PREOXYGENATION AND ‘DELAYED SEQUENCE INTUBATION’ [DSI]

D Pillay

Moderator: S Reddy

School of Clinical Medicine
Discipline of Anaesthesiology and Critical Care
CONTENTS

INTRODUCTION ................................................................................................................................. 3
TRACHEAL INTUBATION IN THE ICU/EMERGENCY DEPARTMENT ................................................. 4
HYPOXAEMIA .................................................................................................................................. 5
PREOXYGENATION .......................................................................................................................... 7
APNEIC OXYGENATION .................................................................................................................. 10
DESATURATION DURING INTUBATION ............................................................................................ 12
DELAYED SEQUENCE INTUBATION .............................................................................................. 13
  Indications ................................................................................................................................... 13
  Procedure ................................................................................................................................... 13
  Evidence ..................................................................................................................................... 13
  Pharmacology ............................................................................................................................ 14
CONCLUSION ................................................................................................................................... 17
REFERENCES ................................................................................................................................. 18
INTRODUCTION

The purpose of preoxygenating a patient prior to tracheal intubation is to provide a “safe time” during the period of apnea so that saturation levels do not become critically low. The bulk of tracheal intubations usually are not problematic and minimal or no drop in saturation is noted.

The majority of patients who require tracheal intubation present for elective surgery and usually have a fairly normal physiology. Other subsets of patients with altered physiology, due to critical illness/ chronic illness or body habitus, therefore require modification in the way preoxygenation is done. Adequate preoxygenation is relative to the individual patient.

It is often the patients who would derive the most benefit from preoxygenation that are likely to deny us the opportunity to provide it to them\(^1\). Therefore conventional methods of preoxygenating certain patients may not give us a safe buffer for tracheal intubation.

This booklet is intended to highlight the technique of ‘Delayed sequence intubation (DSI)’ in the emergent airway, also to discuss the relevance of certain practices such as preoxygenation, apneic oxygenation and reoxygenation\(^1,2\). DSI is already being practiced in certain emergency departments and intensive care units. Many practitioners have encountered the critically ill patient that is hypoxaemic, either in theatre or in the intensive care setting and have not been able to offer them adequate preoxygenation prior to attempting tracheal intubation.

“Delayed sequence intubation” is a concept by Scott Weingart, and has given us another option for hypoxaemic agitated patients in whom we would prematurely attempt intubation.
TRACHEAL INTUBATION IN THE ICU/EMERGENCY DEPARTMENT

In contrast to the controlled environment of the operating theatre, patients that require tracheal intubation in the ICU/ED are usually critically ill; their airways are usually not evaluated adequately and they show little or no response to preoxygenation. This can contribute to life threatening complications such as hypoxaemia and cardiovascular collapse\(^{(3)}\). During apnea, the time for haemoglobin saturation to fall below 85% is approximately 502 seconds in a healthy post-operative adult patient but in a critically ill patient can be as soon as 23 seconds\(^{(4)}\).

According to the 4\(^{th}\) national audit project (NAP4) of major airway complications in the United Kingdom (2011), one in four of the complication events reported to them were from intensive care units and emergency departments. Majority of these events were during Rapid sequence intubation. The figure of most concern is that 60% of the events reported actually led to brain damage or death as compared to theatre, which is 14%.\(^{(5)}\)

A study by Griedsdale et al\(^{(6)}\) looked at the complications in intensive care units that occur during tracheal intubation. They found the overall risk of complications to be 39%.

These included:

- Frank aspiration 5.9%
- Oesophageal intubation 7.4%
- Severe hypotension 9.6%
- Severe hypoxaemia 19.1%

The figures above are alarmingly similar in other such studies. The combination of respiratory compromise and a hypermetabolic state from sepsis or shock make tracheal intubation a life threatening procedure in the ICU. Even in the hands of experienced practitioners these complications occur. Therefore these departments need to have existing protocols/algorithms in place to decrease tracheal intubation complications.

It was highlighted by the NAP4 that one of the reasons for morbidity during airway management was that the patients are inefficiently preoxygenated due to ventilation/perfusion mismatch (commonly shunt) from their disease process and this is frequently exacerbated by poor patient co-operation.\(^{(5)}\)
HYPOXAEMIA

Hypoxaemia is defined as a decreased partial pressure of oxygen in arterial blood, but also in terms of reduced content of oxygen (ml oxygen per dl blood) or percentage saturation of haemoglobin with oxygen.

