	• Ideal for short procedures • Good for hemodynamics, asthma but bad for ICP • May cause hallucinations, therefore it is better to use it in combination with midazolam/lorazepam (prior to drug administration)
Neuromuscular blocking agents					
Succinylcholine	1-4 mg/kg IV	Depolarizing Muscle relaxant	60 seconds	10 minutes	• Good for laryngospasm, urgent paralysis • Contraindicated in hyperkalemic patients, patients with muscle disease, burns, spinal cord trauma or otherwise
Rocuronium	0.6-1.2 mg/kg IV	Non-depolarizing muscle relaxant	60 seconds	15-45 minutes	• Suitable for use in patients with renal failure due to hepatic excretion
Vecuronium	0.1-0.3 mg/kg IV	Non-depolarizing NMB	3-5 minutes	30-75 minutes	• Use with caution in patients with hepatic failure • Minimal hemodynamic effects
Cis-atracurium	0.1 mg/kg	-do-	3-5 minutes	20-35 minutes	• Elimination is by Hoffman degradation and therefore ideal for patients in renal/hepatic failure • May cause histamine release and therefore use with caution in patients with asthma

should be made to intubate the patient with unmaintainable airway after providing bag mask ventilation as a temporary measure.[1-3]

The common indications for intubation may include one or more of the following[1-4]:

1. PaO2 <60mm with FiO2>0.6 (in the absence of cyanotic congenital heart disease)
2. PaCO2> 50 mm Hg (acute and unresponsive to other interventions)
3. Upper airway obstruction, actual or impending
4. Neuromuscular weakness
5. Maximum negative inspiratory pressure >-20 cm H2O
6. Vital capacity <12-15 ml/kg
7. Hemodynamic instability (cardiopulmonary resuscitation, shock)
8. Controlled therapeutic (hyper) ventilation
9. Intracranial hypertension and
10. Pulmonary hypertension

Technique of endotracheal intubation

- Prepare the equipment and select appropriate size endotracheal tube (appendix 1). Also keep one size less and more ready.
- Position the child's head such that the axes of mouth, pharynx and trachea are aligned i.e. in sniffing position.
- Hold the laryngoscope blade in left hand and insert the blade so as to displace the tongue and epiglottis and visualize the glottis opening.
- Insert the tube from the right corner of the mouth and not through the barrel so that you can see the tube passing through the glottis. Help can be taken from an assistant to visualize the glottis by applying cricoid pressure (in unconscious patient) or applying gentle rightward traction on the right corner of the patient mouth.
- Next position ET tube in the mid trachea as per the length calculated (*Appendix 1*).
- Confirm the position of the tube by various methods described subsequently.

Rapid Sequence Intubation (RSI)

To facilitate emergency intubation and reduce the incidence of complications, skilled, experienced providers may use sedatives, neuromuscular blocking agents, (*Table 1*) and other medications to rapidly sedate and neuromuscularly block the pediatric patient. Use RSI only if you are trained, and have experience using these medications and are proficient in the evaluation and management of the pediatric airway. If you use RSI you must have a secondary plan to manage the airway in the event that you cannot achieve intubation.[1-4] The steps involved in RSI include:

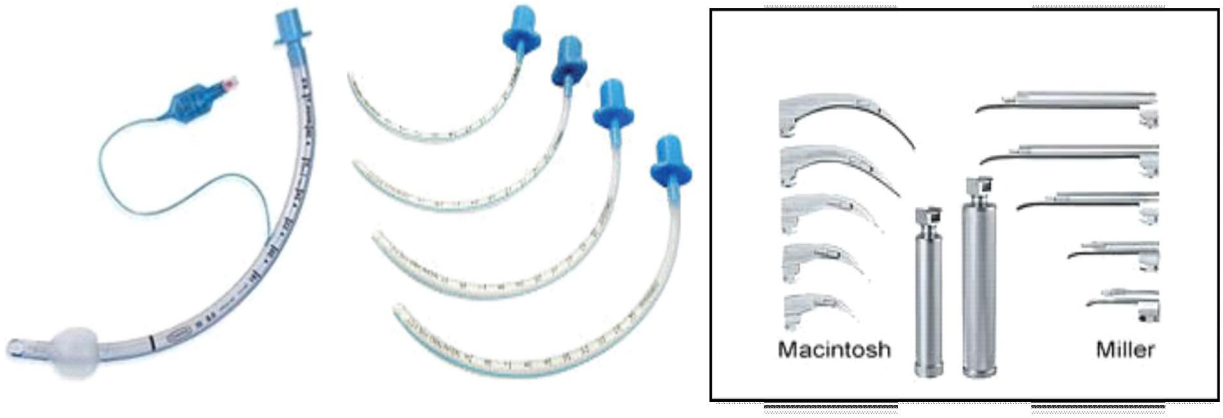
1. Preoxygenation
2. Premedication
3. Sedation
4. Neuromuscular blockade
5. Cricoid pressure (+/-)
6. Intubation

