

**DELAYED SEQUENCE INTUBATION**



*“Portrait of Antoine Laurent and Marie-Anne Lavoisier”, oil on canvas, 1788,  
Jacques-Louis David*

*“It took them only an instant to cut off that head but it is unlikely that a hundred years will suffice to reproduce a similar one”*

*Joseph Louis Lagrange on hearing of the execution of  
Antoine Laurent Lavoisier, 9th May 1794*

*Antoine Laurent Lavoisier was one of the greatest minds of the Enlightenment, indeed one of the greatest in history. Considered by many to have been to modern chemistry, as Isaac Newton was to classical physics, Niels Bohr, to quantum physics, Albert Einstein to relativity, Charles Darwin to biology, or Charles Lyell to geology, he took the dark art of medieval alchemy and turned it into a modern science. He was a brilliant polymath, in the old sense of the word, establishing the foundations of the modern understanding of respiratory physiology which stemmed from his work on oxygen. He was more than a scientist however, he was also a brilliant administrator and respected economist being deeply involved in the economic reform of late Eighteenth century France. He held a succession of important government posts at the highest levels. But he had one fatal flaw. He was an immensely wealthy aristocrat, proud of his status in life at a time when this was a very dangerous thing. One of his posts was as a “Farmer General” or collector of the King’s Taxes, a group that would not prove popular during the Revolutionary National Convention.... and its Reign of Terror.*

*In the late Eighteenth century, the millennia old notions of the four fundamental alchemical elements of the ancients, air, water, earth and fire, was being challenged by brilliant men that included Joseph Priestly, Joseph Black, Henry Cavendish and others, but the at the very vanguard of these was Antoine Laurent Lavoisier. These men systematically demonstrated that the four “elements”, were no such thing, they were in fact composites of still more fundamental substances, the true elements, and there were to be many more of these than just four. The shattering of the traditional world of alchemy was every bit as revolutionary as Copernicus’ shattering of the old Ptolemaic Universe, or, poignantly, in the field of human society, of Robespierre’s claim that sovereignty stemmed from the people, and not from the divine right of monarchs. In the field of the new chemistry Lavoisier was known for the discovery of the first true elements to be recognized, hydrogen and most famously of all oxygen. Priestley and Scheele had both produced oxygen before Lavoisier, but neither had a true appreciation of its nature nor did they understand the reactions that produced it. Lavoisier both appreciated that oxygen was a unique element and correctly described the chemical reactions required to produce it. Thus Lavoisier was the true discoverer of the element oxygen, even though he was not the first to produce it. Most famously at the time, he was able to disprove Priestley’s phlogiston theory of combustion. Phlogiston theory stated that all combustible materials were made of two parts. One part, called phlogiston, was given off when the substance containing it was burned, while the dephlogisticated part was thought to be its true form, or calx. Lavoisier showed that phlogiston did not even exist.*

*At the height of his scientific powers and fame, Revolution broke out in France. As an extremely high profile aristocrat and being closely associated with the Ancien Regime, especially in his capacity as a “Farmer General”, he immediately drew the scorn of radical Jacobin extremists of the National Convention. Along with many other Farmer Generals, he was called to account, essentially for the exploitation of the people, by the Revolutionary Tribunal, which in practice meant assured execution on the scaffold of the guillotine. Many were shocked that such a brilliant son of France, and a good and decent man, could be treated in this way, yet the most radical elements of the Jacobins had only hatred for any aristocrat so closely associated with the Ancien Regime. Many wanted to help Lavoisier but*

were too terrified of speaking up, during a time when one could get sent to the guillotine simply for the offense of being “lukewarm” towards or not showing enough fervor towards the Revolution! Friends, well placed politically, managed to arrange for Antoine’s wife, Marie-Anne, to privately plead he husband’s case with his chief accuser Antoine Dupin, but the meeting did not go well. Lavoisier’s biographer, Jean Pierre Poirier believes that Marie-Anne could have gone a long way towards saving her husband, but her highly aristocratic and somewhat detached manner did not go down well with Dupin and as much as she did her best, the trial went ahead. The “trial” was a foregone conclusion and Antoine Lavoisier along with twenty eight of his colleagues were found guilty of crimes against the people and on the 8th of May 1794, were sent to the guillotine in the Place de Revolution.