Causes of hypoxaemia include:\(^2\):

- Ventilation perfusion mismatch
- Inadequate alveolar oxygenation
- Diffusion abnormalities
- Shunt
- Low venous saturation

Most of these causes have minimal consequences on oxygenation if the inspired fraction of oxygen is increased, with the exception of shunt and low venous saturation as seen in the table below. Therefore we will focus our attention on shunt.

<table>
<thead>
<tr>
<th>Summary</th>
<th>arterial blood</th>
<th>venous blood</th>
<th>Does supplemental oxygen ((\uparrow F_1O_2)) increase PaO2 substantially?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PO₂</td>
<td>PCO₂</td>
<td>PO₂</td>
</tr>
<tr>
<td>Hypoxemia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypoventilation</td>
<td>(\downarrow)</td>
<td>(\uparrow)</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>(\downarrow P_tO_2)</td>
<td>(\downarrow)</td>
<td>(\downarrow)</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>R-L Shunt</td>
<td>(\downarrow)</td>
<td>normal</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>Diffusion defect</td>
<td>(\downarrow)</td>
<td>normal</td>
<td>(\downarrow)</td>
</tr>
<tr>
<td>VA/Q inequality</td>
<td>(\downarrow)</td>
<td>normal</td>
<td>(\downarrow)</td>
</tr>
</tbody>
</table>

**Figure 1. Summary of effects of different causes of hypoxaemia and their response to supplemental oxygen\(^7\)**

A shunt can either be anatomic or physiological. An anatomical shunt is a direct connection between arterial and venous blood, as seen in congenital heart defects such as a VSD. This is seldom the cause of the hypoxaemia we encounter in the emergency department or intensive care\(^2\).

A physiological shunt is frequently the cause of hypoxaemia in the critically ill. This occurs when part of the cardiac output passes through normal pulmonary vasculature but fails to be oxygenated i.e. no gas exchange takes place. This leads to mixing of deoxygenated blood with arterial blood thus causing hypoxaemia\(^2, 7\).

Causes of shunt include:

- Pneumonia
- Atelectasis
- Pulmonary oedema
- Mucus plugs
- ARDS
The key clinical feature of a physiological shunt is that oxygenation will not improve by simply administering supplemental oxygen, as it will not come into contact with the shunted blood. The only way to improve oxygenation drastically is to correct the shunt. However if the shunt is small, increasing the inspired fraction of oxygen can increase the oxygen content of blood, hence we do not usually withhold supplemental oxygen from hypoxaemic patients even if we suspect only a shunt present.

Figure 2 Iso-shunt graph\(^7\)

Critically ill patient could also have low venous saturations that worsen their hypoxaemia. In normal patients venous blood is usually 65-75 percent saturated hence even a little exposure to oxygen brings them close 100 percent saturation briskly. In low cardiac output states there is more tissue extraction from venous blood hence lower than normal oxygen saturation. This blood will then require more time for exposure to oxygen to become fully saturated, and in abnormal physiology this may never occur. When a shunt is also present (Figure 3), the already poorly saturated venous blood mixes directly with the arterial component\(^2\).

Figure 3 Ventilation/perfusion units\(^2\)

Severe hypoxemia can result in cellular hypoxia, organ dysfunction, and death. The degree of organ dysfunction is determined by the rapidity of onset, severity, and duration of hypoxemia and individual susceptibility\(^8\).
PREOXYGENATION

Preoxygenating a patient prior to attempting tracheal intubation is meant to give us a safety period during the episode of apnea. Safe apnea is said to be the time it takes for the patient’s $\mathrm{O}_2$ saturation to drop to 88-90%\(^9\). If saturations fall below this level they then become placed on the steep curve (figure 4) of the oxyhaemaglobin dissociation curve and can precipitously drop to critical saturation levels. If a saturation of 93-95% is not achieved prior to attempting tracheal intubation there is an increased likelihood of the desaturation during the apneic period and during intubation attempts\(^1\).