*Pre-oxygenation:*Aim is to fill the functional residual capacity with 100% oxygen. Pre-oxygenation may not always work in patients with lung disease and the intervention would have to be quicker in such patients to prevent saturations from falling to dangerously low levels and thereby leading to arrest.

Medications for RSI: Several types of medications are used during RSI (Table 1). These are used in order to achieve ideal intubating conditions for the patients as well as the practitioner and comprise of agents that can cause *amnesia, analgesia, sedation and muscle paralysis*. There is no perfect combination of drugs that exists for all patients; providers should select drugs based on the patient's condition and the provider's expertise. Most children require some degree of sedation to facilitate intubation and to reduce their awareness of paralysis and intubation.

Pre-medications: These are drugs that are

Figure 11: Cuffed, uncuffed endotracheal tubes and blades



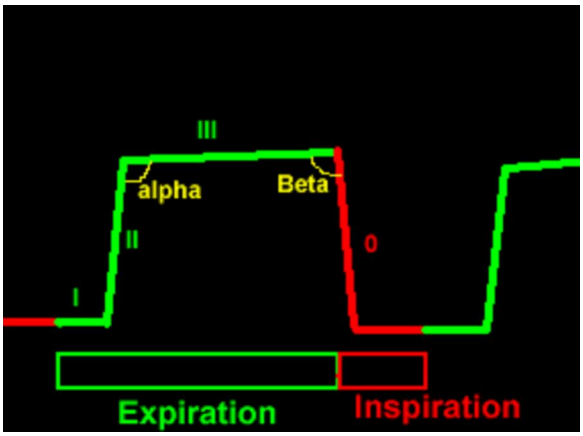
commonly used to counter the bradycardia that can develop during RSI as a result of airway manipulation and/or to counter the side effects of some of the drugs used during RSI. Bradycardia can develop during RSI as the result of airway manipulation and as a side effect of some of the RSI drugs. It can significantly reduce oxygen delivery, especially in patients with limited cardiac output. The drugs commonly used to counter the bradycardia that may occur as a result of airway manipulation during RSI are atropine and glycopyrrolate. The American Heart Association Pediatric Advanced Life Support guidelines recommend the use of atropine for infants who undergo RSI, for children 1 to 5 years of age receiving succinylcholine, and for adolescents receiving a second dose of succinylcholine. Although, atropine may prevent bradycardia and reduce oral secretions (facilitating airway visualization), the time to the onset of this effect is longer (15 to 30 mins) than most providers are prepared to wait before airway instrumentation.

Sedatives and analgesics: The sedatives and analgesic agents used during RSI mostly belong to the benzodiazepines (BZD), barbiturates and opioid group of drugs. Some of the commonly used agents of these groups of drugs and their physiologic effects are summarized in Table 1. Although the list of drugs is long one must choose what works best for them in their set up.

The "classic" combination of drugs used for rapid sequence induction/intubation is sodium thiopental (4-6 mg/kg) and succinylcholine (1-4 mg/kg) with a prior defasciculating dose of a non-depolarizing muscle relaxant such as vecuronium. In hemodynamically unstable patients, alternative drugs include ketamine, etomidate, or a benzodiazepine alone or in combination with a short-acting narcotic. Succinylcholine has multiple undesirable side effects (Table 1) that may include increased intragastric pressure. Most of the non-depolarizing relaxants, given in amounts two to three times the usual intubating dose, produce good conditions for intubation nearly as quickly as succinylcholine (60-90 seconds), without adverse side effects but lasting longer. Rocuronium is the current best alternative, with its rapid onset and short duration of action.

