Is inhalational induction justifiable in paediatric emergencies?

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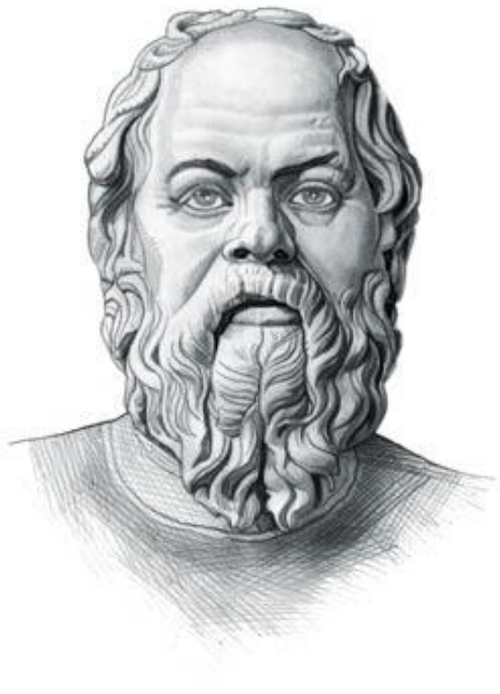
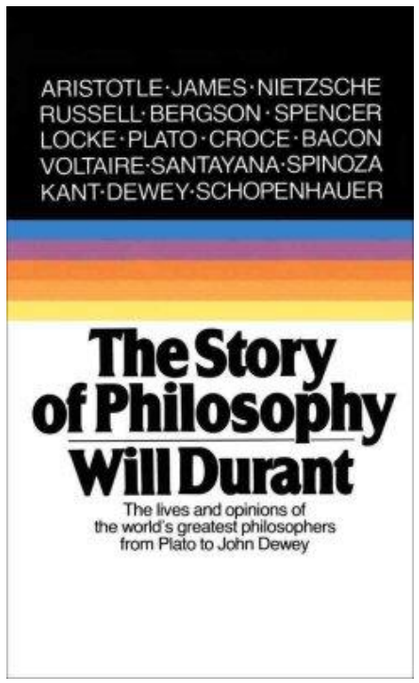


"The beginning of wisdom is the definition of terms."

–Socrates



“If you wish to converse with me,” said Voltaire,
“define your terms.”

–Will Durant
The story of philosophy
Chapter 2 part 3: the foundation of logic, page 59

Emergencies

- A B C
- Intervention required within 24 hours

Anatomical Airway Obstruction

- **Principle**: maintain spontaneous ventilation until the airway is secure
- **Rationale**: to retain some muscle tone in the upper airway and allow time for laryngoscopy and intubation
- Why not give a muscle relaxant? - to avoid the scenario where a muscle relaxant has been given, bag-mask ventilation proves difficult or impossible, the child becomes hypoxaemic, and cannot be intubated - CICO

The management of difficult intubation in children.

*Paediatric Anesthesia 2009; **19** (Suppl. 1): 77 - 87*

RM Walker and J Ellwood.

Anatomical Airway Obstruction

- Inhalational induction still popular in paediatrics
- ***NAP 4 census report*** - management of the predicted difficult airway in children:
  - Inhalational induction - 63%
  - Intravenous induction - 37%
  - Awake intubation - 0%

Anatomical Airway Obstruction

Canadian paediatric anesthesiologists prefer inhalational anesthesia to manage difficult airways: a survey

Canadian Journal of Anesthesia 2005; ***52****:3 pp 285 - 290*

Peter Brooks et al.

- 6 scenarios - web-based survey
- 63 responses from 136 invitations- experienced paediatric anaesthetists
- 2 scenarios - emergencies with a compromised airway
- 2 year old child with potential epiglottis needing emergency endotracheal intubation - **95% of respondents chose to keep the patient breathing spontaneously and 97% would use an inhalational agent to do this.**

Anatomical Airway Obstruction

Rigid bronchoscopy for foreign body removal: anaesthesia and ventilation

Pediatric Anesthesia 2004 ***14****: pp84 -89*

PT Farrell

- “in an emergency situation or with a distressed infant, establishing iv access immediately after inhalation induction is acceptable”
- “spontaneous ventilation must be maintained until it is certain that the child can still be ventilated under anaesthesia”
- “most experienced anaesthesiologists prefer inhalational rather than intravenous induction”

Anatomical Airway Obstruction

A child with a difficult airway: what do I do next?