![Figure 4 Oxyhaemaglobin dissociation curve](image)

Anaesthesiologists established a ‘Rapid sequence induction’ for patients that were high risk for aspiration. It involves administration of induction agents and paralytics without ventilating the patient (Apneic period) until paralysis is achieved to optimize tracheal intubation. It is utilized in most emergency and intensive care units if tracheal intubation is required\(^9\).

Anaesthetists realised in the 1950’s that by filling the alveoli with 100% oxygen, it increased time to desaturation. A patient that is breathing room air will begin to desaturate 45-60 seconds after induction, hardly enough time for paralysis to set in let alone secure the airway\(^9\).

Preoxygenation is not always deemed necessary in the elective surgical patient who is not undergoing a rapid sequence induction. These patients usually have normal physiology and minimal metabolic requirements. Ventilation will continue throughout the induction until the airway is secured, so the chances of desaturation are remote\(^1\).
Most anaesthetic circuits can deliver 90-100% oxygen if used with a tightly fitting mask, however in most casualties the usual oxygen source is a facemask with an oxygen reservoir, which at 15 l/min delivers only 60-70% inspired oxygen. If a true non-rebreather mask with one-way valves is used, you could get up to 90% inspired oxygen with 15 l/min. If a bag-valve mask is used with a tight seal, more than 90% oxygen can be delivered. But to deliver adequate amounts of oxygen, the patient must create enough inspiratory pressure to open the valve or the bag must be squeezed. A tight seal must be provided as holding a bag valve mask just above the patients face only provides room air.(9)

Three minutes of preoxygenation or 8 vital capacity breaths with high FiO₂ is usually acceptable for patients with normal respiratory mechanics. Ideally though, patients should be preoxygenated until the functional residual capacity is completely denitrogenated and they have an end tidal oxygen level of more than 90%. (10)

In some cases it is nearly impossible to achieve saturations greater than 90%, despite any length of standard preoxygenation. Patients such as these have a shunt present and as discussed in the physiology, increasing the inspired oxygen content is not going to make a substantial difference. Many practitioners have been in a situation such as this numerous times and when they notice a minimal improvement in saturations, tracheal intubation is prematurely attempted. These patients are already on the steep part of the oxyhaemaglobin dissociation curve and are perilously close to severe complications from desaturating, such as arrhythmias or cardiac arrest. (9)

What are our options if standard preoxygenation is not enough?

A study by Mort et al(11, 12) compared preoxygenation with a BVM for 4 minutes in stable patients undergoing cardiac surgery versus unstable critically ill patients.

The findings were as follows
- Controls: PaO₂ increased from 79+/-12.3 to 403.6+/-71.8
- ICU patients: PaO₂ increased from 64.2+/-3.5 to 86.8+/-9.5

This suggests that conventional preoxygenation may fail to improve oxygenation safely and minimal periods of apnea in the critically ill could be deleterious.

One option to enhance preoxygenation, especially in those that show signs of a shunt, is non-invasive ventilation(13). Inspired oxygen content close to 100% can be assured if appropriately fitted masks are used. If CPAP is added to this and titrated upwards from 5 to 15cm H₂O, saturations close to 100% can be achieved in this subset of patients. In a prospective randomized trial by Baillard et al(14) critically ill patients in two intensive care units were studied. They compared NIPPV versus standard preoxygenation in these patients. It was found that at the end of preoxygenation, the non-invasive positive pressure group had a mean Hb saturation of 98% and the standard group a mean of 93%.

Below is a table of evidence that supports preoxygenation with increased airway pressure as being more effective in certain cohorts than increased FiO₂ alone. In some settings a ventilator is not available to offer this and a bag valve mask with a PEEP valve attached to it could assist in ameliorating a shunt when present, although not as effectively as a ventilator will.

Below is a table of evidence that supports preoxygenation with increased airway pressure as being more effective in certain cohorts than increased FiO₂ alone. In some settings a ventilator is not available to offer this and a bag valve mask with a PEEP valve attached to it could assist in ameliorating a shunt when present, although not as effectively as a ventilator will.