Cricoid pressure: There are no data to show that cricoid pressure prevents aspiration during rapid sequence or emergency tracheal

Figure 12: Exhaled CO_2 monitoring



intubation in infants or children. The 2010 PALS guidelines suggest the following recommendations for cricoid pressure.[5] In case of emergency intubations in infants and children, cricoid pressure should be discontinued if it impedes ventilation or interferes with the speed or ease of intubation.

Intubation: Both cuffed and uncuffed endotracheal tubes are acceptable for intubating infants and children. If cuffed endotracheal tubes are used, cuff inflating pressure should be monitored and limited usually to less than 20 to 25 cm H_2O. In certain circumstances (e.g., poor lung compliance, high airway resistance, or a large glottic air leak) a cuffed endotracheal tube may be preferable to an uncuffed tube, provided that attention is paid to endotracheal tube size, position, and cuff inflation pressure.

RSI in special situations

Raised ICP

- If there are no airway contraindications, administer anaesthetic and neuromuscular blocking agents.
- In case of raised ICP with cardiovascular compromise - etomidate (0.3 mg/kg IV), or midazolam (0.2-0.3 mg/kg IV), and fentanyl (5-10 mcg/kg IV), plus lidocaine (1.0-1.5 mg/kg IV), and rocuronium (0.6-1.2 mg/kg IV) or other relaxant
- If there is no associated cardiovascular compromise or hypovolemia associated with raised ICP- Thiopental (4-6 mg/kg IV), plus lidocaine (1.0 mg/kg IV), plus rocuronium (0.6-1.2 mg/kg IV) or other relaxant
- Ventilate patient until drug effect achieved (consider short-term hyperventilation in patients with signs of critically elevated intracranial pressure)
- Perform laryngoscopy and orotracheal intubation

Shock

- In case of cardiovascular compromise - etomidate and fentanyl (5-10 mcg/kg IV) (for sedation), plus succinylcholine/ rocuronium (0.6-1.2 mg/kg IV) or any other relaxant (paralysis).

Asthma

- Etomidate (0.3 mg/kg IV) and/or ketamine (1mg/kg IV) (for sedation), plus succinylcholine/ rocuronium (0.6-1.2 mg/kg IV). Avoid histamine releasing agents such as atracurium and cis-atracurium.

Verification of endotracheal tube placement[1]

1. Look for bilateral chest movement and listen for equal breath sounds over both lung fields, especially over the axillae.
2. Listen for gastric insufflation sounds over the stomach. They should *not* be present if the tube is in the trachea.
3. If there is a perfusing rhythm, check oxy-hemoglobin saturation with a pulse oximeter. Remember that following hyperoxygenation, the oxyhemoglobin saturation detected by pulse oximetry may not decline for as long as 3 minutes even without effective ventilation.
4. If you are still uncertain, perform direct laryngoscopy and visualize the endotracheal tube to confirm that it lies between the vocal cords.

Exhaled or End-Tidal CO_2 monitoring

When available, exhaled CO_2 detection (capnography or colorimetry) (Figure 12) is recommended as confirmation of tracheal tube position for neonates, infants, and children with a perfusing cardiac rhythm in all settings.[1]

Trouble shooting in an intubated patient

If an intubated patient's condition deteriorates at any point of time – first of all disconnect the patient from the ventilator if applicable and start bag tube ventilation. Then rule out **DOPE** systematically which stands for:

Appendix 1: Guidelines for Laryngoscope, Tracheal Tube, and Suction Catheter Sizes

Age of Patient	Laryngoscope	Internal Diameter of Tracheal Tube (mm)	Distance from Mid-trachea to Lips or Gums(cm)	Suction Catheter (F)
		Uncuffed tube= Age (years) / 4+ 4 Cuffed tube = Age (yrs)/4 + 3.5	<44 weeks gestational age *6 + Weight (Kg)* >44 weeks gestational age *3 x TT size*	2 x TT size
Preterm infant	Miller 0+	2.5, 3.0 uncuffed	7-8	5-6
Term infant	Miller 0-1+ Wis-Hipple 1 Robertshaw 0	3.0, 3.5 uncuffed	9-10	6-8
6 months		3.5, 4.0 uncuffed	10.5-12	8
1 year	Miler 1 Wis-Hipple 11/2 Robertshaw 1	4.0, 4.5 uncuffed	12.13.5	8
2 years	Miller 2 MacIntosh 2 Flagg 2	4.5 uncuffed 4.0 cuffed	13.5	8
4 years		5.0, 5.5 uncuffed 4.5 cuffed	15	10
6 years		5.5 uncuffed 5.0 cuffed	16.5	10
8 years	Miller 2 MacIntosh 2	6.0 cuffed	18	12
10 years	Macintosh 2	6.5 cuffed	19.5	12
12 years	Macintosh 3	7.0 cuffed	21	12
Adolescent	Macintosh 3 Miller 3	7.0, 8.0 cuffed	21	12