Current Opinion in Anesthesiology 2012; ***25****(3): 326 -332*

T Engelhardt and M Weiss

“the recent NAP 4 audit suggests that spontaneously breathing adult patients who lost the airway do not recover rapidly. Full recovery of a child with lower oxygen reserves is even more unlikely and as yet not reported in the literature.”

Anatomical Airway Obstruction

***NAP 4 report**: Chapter 13 management of the CICV situation, page 113*

Recommendation: Even if it was not part of the initial airway management strategy, if CICV occurs and waking the patient up is not an option, a muscle relaxant should be given before determining the need to proceed to a surgical airway.

Anatomical Airway Obstruction

DAS 2015 guidelines for the management of the unanticipated difficult intubation in adults

Plan C - the final attempt at face-mask ventilation

- If face-mask ventilation is impossible - paralyze
- ensuring full paralysis offers a final chance of rescuing the airway without recourse to Plan D
- airway rescue via the front of neck should not be attempted without complete neuromuscular block

Anatomical Airway Obstruction

Cannot ventilate - paralyze!

Pediatric Anesthesia 2012 ***22*** *1147 - 1149*

M Weiss and T Engelhardt

- Treat functional airway obstruction
- Functional airway obstruction is the leading cause of difficult or failed facemask ventilation
- “a deeply anesthetized, hypoxic brain is unlikely to restart spontaneous breathing and establish airway patency. There is no way back…”

Anatomical Airway Obstruction

APA/DAS guidelines for the management of the unanticipated difficult airway in paediatric practice

Pediatric Anesthesia 2015 25 346 - 362

AE Black et al.

- “the CICV scenario is considered in the context of the paralysed child”

- “sugammadex should not be given to reverse rocuronium or vecuronium if the child is rapidly deteriorating with decreasing SpO2 and haemodynamic compromise”

Functional Airway Obstruction

Which port in a Storm? Use of suxamethonium without intravenous access for severe laryngospasm

RWM Walker and R Sutton

Anesthesia 2007 ***62****: 757 -759*

Suxamethonium 4 mg/kg into the deltoid muscle - should work within 1 min

Anterior mediastinal mass

Anterior mediastinal mass

Anesthetic management of children with an anterior mediastinal mass

Journal of Clinical Anesthesia 2010 ***22****: 159 -163*

PA Stricker, HG Gurnaney, and RS Litman

- **Spontaneous ventilation** was maintained in 21 of 46 cases

- 26 patients had signs and symptoms suggestive of cardiopulmonary compromise as well as radiologic evidence of respiratory or cardiovascular compression

  - muscle relaxant was avoided in 18 of these cases

  - 17 of these case received **iv sedation with spontaneous ventilation and a natural airway, often in the Semi-Fowler's position**

  - one complication in the 8 patients who received muscle relaxant and IPPV - bronchospasm that resolved with administration of a bronchodilator

Anterior mediastinal mass

The anaesthetic management of children with anterior mediastinal mass

*Anaesthesia 2008, **63**: 837 - 846*

HA Hack, NB Wright, and RF Wynn

- 53 anaesthetic charts available for inspection
- **25/53 - inhalational induction**; 2 of these in the sitting position, 1in the lateral position.
- 28/53 - iv induction in the supine position
- **18/53 - maintained spontaneous ventilation**; FM, LMA, ETT.
- 35/53 - IPPV
- no significant difference in the tracheal cross-sectional area

Risk of aspiration

- ***NAP 4*** - aspiration was the main cause of adverse outcome at induction

- ***NAP 4*** - aspiration was the cause of 50% of anaesthesia deaths and 53% of outcomes of death or brain damage

- ***Recommendation:*** On balance, rapid sequence induction should continue to be taught as a standard technique for protection of the airway. Further focused research might usefully be performed to explore its efficacy, limitations and also explore the consequences of its omission.