A recommendation by Weingart and Levitan is that CPAP masks, noninvasive positive pressure ventilation, or PEEP valves on a BMV device should be considered for preoxygenation and ventilation during the onset phase of muscle relaxation in patients who cannot achieve saturations above 93-95% with increased FiO₂(9).
Additional ways of improving preoxygenation include optimizing patient position. In the supine position, posterior lung segments are prone to atelectasis, this decreases safe apnea time\(^{15}\). Weingart and Levitan also recommend that a patient should receive preoxygenation with the head up if possible and if other reasons such as spinal cord injury prevent this, placing the patient reverse trendelenburg could be feasible.\(^{9}\)

![Table 1](image)

**Table 1.** Evidence for increased mean airway pressure as a preoxygenation technique.

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients Description</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay et al(^{25})</td>
<td>RCT of 26 obese, operative patients</td>
<td>Noninvasive ventilation</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>The patients in the noninvasive positive-pressure ventilation group achieved faster and more complete desaturation than the standard group, as measured by an exhaled oxygen level $&gt;90%$.</td>
</tr>
<tr>
<td>Futier et al(^{26})</td>
<td>RCT of 66 obese, operative patients</td>
<td>Two treatment groups: noninvasive ventilation or noninvasive ventilation with post-tracheal intubation recruitment maneuver</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>At the end of preoxygenation, PaO(_2) was higher in the NPPV and NPPV + RM groups compared with the spontaneous ventilation group and remained higher after TI and the onset of mechanical ventilation.</td>
</tr>
<tr>
<td>Cressey et al(^{27})</td>
<td>RCT of 20 morbidly obese women undergoing bariatric surgery</td>
<td>CPAP preoxygenation</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>Showed a 40-s increase in time to desaturation through the use of noninvasive positive pressure. Nonsignificant primary outcome.</td>
</tr>
<tr>
<td>Gander et al(^{28})</td>
<td>RCT of 30 morbidly obese operative patients</td>
<td>CPAP preoxygenation</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>The time until reaching a saturation of 90% after apnea was extended by a minute in the CPAP group.</td>
</tr>
<tr>
<td>Herriger et al(^{29})</td>
<td>RCT of 40 ASA I-II operative patients</td>
<td>CPAP preoxygenation</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>Application of positive airway pressure during induction of anesthesia in adults prolongs the nonhypoxic apnea duration by $&gt;2\text{ min}$.</td>
</tr>
<tr>
<td>Antonelli et al(^{30})</td>
<td>RCT of 26 hypoxemic ICU patients requiring bronchoscopy</td>
<td>Noninvasive ventilation</td>
<td>Spontaneous ventilation at zero pressure</td>
<td>The PaO(_2)/FiO(_2) ratio improved in the noninvasive positive-pressure ventilation group and worsened in the high-FIO(_2)-alone group.</td>
</tr>
</tbody>
</table>

\(\text{RCT, Randomized controlled trial; NPPV, noninvasive positive-pressure ventilation; RM, recruitment maneuver; CPAP, continuous positive airway pressure; ASA, American Society of Anesthesiologists; TI, tracheal intubation.}\)

**Figure 5\(^{9}\)**
APNEIC OXYGENATION

Oxygen and carbon dioxide can move across the alveolar membrane even if there are no spontaneous ventilations. Oxygen however can be taken up at a much faster rate than carbon dioxide is released due to differences in gas solubility and haemoglobin’s affinity for oxygen\(^\text{16}\). As this occurs the pressure in the alveoli drops below atmospheric pressure and causes the gas in the pharynx to be essentially pulled down.

This is the basic concept behind apneic oxygenation, by providing an oxygen source and a patent airway; a patient can still be oxygenated. They will however still, retain carbon dioxide and become acidotic\(^\text{17}\). In study a group of patients receiving O\(_2\) at 5L/min via a nasal cannula showed no desaturation up to 6min, however in the control group its showed that a decrease saturation up to the cut off of 95% took about 3.65min.\(^{\text{18}}\)

Apneic oxygenation can extend the duration of safe apnea after sedatives and muscle relaxants are given. In most emergency departments a nasal cannula, which can administer O\(_2\) at 15l/min, is readily available and is effective in providing apneic oxygenation.