***D**isplacement of the tube*: Auscultate the chest bilaterally and over the stomach for breath sounds. If resistance is low while bagging or saturation does not improve suspect displacement- confirm by direct laryngoscopy.

***O**bstruction of the tube:* Start bag mask/tube ventilation and observe for secretions in the tube. Suction the tube. If after suctioning there is no improvement - feel for resistance while bagging with poor chest rise which could imply a partial or complete obstruction. One may make use of end tidal CO_2 monitoring if available which will show low exhaled CO_2 levels to confirm the same.

***P**neumothorax:* Look for asymmetrical chest rise. Percuss for hype resonant note bilaterally and identify areas of hyper resonance. Also auscultate for equality of breath sounds bilaterally. Confirm by needle aspiration on the midclavicular line at the second intercostal space with underwater seal.

***E**quipment failure:* After ruling out all of the above steps one by one inspect the ventilator,

its tubing's and connections for troubleshooting and correct any abnormalities detected. If the ventilator is also functioning optimally then the problem is with the patient and we may need to titrate the ventilator settings accordingly to suit his requirements.[1]

Key messages

1. Establishing a patent airway is one of the basic and most important components of basic and advanced life support.
2. While assessing airway patency we must establish if airway is clear, maintainable by simple measures such as head tilt-chin-lift or jaw thrust or not maintainable requiring advanced airway.
3. Avoid using airways in conscious patients with good gag reflex.
4. Bag and mask ventilation is often used as the initial method to maintain ventilation and is often used as a rescue measure before intubating a patient for failed intubation attempts.
5. RSI is a technique used by providers to rapidly sedate and neuromuscularly block the patient using a combination of sedatives, neuromuscular blocking agents and other medications.
6. If an intubated patient deteriorates at any point of time one must rule out **D**isplacement, **O**bstruction, **P**neumothorax and **E**quipment failure before changing any ventilatory settings.

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Case Report

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Spontaneous Bilateral Pneumothorax in the Newborn

Gaurav Singla, MD; Kamaldeep Arora, DM; Harmesh Singh Bains, MD; Tanya Thakkar, MD

Abstract

Pneumothorax is a recognised cause of respiratory distress in the neonatal period. It may occur spontaneously (idiopathic) or secondary to various underlying lung diseases. In considerable cases of pneumothorax, intercostal drain is inserted to relieve respiratory distress. Pneumothorax results in longer hospital stays due to the requirement of these surgical interventions. But, here we would like to take the opportunity to share our clinical experience of the newborn with spontaneous pneumothorax with mild to moderate respiratory distress who recovered completely with conservative management with an oxygen-enriched atmosphere and no surgical intervention.

Keywords: Spontaneous pneumothorax; Newborn; Pneumothorax; Intercostal drain.

Introduction

Spontaneous pneumothorax can occur in the newborn infant and if not recognized may have fatal consequences. It should be suspected in any infant with respiratory distress. In children, incidence of spontaneous pneumothorax is highest during neonatal period, most probably due to high transpulmonary pressures generated with onset of breathing. Detection in newborn infants depends as much on a high degree of awareness of its possibility as on the knowledge of its predisposing factors and cincial features. The estimated incidence varies from 0.3% to 1.3% based on clinical symptoms or on radiological findings respectively.[1,2] We present here a case of bilateral pneumothorax in neonate which was managed conservatively with high oxygen flow without any surgical intervention.