  Chapter 19, page 163

Risk of Aspiration

Pulmonary Aspiration in pediatric anesthetic practice in the UK: a prospective survey of specialist pediatric centres over a one year period

Pediatric Anesthesia 2013 ***23****: 702-711*

Robert W.M. Walker

- 1 year, 11 paediatric centres, denominator 118 371
- 2 per 10 000 cases for elective work
- 2.2 per 10 000 cases for non-elective work
- **no deaths**
- 5 cases with serious morbidity - needing PICU

Risk of Aspiration

Pulmonary Aspiration in pediatric anesthetic practice in the UK: a prospective survey of specialist pediatric centres over a one year period

Pediatric Anesthesia 2013 ***23****: 702-711*

Robert W.M. Walker

- **12** / 24 cases of pulmonary aspiration of gastric contents occurred **at induction**
- **7** /12 cases of pulmonary aspiration of gastric contents at induction = **iv induction**
- **5** / 12 cases of pulmonary aspiration of gastric contents at induction = **inhalational induction**
- **8** /12 cases of pulmonary aspiration of gastric contents at induction = **elective** cases (3 had inhalational induction)
- **4** /12 cases of pulmonary aspiration of gastric contents at induction = **non-elective** (2 had inhalational induction)

Risk of aspiration

Perioperative pulmonary aspiration in infants and children

Anesthesiology 1999; ***90****: 66 - 71*

MA Warner et al.

- 3.8 per 10 000 cases
- 2 per 10 000 for elective cases
- 25 per 10 000 for emergency cases
- 63 180 consecutive anaesthetics
- **no deaths**

Risk of aspiration

Pulmonary aspiration in pediatric patients during general anaesthesia: incidence and outcomes

Journal of Clinical Anesthesia 1998; 10: 95 - 102

LM Borland et al.

- 10.2 per 10 000 cases
- 50 880 anaesthetics
- **no deaths**

Risk of aspiration

Pulmonary aspiration under GA: a 13-year audit in a tertiary pediatric unit

Z Tan and SY Lee

*Pediatric Anesthesia 2016, **26**: 547-552*

- 22 cases of pulmonary aspiration / 102 425 general anaesthetic
- 2.15 per 10 000
- 12/ 22 - iv induction
- 10/ 22 - inhalational induction
- **iv vs inhalational induction odds ratio 1.139 (95%CI 0.457 - 2.818)**
- emergency surgery vs elective surgery odds ratio 4.321 (95% confidence interval 1.735 - 10.687)

Risk of aspiration

- minimise the **gastric volume** - fasting, prokinetics, and NG tube; use ultrasound to check

- increase the **pH** of gastric contents - sodium citrate, ranitidine, PPI

- **RSI** - cricoid pressure; apnoeic inducton

Effects of different combinations of H2 receptor antagonists with gastrokinetic drugs on gastric fluid pH and volume in children - a comparative study

*Int j Pharmacol Ther 1997; **35**: 561-654*

Kulkarni PN, Batra YK, Wig J

Risk of aspiration

Avoid:

- Decreasing intrathoracic pressure: airway obstruction, hiccup
- Elevating intra-abdominal pressure: laryngoscopy during light anaesthesia, coughing or straining during induction or intubation, inflating the stomach during bag-mask ventilation
- Oesophageal intubation
- Haste
- Hypoxaemia

Risk of aspiration - apnoeic induction?

Controlled rapid sequence induction and intubation - an analysis of 1001 children

D Neuhaus, A Schmitz, A Gerber, et al.

Pediatric Anesthesia 2013, 23: 734 - 740

- gentle face-mask ventilation prior to intubation, avoidance of cricoid pressure, non-depolarising neuromuscular blocking agent
- moderate hypoxaemia (SpO_2 80 - 89%) in 0.5%; n = 5
- severe hypoxaemia (SpO_2 < 80%) in 0.3%; n =3
- 1 episode of regurgitation without aspiration

Is cricoid pressure harmful?