One of the concerns with providing a high concentration of oxygen is absorption atelectasis. The reason we provide such a high concentration of oxygen is to remove the nitrogen from the alveoli. But nitrogen usually maintains patency of the alveoli and if this is lost, it could worsen a shunt. A way to prevent this is to utilize non-invasive ventilation with CPAP thus maintaining alveolar patency. If we are using a BVM with a peep valve to preoxygenate, positive airway pressure is only achieved if the patient is breathing spontaneously or assisted ventilation given.\(^{\text{9}}\)

Procedure of apneic oxygenation\(^{\text{19}}\)

- Preoxygenate patient (including use of nasal cannulae at 15 L/min)
- Induce
- Once patient is induced increase the nasal cannula flow rate to 15 L/min and administer oxygen by non-rebreather mask or BVM.
- If SpO\(_2\) <95% consider apneic oxygenation with CPAP or with BVM with PEEP valve (either 6 gentle ventilations/minute or with continuous administration of oxygen at 15 L/min via nasal cannula)
- Maintain an open airway with jaw thrust, nasopharyngeal or oropharyngeal airway
- Remove the mask at the time of intubation, but continue to oxygenate via the nasal cannula (this has been termed NO DESAT: nasal oxygen during efforts securing a tube (Levitan et al))\(^{\text{20}}\)
Below is a table with human evidence for apneic oxygenation.

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients</th>
<th>Intervention</th>
<th>Comparator</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conmee et al. 177</td>
<td>Obs trial of 2 patients with neurologic injuries</td>
<td>Endotracheal insufflation of 6–11 L/min of oxygen</td>
<td>None</td>
<td>Observation of long duration till $\text{SaO}_2 &lt; 90%$ in numerous separate experiments</td>
</tr>
<tr>
<td>Enghoff et al. 89</td>
<td>Obs study of 7 operative patients</td>
<td>Tubing placed down ET tube connected to 100% $\text{FiO}_2$</td>
<td>None</td>
<td>No decrease in ABG $\text{PaO}_2$ for 5–7 min</td>
</tr>
<tr>
<td>Holmdahl 89</td>
<td>Documentation of separate Obs studies</td>
<td>Endotracheal insufflation of 100% $\text{FiO}_2$</td>
<td>None</td>
<td>Extended time until desaturation in separate studies</td>
</tr>
<tr>
<td>Frumin et al. 89</td>
<td>Obs study of 8 operative patients</td>
<td>Intubated, administered 100% $\text{FiO}_2$ and left apneic</td>
<td>None</td>
<td>No desaturation for between 18 and 55 min. Patients had marked hypercapnia and commensurate decreased pH.</td>
</tr>
<tr>
<td>Babinski et al. 81</td>
<td>Obs study of 5 operative patients</td>
<td>Two endobronchial catheters placed</td>
<td>None</td>
<td>30 min of apnea without significant desaturation</td>
</tr>
<tr>
<td>Teller et al. 82</td>
<td>RCT, blinded, crossover trial of 12 pts</td>
<td>Nasopharyngeal catheters attached to 100% $\text{FiO}_2$ at 3 L/min</td>
<td>Nasopharyngeal catheters attached to room air</td>
<td>Outcome was a sat of ≈92% or 10 min. None of the patients in the insufflation arm desaturated below 98% during the 10 min.</td>
</tr>
<tr>
<td>Taha et al. 89</td>
<td>RCT of 30 pts</td>
<td>Nasal catheters attached to 5 L/min of 100% $\text{FiO}_2$</td>
<td>Room air</td>
<td>No desaturation during the course of the 6-min predetermined stopping point in patients receiving apneic oxygenation. The control group desaturated to the study cutoff of 95% in an average of 3.65 min.</td>
</tr>
<tr>
<td>Ramachandran et al. 80</td>
<td>RCT of 30 obese, operative patients</td>
<td>Nasal cannula attached to 5 L/min 100% $\text{FiO}_2$</td>
<td>Room air</td>
<td>The apneic oxygenation group had significant prolongation of $\text{SpO}_2 &gt; 95%$ time (5.29 versus 3.49 min), a significant increase in patients with $\text{SpO}_2 = 95%$ at the 6 min mark (8 patients versus 1 patient), and significantly higher minimum $\text{SpO}_2$ (94.3% versus 87.7%).</td>
</tr>
</tbody>
</table>

Obs, Observational trial.