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Case report

A 3350 gm female infant was born at term gestation (39 weeks) by caesarean section (indication-non progression of labour) to a primi gravida mother after an uneventful antenatal period. There was no history of any trauma during delivery or meconium stained liquor. Baby cried immediately after birth and did not require any resuscitation but shortly, developed tachypnea with grunting and cyanosis. She required supplemental oxygen via head box with resolution of cyanosis, but respiratory distress persisted Physical examination revealed a heart rate of 156 beats/min, capillary refill time of 2 seconds, good volume pulses and respiratory rate 68 breaths/min. Breath sounds were decreased bilaterally with no crepts or wheeze. Moderate chest retractions with RDS score (Downe's) of 4-5 was recorded. Rest of the systemic examination was normal. An arterial blood gas measurement in 40% ambient oxygen revealed a pH of 7.201, $PaCO_2$ of 62 mmHg and PaO_2 of 80 mmHg with base excess of - 8.0. The chest radiograph revealed bilateral pneumothoraces with normal pulmonary vasculature and normal cardiac silhouette (Fig 1). Septic profile and blood culture were negative. She was managed with high flow oxygen via oxygen hood. Respiratory distress decreased within 24 hours and she was off oxygen after 72 hours. She did not require

Figure 2: Chest Xray (AP view) showing resolution of bilateral pneumothoraces

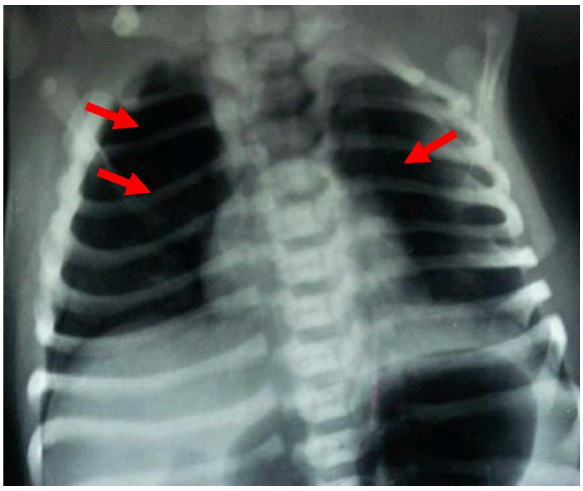
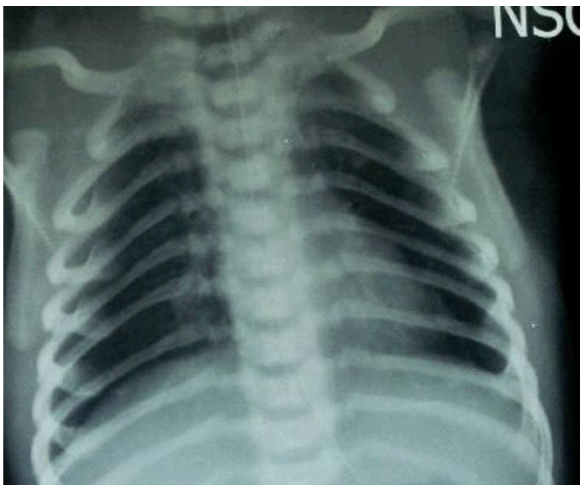


Figure 2: Chest Xray (AP view) showing resolution of bilateral pneumothoraces



any surgical intervention in form of needle thoracocentesis or chest tube placement. Repeat chest radiograph done after 24 hours showed resolution of pneumothoraces (Fig 2).

Discussion

Spontaneous pneumothorax is a recognised cause of respiratory distress in newborn period. The estimated incidence of spontaneous pneumothorax varies from 0.3% to 1.3% based on clinical symptoms or on radiological findings respectively.[1,2] In the newborn period, pneumothorax may occur spontaneously (idiopathic) or secondary to underlying lung diseases such as respiratory distress syndrome, meconium aspiration syndrome, vigorous resuscitation, positive pressure ventilation, pulmonary hypoplasia, pneumonia and congenital pulmonary cystic malformations. Yu *et al* [1] studied the clinical course of pneumothorax and its allied conditions in 34 newborn infants. They found an overall incidence of 3/1000 live births. 11 term infants without obvious pulmonary pathology presented early (within minutes of birth); 6 of these had aspirated meconium or blood. The remaining 23 were preterm infants with hyaline membrane disease (HMD) and accounted for 68 % of the infants.