- airway occlusion
- distorted anatomy
- failed intubation
- difficult or impossible face-mask ventilation
- relaxation of the lower oesophageal sphincter
- a trigger for vomiting?
- may provoke bucking or straining
- interferes with a smooth induction

Cricoid pressure: apply - but be ready to release

Anaesthesia 2016, 71, 999-1003

J Turnbull, A Patel, V Athanassoglou, JJ Pandit

Cricoid pressure

Aspiration and regurgitation prophylaxis in paediatric anaesthesia

*Pediatric Anesthesia 2001; **11**: 147-150*

Engelhardt T, Strachen L, Johnston G

- "Up to 50% of paediatric anaesthetists would not use cricoid pressure in the "full stomach" situation"

- Do you ***routinely*** employ the following ***prior to anaesthesia*** in ***all children regardless of risk factors?***

- **42%** (37 / 88 replies) would **routinely apply cricoid pressure** in **children < 1year** of age having **emergency surgery**

- **49%** (43 / 88 replies) would **routinely apply cricoid pressure** in **children aged 1 - 14** years having **emergency surgery**

Cricoid Pressure

Effect of cricoid force on airway calibre in children: a bronchoscopic study

British Journal of Anaesthesia 2010; ***104****: 71-74*

Walker RWM, Ravi R, Haylett K

- **5N** = the force required to cause **50% occlusion of the subglottic airway** with the application of cricoid pressure in **infants**

“Rapid sequence induction has no use in paediatric anesthesia”

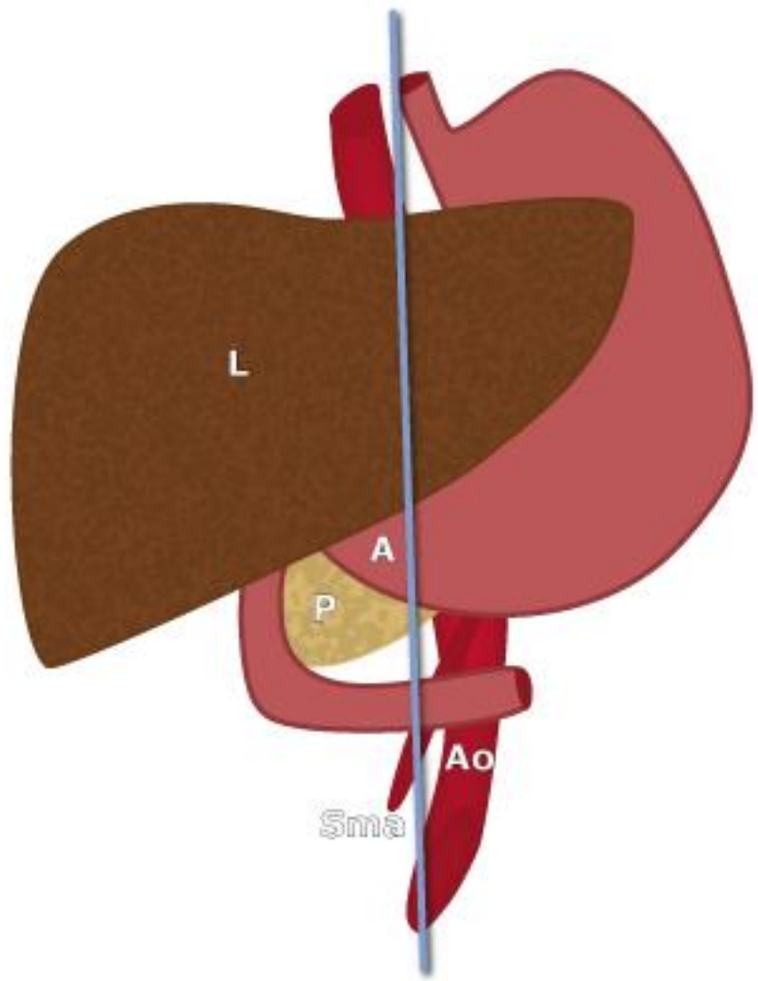
Pediatric Anesthesia 2015; ***25****: pp 5-8*