We have left to us a grand but touching portrait of Antoine Laurent Lavoisier with his wife Marie-Anne, painted just six years before his death at the high of his fame, by the immortal Jacques Louis David, who incidentally would become a member of the National Convention. They commissioned David to do the painting for the astonishing sum of 7000 livres. Antoine looks back lovingly to his wife, who was both his scientific muse and brilliant collaborator in her own right, with his work. Marie-Anne places a protective hand over her husband and looks back at us as if being momentarily disturbed from her important work with him. Both are dressed in the finest Ancien Regime garments, Marie-Anne with her masses of blonde curls, fine lace dress and blue silk ties and Antoine with his neat powdered wig, richly textured black velvet jacket, right leg stretched forward to show an elegant silver buckled shoe. It is an image of the very height of privileged bourgeoisie domestic bliss. Marie Anne is portrayed as the dominant personality, strong and aristocratic, staring directly back at the viewer who has interrupted their work, while Antoine seems almost meek and submissive, but also deeply loving towards his wife. Surrounding Antoine we see all the symbols of his greatest scientific achievements. On the table beside the inkwell we see his mercury gasometer with which he conducted experiments on the extraction of oxygen from mercuric oxide and which helped determine that air was not an element. On the floor lies a large glass flask evoking the equipment used in the determination of the composition of water, and the discovery that water, like air is not a fundamental element. To the left is a large portfolio sitting on an armchair that contains fine quality plates demonstrating Lavoisier’s work, skilfully drawn and engraved, under David’s supervision by Marie-Anne, an accomplished Artist in her own right.

People were horrified that France’s “Isaac Newton” had been sent to the scaffold by political fanatics. Eugene Cheverny wrote, “Everybody knew about the barbarous executions of these decent men. M de. Lavoisier, summoned the night before to present the balanced accounts, was condemned along with the others. He prepared them for death. They met their ends with great dignity. But the poor M. De. Boullongne was led to the scaffold in a pitiful state”.

But perhaps the most famous reaction of all came from Joseph Louis Lagrange, who on hearing of the execution of Lavoisier the next day exclaimed, “It took them only an instant to cut off that head but it is unlikely that a hundred years will suffice to reproduce a similar one”.

Antoine Laurent Lavoisier was one of the giants of the Enlightenment. He established oxygen as an element and was one of the first to understand not only its chemistry but also its vital importance to life. Over two centuries later we now manipulate the delivery life giving oxygen in ever more sophisticated ways, such as the Delayed Sequence Intubation. Antoine Lavoisier and Marie -Anne would have been well pleased.

## DELAYED SEQUENCE INTUBATION

### Introduction

**Delayed Sequence Intubation (DSI)**, is a relatively new technique, that can be thought of as a procedural sedation, where the procedure is **preoxygenation** of a patient.

**It is employed to provide for and optimize preoxygenation in hypoxic *uncooperative or intolerant* patients, who are critically unwell, and who are at high risk of oxygen desaturation during the apnoeic period of intubation.**

It is essentially a **rapid sequence intubation**, but with this *added component* of a procedural sedation in order to achieve adequate preoxygenation.

The procedure can also be supplemented by the technique of **apnoeic oxygenation**.

**Ketamine** is the best agent to use for DSI, as:

- **Airway reflexes are preserved**
- **Ventilation is preserved**
- It *rarely* causes vomiting during induction (more likely to occur at emergence)

**See also separate document on RSI (Critical Care Folder)**

### Pathophysiology

The shape of the curve demonstrates that at 90 % saturation, the patient is at risk of critically low oxygen levels (< 40 mm Hg PaO<sub>2</sub>) if even a **brief** period of time elapses without reoxygenation.

Patients will take a much longer time to desaturate from 100 % to 90 % than to go from 90 % to 70 %.

By optimally preoxygenating a hypoxic/ unwell patient, the safe apnoeic period during a RSI may be significantly improved.

**See Appendix below.**

### Indications

These include:

1. Patients not predicted to have a difficult airway:

*And*

2. Are **hypoxic/ unwell and are uncooperative/ intolerant of preoxygenation** via nasal prongs, non-rebreather mask, bag-valve-mask, and/or non-invasive ventilation

These patients are at high risk of oxygen desaturation during the apnoeic period of intubation.

*Possible additional uses:*

3. 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)
4. Occasionally DSI may **avert** the need for intubation as the patient (e.g. severe asthma):
  - With dissociated and sedation the asthmatic patient is no longer agitated and as oxygenation improves, intubation may not be necessary. Either allow the sedative to wear off or administer further boluses to maintain ongoing oxygenation. Note that this technique requires further study however.

### Contraindications

Contraindications to delayed sequence intubation include:

1. Predicted difficult airway
  - Consider awake technique instead.
2. Inadequate expertise present to manage an emergent intubation:
  - This is not a technique to use whilst waiting for back-up to arrive.
3. Paediatric airway scenarios
  - Not studied in this population.
4. Consider risk benefit in situations where ketamine may produce adverse effects; (i.e. aortic dissection, intra-cranial haemorrhage, acute coronary ischaemia, etc.)

### Technique

**Delayed sequence intubation requires careful preparation and good assistance.**

It is essentially a rapid sequence intubation, but with an added component of procedural sedation in order to achieve adequate preoxygenation.