Spontaneous pneumothorax at birth may result from rupture of alveoli secondary to high pressure needed to expand previously uninflated lungs or from uneven distribution of inflating pressures among groups of alveoli. Administration of 100% oxygen (nitrogen washout therapy) to infants with pneumothorax accelerates the resolution of air leaks and shortens the duration of extra pulmonary air collection from 2 days to 12 hours.[3] Al Tawil *et al* conducted study on 80 newborns with spontaneous pneumothorax in which majority of them were managed conservatively. Only 6/80(7.5%) symptomatic term infants with spontaneous pneumothorax required chest tube insertion or needle thoracocentesis.[4]

It should be stressed that infants with even a small pneumothorax should be placed in an atmosphere with moderately high concentration of oxygen. In an infant who develops a pneumothorax in room air, a good percentage of air, present in the pleural space will be composed of nitrogen. If the child is then placed in oxygen enriched environment, the blood and tissues become saturated with oxygen. There will be a much higher gradient between the nitrogen content in the pleural space and that in the tissues. This will stimulate a more rapid absorption of the nitrogen from the pleural space, and the pneumothorax may absorb rapidly.

Conclusion

All cases of pneumothorax in newborns do not require intercostal drain. Newborn with spontaneous pneumothorax having mild or moderate distress may recover completely with no treatment other than observation in an oxygen-enriched atmosphere.

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Management of Pediatric/Neonatal Emergencies Current Evidence from Cochrane/Other systematic Reviews

Clinical Question: Second Line Agent in Status Epilepticus: Phenytoin or Valproate

Deepak Sachan, MD

Abstract

In this article, we have tried to review the evidence regarding the use of second line agents in status epilepticus, comparing phenytoin and valproate in particular. While phenytoin continues to be used as the preferred second line agent, valproate is equally effective and safe. However, there is need for generating more evidence particularly with respect to safety profile of these two drugs in comparison to each other so that, a consensus may be arrived at in future as to, which is the best second line drug among these two agents in terms of both safety and efficacy.

Keywords: Phenytoin, Valproate; Status epilepticus; Second line agents; Diazepam; Midazolam.

Case scenario

A 5 year old child was admitted to pediatric emergency unit with generalized seizures from last 15 minutes. There was no history of fever, vomiting, headache or head injury. On examination child was unconscious and generalized tonic–clonic movement were seen along with frothing from mouth.

Child was stabilized and was put under oxygen. Immediately after accessing IV line benzodiazepam loading dose was given. Seizures continued for 5 minutes. Now what should be the management strategies?

1) What should be our second line drug; Phenytoin, Valproate or others?
2) What is the evidence of second line drug for SE?
3) How should we monitor the patients?
4) Any future or newer therapeutic modalities are available?

Let us briefly review the evidence to answer the above questions…..

Introduction

Status epilepticus is a major neurological emergency with an incidence of about 20/100,000 and mortality between 3 and 40 % depending on etiology, age, status type, and status duration.[7] Benzodiazepam and Phenytoin/Fosphenytoin are traditionally used as first line drugs and are effective in about 60% of all episodes. However, a notable portion of patients remain in SE. unfortunately, high level evidence is available only for the first-line medication; in particular for lorazepam which had been shown to be more effective than phenytoin (PHT) or placebo.[2,9] However, because first line therapy fails to control at least 35-45% of patients with SE[2], additional treatment are needed, for whom convincing evidence is lacking. Historically, phenytoin[1] has been used before valproic acid (VPA)[3,4] as a second-line agent.

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Table 1: Common etiology of status epilepticus in children

1. Acute
• Acute CNS infection (bacterial meningitis, viral meningitis, encephalitis)
• Metabolic derangement (hypoglycemia, hyperglycemia, hyponatremia, hypocalcaemia, anoxic injury)
• AED noncompliance or withdrawal
• Prolonged febrile convulsion (23%–30%)
2. Remote
• Inflamatory granuloma
• Cerebral migrational disorders (lissencephaly, schizencephaly)
• Perinatal hypoxic-ischemic encephalopathy
• Progressive neurodegenerative disorders
3. Idiopathic/cryptogenic

A small prospective randomized study[5,6] analyzed PHT and VPA after diazepam failure and showed that both drugs were surprisingly highly effective (controlling SE in 88% and 84% of patients, respectively). More recently, levtiracetam (LEV)[7,8] has also been described for this indication, but again without any comparison to other agents. To address this relevant lack of information, we searched medical database to investigate the relative role of PHT, VPA and LEV in the treatment of SE as second line agent.