Figure 6 (9)
DESATURATION DURING INTUBATION

If initial attempts at intubation fail and the patients starts to desaturate (<90-95%), more attempts at intubation without oxygenating could be prove fatal. In the ICU/ED this can be achieved with a BVM with high flow O₂, placement of an oropharyngeal/nasopharyngeal airway and PEEP valve could be beneficial.

The correct manner in which to reoxygenate these patients is in a slow gentle approach in order to avoid opening the lower oesophageal sphincter (Pressure of 20-25cmH₂O). The rate of ventilations should be 10 breaths per minute; a faster rate does not raise O₂ saturation any faster than a controlled rate. Every breath increases risk of aspiration due to gastric insufflation. This is very easy for one to write down but when practitioners are under duress these principles are easily forgotten⁵⁸.

Other ways of enhancing reoxygenation are basic principles, more than one practitioner, tight fitting mask, correct patient positioning.

Another study by Mort⁵¹ of more than 10,000 emergency tracheal intubations outside the operating theatre found multiple attempts at intubation (≤2 versus >2 attempts) to be related to increases in⁵¹:

- Hypoxaemia (11.8% versus 70%)
- Regurgitation of gastric contents (1.9% versus 22%)
- Bradycardia (1.6% versus 21%)
- Aspiration (0.8% versus 13%),
- Cardiac arrest (0.7% versus 11%)
DELAYED SEQUENCE INTUBATION

Definition: Dissociative medication administration for the sole purpose of preoxygenation. Alternatively described as procedural sedation, the procedure being adequate preoxygenation\(^1\).

If a critically ill patient is able to achieve adequate saturation by standard preoxygenation or able to tolerate noninvasive ventilation, conventional rapid sequence intubation can most likely be performed. As mentioned previously however, patients that require adequate preoxygenation are the ones that impede its implementation- they may be hypoxic or hypercapneic that leads to delirium.

This is usually the point when an injudicious decision to induce and intubate despite poor saturations is made, with sometimes detrimental consequences. There is an alternative that could be used. The usual method is preoxygenating and subsequently administering both induction and paralytic simultaneously while not providing any ventilation till tracheal intubation is confirmed. The alternative ‘Delayed sequence’ intubation breaks the sequence by allowing adequate preoxygenation without the risk of gastric insufflation or aspiration by administering a specific sedative that does not blunt airway reflexes or spontaneous ventilation. During this period preoxygenation can be provided, in an appropriate manner as mentioned earlier, and we should have a more cooperative patient. Thereafter the patient can then be paralysed and intubated\(^1, 2\).

Indications
- Patient who is agitated does not accept other forms of oxygenation.
- Another procedure is required before intubation, but the patient will not tolerate it (e.g. nasogastric tube placement prior to intubation in the setting of GI haemorrhage)

Procedure \(^{(22)}\):
- Correct indication for procedure
- Administer induction agent, preferably ketamine 1-2 mg/kg
- Place non-rebreather mask and nasal cannula at 15 L/min each
- If SpO2 is <95% then use CPAP or BMV with PEEP valve at 5-15 cmH2O (this usually takes 2-3 minutes, but may take up to 10 minutes – if oxygenation does not improve during this time then it may be necessary to proceed with intubation with SpO2 <95%)
- Administer neuromuscular blocker and wait 45-60 seconds
- Perform apneic oxygenation using 15 L/min O\(_2\) via nasal prongs +/- CPAP
- Intubate patient

Evidence \(\text{Weingart et al, 2014}\(^1\)\):
- Prospective observational study
- Convenience sample of 64 patients (two lost to analysis)
- Patients were those requiring emergency intubation who did not tolerate preoxygenation with traditional methods, and were not predicted to have a difficult airway
- DSI was performed using ketamine resulting in notably improved oxygen saturations prior to intubation: 88.9% vs 98.8% (increase of 8.9%, 95% C.I. 6.4-10.9)
- Two patients with asthma improved sufficiently to avoid intubation all together
- There were no complications – two well oxygenated patients had minor reductions in their oxygen saturations but they did not receive nasal cannulae for pre/apneic oxygenation
Pharmacology