Steps involve:

1. Identify agitated / hypoxic patient requiring intubation:

- A hypoxic patient, who requires intubation, but resists preoxygenation, because of delirium/ anxiety intolerance.
2. Administer induction agent:
- This should be **ketamine 1-2 mg/kg IV**
- Give by *slow* IV push to minimize risk of apnoea**
- Give an initial 1 mg/kg IV dose; then if the patient is not adequately dissociated, give further doses of 0.5 mg/kg IV until desired effect is achieved. This titration of dosing aims to minimise possible side effects such as apnoea or hypersalivation.**
3. Place non-rebreather mask and nasal cannula at 15 L/minute for each device
- The nasal cannula will assist in additional apneic oxygenation, following paralysis.
4. If SaO<sub>2</sub> is > 95 % then use:
- A **non-rebreather face mask** with a good seal at 15 L/min O<sub>2</sub> (will provide high FiO<sub>2</sub> with limited entrainment of air).
- If SaO<sub>2</sub> is < 95 % then use:
- Bag-valve -Mask with **PEEP valve** at 5-15 cm H<sub>2</sub>O with oral airway/ nasopharyngeal airways.
- Or*
- CPAP - NIV mask, set at 100 % oxygen with 5- 15 cm H<sub>2</sub>O
- This usually takes 3 minutes, but may take up to 10 minutes to reach adequate preoxygenation.
5. *Be ready to intervene:*
- If vomiting occurs
  - If oxygenation does not improve during this time then it may be necessary to proceed with rapid sequence intubation even with SaO<sub>2</sub> < 95 %
6. Administer neuromuscular blocker (suxamethonium or rocuronium) and wait 45-60 seconds:
- Apnoeic oxygenation continues during this time using 15 L/min O<sub>2</sub> via nasal prongs +/- continuing the BVM/ CPAP oxygenation.

- Once paralysis has occurred remove the non-rebreather/ BVM/ CPAP mask, (nasal prongs are left in situ).

7. Intubate the patient.

8. Confirm tube position.

Alternative induction agents to ketamine:

Ketamine is far and away the best agent to use for DSI, because of the advantages this agent has as listed above.

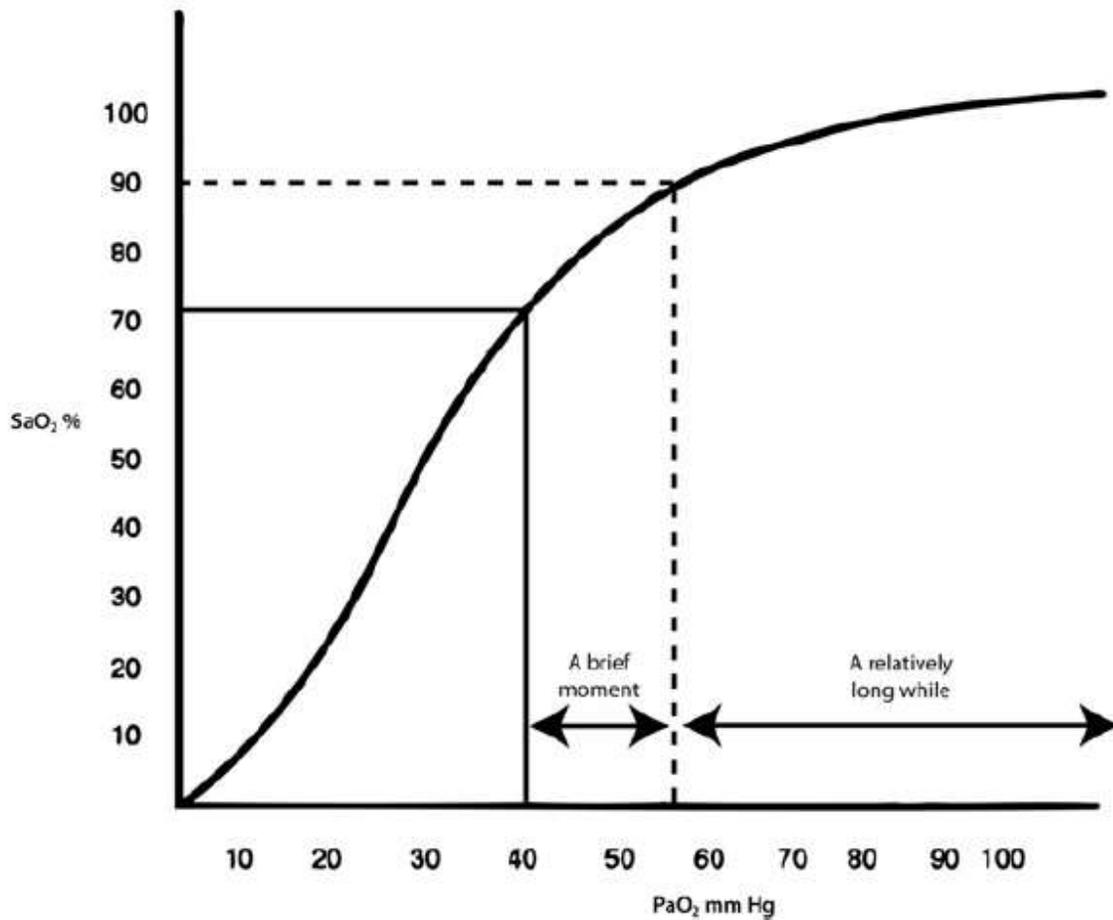
Propofol, fentanyl, thiopentone **cannot** be used for DSI