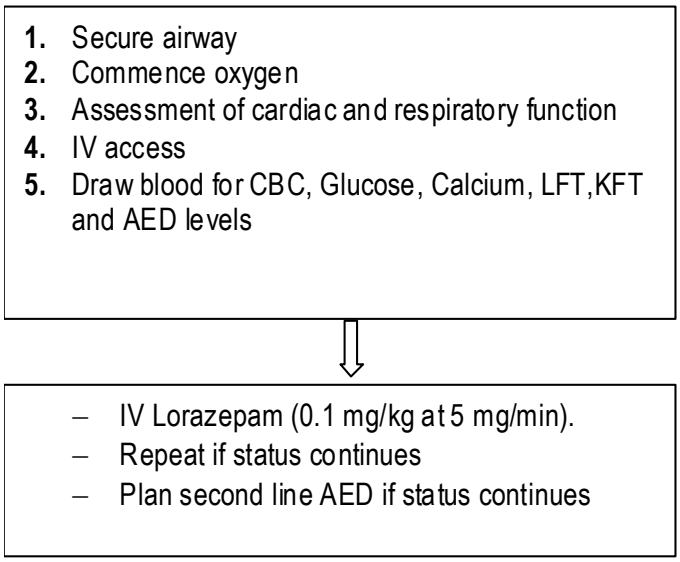
Definition

SE is defined as a single seizure lasting more than 30 minutes or repeated seizures over a period of more than 30 minutes without gaining consciousness. However, for practical reasons, this definition was recently modified by working group on status epilepticus[4]: particularly for generalized seizures, seizures activity persisting for more than 5 minutes is considered to be SE and should be treated accordingly.[9]

Epidemiology

The average incidence of SE is at least 20/100,000 for the Caucasian population in industrialized countries.[7] The incidence from developing world is lacking. The incidence of SE has a bimodal distribution, with the highest incidences during the first year of life and after the age of 60. Among children, babies younger than 12 months had the highest incidence and frequency of status epilepticus. The most common cause in children is febrile seizures or infections, accounting for more than 52% of pediatric cases (Table 1). Remote symptomatic cause and low antiepileptic drug levels account for another significant percentage in children. Patient age at diagnosis, etiology of SE, severity of underlying disease, and duration of SE are the main predictors of increased short term mortality.[11-13] Therefore early and aggressive treatment is very important for successful management.

Flow chart showing initial management in status epilepticus



Management of SE

Initially airway, breathing and circulation should be stabilized, blood sugar should be checked and oxygen should be administered. Then, an intravenous line should be placed for the injection of medication and to draw blood samples (glucose level, electrolyte, blood count, liver and kidney function test, drug levels and toxic drug screen). A screening neurological should be performed for signs of focal or diffuse intracranial lesion. Before aggressive treatment is initiated, possible differential diagnosis should be considered. Treatment can be divided into two parts: initial treatment in the emergency room, second line drug for treatment failure.

Initial treatment in the emergency room

Benzodiazepines

The benzodiazepines most commonly used for the treatment of SE are diazepam (DZP), lorazepam (LZP), and midazolam. LZP is less lipophilic; it has a smaller volume of distribution and a longer intracerebral half-life (12 hours) as compared with DZP (15-30 minutes) and therefore, a potentially longer anticonvulsive effect. Several studies have compared the effectiveness of lorazepam and diazepam in the treatment of status epilepticus.[9,14] Most studies have found non-significant but relevant difference in favor of LZP. In children, treatment with intravenous LZP in the emergency department was associated with a 3.7 times (95% CI: 1.7-7.9) greater likelihood of seizure termination than was treatment with rectal diazepam (10). In accordance with these data and a recent Cochrane review[15] we consider LZP the first line benzodiazepine in SE. If SE persists after 20 minutes, benzodiazepine treatment should be followed by second line anticonvulsant.

Second line drug for treatment failure

Traditionally, benzodiazepine treatment is followed by 15-20mg/kg of intravenous phenytoin given at a maximal infusion speed of 50 mg phenytoin/minute.[16] No randomized controlled data supporting phenytoin as a second line treatment are available, but one uncontrolled study suggested that 50% of patients not successfully treated with benzodiazepine alone would respond to second line treatment.[17] Traditionally, based on a long clinical experience, and case controlled study, intravenous phenytoin has been used as the second line drug.