The agent of choice for DSI is ketamine. Ketamine functionally dissociates the thalamus from the limbic cortex. It does produce a sympathetic response that can be offset by the addition of a small dose of a benzodiazepine or labetalol\(^{(23)}\). It does not blunt spontaneous breathing or airway reflexes and patients that were agitated and confused become dissociated thereby allowing application of facemask or NIV. ‘A dose of 1mg/kg is given as a slow IV push, if appropriate dissociative state is not achieved further boluses of 0.5mg/kg can be given. This usually provides a patient that is calm in about 45seconds. Preoxygenation is then commenced in standard or other appropriate methods till a saturation of 100% is achieved. To adequately denitrogenate the alveoli, a further 2-3minutes of high-inspired oxygen is given\(^{(2)}\).

Dexmedetomidine is an alpha2 agonist that is an alternative to ketamine, as it does not give you the sympathomimetic effects. Dexmedetomidine is associated with only limited respiratory effects, even when dosed to plasma levels up to 15 times of those normally achieved during therapy, leading to a wide safety margin\(^{(24)}\). Given as a bolus of 1mcg/kg over 10min usually produces conditions suitable for preoxygenation. For continued sedation an infusion of 0.5mcg/kg/h can be started.

Each of the drugs has their drawbacks\(^{(22)}\):

Ketamine:
- Sympathomimetic effects (beneficial in some patients)
• Nausea and Vomiting (Usually on emergence)
• Increased salivation
• Very rarely airway obstruction and laryngospasm

Dexmedetomidine:
• Bradycardia
• Heart block
• Hypotension
• Rarely nausea

Other options for this procedural sedation include:
• Propofol
• Remifentanil
• Benzodiazepines

However these do not maintain airway reflexes and you may potentially end up with a situation where you have an inadequately oxygenated as well as apneic patient leading to disastrous consequences.

Ketamine and Dexmedetomidine are not without their negative effects as well, so each practitioner will have to weigh up the risks and benefits before selecting the drug to use.

One must consider the muscle relaxant used as well, as Suxamethonium is associated with increased oxygen utilization.\(^{(23)}\)
Delayed Sequence Intubation (DSI) Progression

**Patient**
A patient requiring emergent airway management, but resistant to pre-intubation preparations because of oedema

**Dissociation**
Administer a dissociative dose of Ketamine by slow IV-Push; administer additional doses until the pt is dissociated
10-15 seconds

**Preoxygenate**
Use Non-Rebreather Mask plus Nasal Cannula. If saturation is <95%, switch to Non-Rebreather for Non-Invasive CPAP. Ventilate for 3 minutes.
3 minutes

**Paralyze**
Administer Succinylcholine or Rocuronium

**ApOx**
Perform apneic oxygenation with nasal cannula
45-60 seconds

**Intubate**

Note: From our study, we found most patients will become dissociated between 1-1.5 mg/kg. Since the effects of ketamine are almost instantaneous and many side effects such as hyper-calcemia are dose dependent, it may make sense to administer a smaller than usual initial dose (1 mg/kg). If the patient doesn’t achieve dissociation with the initial dose, follow with additional aliquots of 0.5 mg/kg. Apnea may result from rapid pushes of ketamine, so push slowly or expect a brief, self-limited period of apnea.

Note: Other Procedures such as the placement of a nasogastric tube may also be performed during this stage.

Note: While two patients in this cohort were not intubated after dissociation, we cannot recommend this strategy without further study to establish safety.

Figure 8 (1)
CONCLUSION

Preoxygenation in the emergent airway before tracheal intubation is not to be taken lightly; the complications are more common than we anticipate, even with experienced hands. Basic principles of preoxygenation should be followed, and then augmented in a stepwise approach to ensure adequate preoxygenation is achieved.

Concepts of altered physiology in the critically ill must be kept in mind and a rational and methodological approach should be adhered when preparing for tracheal intubation. Emergency departments and intensive care units should have protocols in place for these very situations.

The concept of Delayed sequence intubation introduced to us by Scott Weingart is extremely valuable as it adds another skill to our armamentarium. By utilizing DSI in the delirious patient the practitioner has more control when intubating. The evidence thus far is small but the signal is that DSI seems to safe and effective way to manage an emergent airway.
REFERENCES