Thomas Englehardt

- “Regurgitation and vomiting with aspiration are processes elicited by direct laryngoscopy under **light anaesthesia** and **incomplete muscle paralysis**”
- Advocates mask ventilation with pressures not exceeding 10 -12 cmH_2O following induction and before intubation in paediatric RSI
- induction of sufficiently deep anaesthesia
- avoid cricoid pressure
- confirm complete muscle paralysis before laryngoscopy

Is cricoid pressure effective

- No RCTs
- Absence of evidence is not evidence of absence
- Argument from ignorance - a proposition is true because it has not yet be proved false
- Aspiration does occur despite the application of CP
- Anatomy - the oesophagus is postero-lateral to the cricoid ring in 50% of people; lateral displacement increases with CP, but it is the post-cricoid hypo pharynx that is compressed and occluded - MRI, videolaryngosocpy, attempts to pass 4mm NG tube



http://gastricultrasound.org/index.html

Gastric Ultrasound

- Gastric antrum
- Right lateral decubitus position – only the RLD antrum CSA and age were shown to be independent predictors of endoscopically suctioned gastric volume
- Sagittal or right para-sagittal
- Between the left lobe of the liver and the pancreas at the level of the aorta and superior mesenteric artery or inferior vena cava

Ultrasound assessment of gastric volume in the fasted pediatric patient undergoing upper gastrointestinal endoscopy: development of a predictive model using endoscopically suctioned volumes

Pediatric anesthesia 2015; ***25:*** *301 - 308*

Adam O. Spencer, Anrew M Walker, Alfred K. Yeung, et al.

Gastric Ultrasound

Qualitative assessment

- Grade 0: no fluid visible in the antrum in either the supine or RLD position
- Grade 1: antral fluid visible in the RLD position but not in the supine position
- Grade2: antral fluid visible in both the supine and RLD position

Quantitative assessment

- Antral cross-sectional area in the RLD position
- Volume = -7.8 + (3.5 x RLD CSA) + (0.127 x age in months)

Ultrasound assessment of gastric volume in the fasted pediatric patient undergoing upper gastrointestinal endoscopy: development of a predictive model using endoscopically suctioned volumes

Pediatric anesthesia 2015; ***25:*** *301 - 308*

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Gastric ultrasound in babies with hypertrophic pyloric stenosis undergoing pyloromyotomy

- 34 infants
- Ultrasound of gastric antrum in the right lateral decubitus position before and after aspiration of gastric contents through 10Fr gastric tube
- Ultrasound examination before aspiration failed in 3/34 - gas in the stomach or infant agitation
- No failed examinations after gastric aspiration
- 9/31 empty stomach on first ultrasound
- 22/31 full stomach on first ultrasound
- The aspirated gastric volume correlates with the antral cross sectional area measured in the RLD – Pearson correlation coefficient 0.83 (95% CI 0.62 -0.93; $p<0.0001$)
- 30/34 non-rapid sequence induction

Ultrasound assessment of the gastric contents for the guidance of the anaesthetic strategy in infants with hypertrophic pyloric stenosis: a prospective cohort study

British Journal of Anaesthesia 2016; ***116(5)****: 649-54*

A.C. Gagey, M. de Queiroz Siqueira, F.P. Desgranges, et al.

The humane argument
The pragmatic argument

- Have you ever induced anaesthesia via an IO?

- Careful assessment, good judgement, good decision making, smooth execution

Conclusion
Is inhalational induction justifiable in paediatric emergencies?

- Anatomical Airway Obstruction – yes
- Anterior mediastinal mass – yes
- Hypertrophic pyloric stenosis – yes
- Neonatal surgery – yes
- Older children at risk of aspiration – not my first choice but I would seldom rule it out completely

Conclusion
To reduce the risk of aspiration

- Reduce the gastric volume
- Increase the pH of the gastric contents
- Smooth induction
- Ensure an adequate depth of anaesthesia before attempts at intubation
- Complete muscle paralysis before laryngoscopy