Starting in the 1980s, the use of intravenous valproate has been reported in an increasing number of uncontrolled case series, indicating relatively ease of use; good tolerability and suggesting that it may be efficacious.[18 In one

Table 2: Summary of the studies showing comparison of valproate and phenytoin in status epilepticus

Source/authors	classification	Level of evidence	Results	conclusion
Agarwal *et al*. seizure. 2007 sep; 16(6): 527-32	RCT	Ia.	100 patients with diazepam refractory SE received either IV phenytoin or IV valproate loading dose of 20mg/kg at 40 mg /min. 88% had control of SE vs. *84% for phenytoin. No hypotension or respiratory depression was seen in valproate group, although mild elevation in liver enzymes was found in 4/50 pts.	IV valproic acid is as effective and has better tolerability than IV phenytoin when treating benzodiazepine resistant status epilepticus.
Yu *et al*.Epilepsia. 2003 may; 44(5): 724-6	Retrospective review	III	18 pediatric patients with lorazepam resistant SE received 25mg /kg/min of valproic acid. All had seizure cessation within 20 minutes.	Valproic acid bolus of 25mg/kg at 3 mg/kg/min is safe and effective for the treatment of SE in children.
Mehta *et al*.j child neurol.2007 oct;22(10):1191-7	RCT	Ia.	Open-label RCT of 40 children with refractory SE (diazepam+phenytoin)received valproate 30mg/kg over 2-5 minutes or diazepam infusion. Time to control seizures was 5 minutes in valprote group vs. 17 min. in diazepam group.	IV sodium valproate is an effective alternative to diazepam in controlling refractory status epilepticus in children and is without any complication.
Alvarej V *et al*. Epilepsia 2011: 1-5	Retrospective review	III	Study analyzed 187 episodes of SE in which PHT, VPA or LEV were given. VPA failed to control SE in 25.4%, PHT in 41.4% and LEV in 48.3% episodes. LEV failed more often than VPA(OR 2.69; 95%CI 1.19-6.08).	Leveracetam seems less effective than valproate to control SE after benzodizepines.
Rai A *et al*. pediatric neurology 2011;45 :300-304	RCT	Ia.	100 children with motor focal seizures or generalized seizures were randomized to receive valproate or phenytoin. The primary end point efficacy was 93% and 97% respectively. Time to regain consciousness was less in valproate group.	IV valproate is safe and efficacious with less time to regain consciousness.
Gilad± R *et al*. acta neurol scand 2008; 118: 296-300	Case series	III	Seventy-four adult patients with SE participated in the study, 49 with VPA and 25 PHT . In 43 (87.8%) of the VPA patients, the seizures discontinued. Similar results were found in the PHT group in which seizures of 22 (88%) patients were well controlled. Side effects were found in 12% of the PHT group, and in none of the VPA group.	VPA i.v. seems to be effective and well tolerated in adult patients with SE or ARS.
Misra *et al*. neurology 2006; 67: 340-342	Pilot study	III	Sixty-eight patients with SE were randomly assigned to two groups to study efficacy of sodium valproate and phenytoin. Seizures were aborted in 66% of valproate group and 42% in phenytoin group.	Sodium valproate may be preferred in SE because of its higher efficacy.

study, 20 adult patients in acute or static SE with generalized tonic-clonic seizures or simple partial motor seizures were administered IV valproic acid in a bolus dose of 1mg/kg/h for 24 hour safely. SE was interrupted in less than 30 minutes in 80% of cases.[19 Recently, there are other reports about successful use of IV valproate in controlling SE. we searched Cochrane database of systematic reviews but could not find any reviews comparing the two in SE.

No other systematic reviews or meta-analysis were found in children comparing phenytoin versus valproate as a second line drug for management of SE. However a number of controlled and descriptive studies have been reported on the efficacy/safety of these drugs, the findings of which are summarized below (Table 2). There are no trials on use of lacosamide in SE. An initial intravenous replacement trial in 60 patient showed the LCM was well tolerated when given over 30 or 60 minutes.

Conclusion

Having reviewed the available evidence following recommendation can be made

1. Valproate is as effective as Phenytoin in controlling status epilepticus(SE) in children (class I).
2. Valproate may be safer than Phenytoin but class I evidence are lacking. In all the RCT the difference in safety profile was not significant because of small sample size.
3. Valproate should be avoided in hepatic failure and metabolic disorder. Patient should be monitored for cardio respiratory parameter especially when phenytoin infusion is given.
4. Leveracetam is less effective than sodium Valproate in controlling SE.(class III evidence; adults).

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