If there is a *significant contraindication* to ketamine, then alternative agents to ketamine could possibly include:

- Dexmedetomidine
- Remifentanyl (an ultra short acting opioid, given by continuous infusion).
- Droperidol (5 - 10 mg IV)

**Note however that these agents do not have the same desirable properties of rapidity of onset, preservation of airway reflexes, preservation of respiratory drive and safety profile compared to ketamine.**

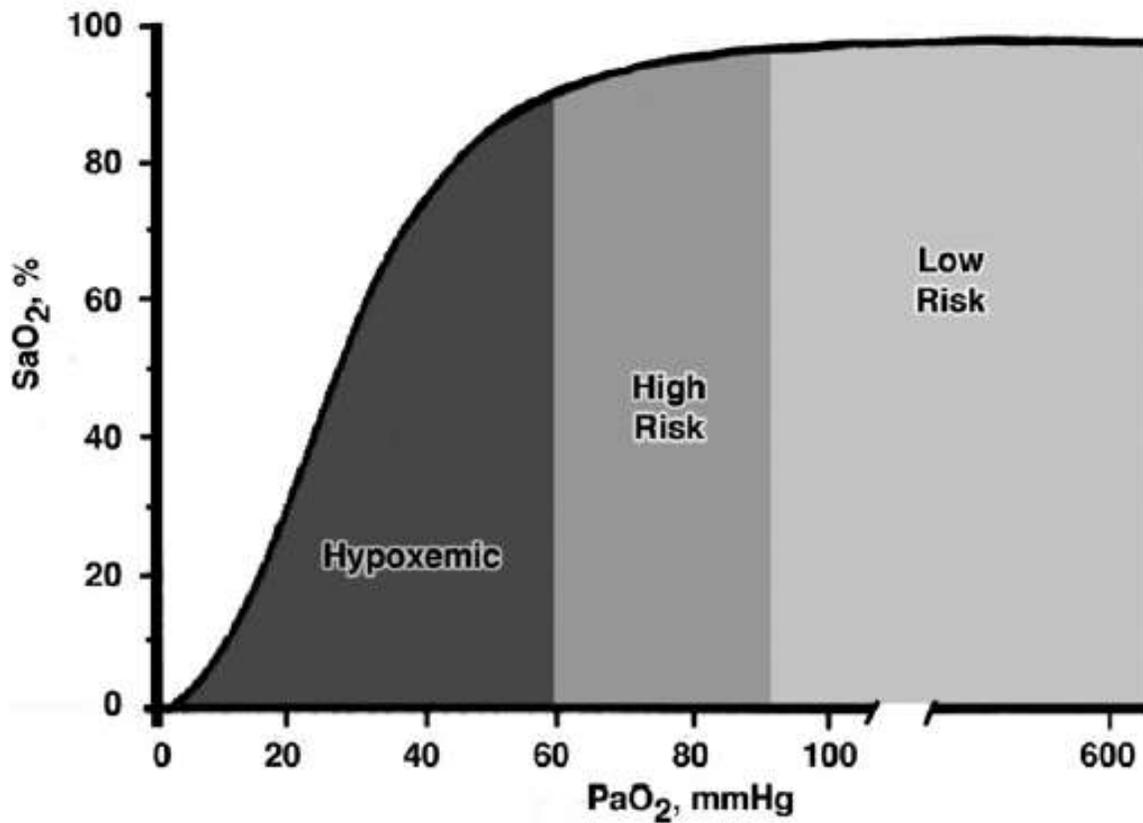
## Appendix 1



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*Oxyhemoglobin dissociation curve demonstrates the SaO<sub>2</sub> from various levels of PaO<sub>2</sub>. Risk categories are overlaid on the curve. Patients near an SaO<sub>2</sub> of 90% are at risk for precipitous desaturation, as demonstrated by the shape of the curve.*

## References

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*Acknowledgements:*

Dr Gerrard Marmor

April 2015.