The role of high flow nasal oxygen therapy in anaesthesia

ABSTRACT

The delivery of oxygen is a key component of anaesthetic practice. High flow nasal oxygen therapy is a relatively new addition to more traditional means of oxygenation which provides heated and humidified flows of controlled oxygen/air mixes achieving rates of up to 120 litres/min. The physiological benefits include nasopharyngeal dead space washout, reduced work of breathing, alveolar recruitment, maintained mucociliary function and the ability to provide apnoeic oxygenation. This article considers the current evidence for high flow nasal oxygen therapy in perioperative anaesthetic care during pre-oxygenation and intubation, management of the difficult airway, oxygenation for shared airway surgery, extubation and postoperative support, obstetric and paediatric anaesthesia.

The ability to deliver oxygen to a patient is a mainstay of anaesthetic practice. Although often uneventful, airway manipulation may be complicated by adverse outcomes with the risk of hypoxia, hypoxic arrest and related sequelae.

The importance of oxygenation at all costs is reflected in the 4th National Audit Project of the Royal College of Anaesthetists (Cook et al, 2011) and in the plethora of Difficult Airway Society guidelines – intubation (Frerk et al, 2015), intubation in critically ill adults (Higgs et al, 2018), extubation (Popat et al, 2012), obstetric (Mushambi et al, 2015) and paediatric (https://www.das.uk.com/files/APA2-UnantDiffTracInt-FINAL.pdf). This primacy of oxygenation has resulted in a paradigm shift in terminology from 'can't intubate can't ventilate' to 'can't intubate can't oxygenate' (Chrimes and Cook, 2017).

High flow nasal oxygen therapy is a system for delivering warm, humidified oxygen and air mixtures at flows up to 120 litres/min. Inspired oxygen concentration (FiO_2) can range from 21% to 100%. The Difficult Airway Society intubation guidelines (Frerk et al, 2015) acknowledge the potential efficacy of high flow nasal oxygen therapy as a tool for preoxygenation and apnoeic oxygenation; however, the authors did not consider there to be enough evidence to specifically endorse its use. Since the publication of these guidelines, high flow nasal oxygen therapy is increasingly regarded as a potential 'game-changer' in airway management with a growing body of opinion and evidence regarding its use in elective and emergency anaesthesia, intensive care and the management of airway emergencies (Nekhendzy, 2017). This attitudinal change is reflected in the most recent Difficult Airway Society guidelines for the management of tracheal intubation in critically ill adults which advocate high flow nasal oxygen therapy as a valid alternative or adjunct to traditional oxygen delivery systems (Higgs et al, 2018).

This narrative review concerns the role of high flow nasal oxygen therapy in perioperative anaesthetic airway management. A detailed review of its role in the emergency room, and adult or paediatric critical care is beyond the scope of this article.

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Components of a high flow nasal oxygen therapy system

High flow nasal oxygen therapy comprises an oxygen/air blender, used to control flow and FiO_2 delivery, a heater-humidifier (conditioning the gas temperature to 37°C and absolute humidity up to 44 mgH_2O/litre) and a delivery system comprising a sterile water reservoir, non-condensing circuit and patient interface system. There are several devices available with flow rates up to 80 litres/min. Administration of high flow nasal oxygen therapy requires a high pressure gas supply of air and oxygen. An example of the system is shown in *Figure 1*.

Physiology

Table 1 summarizes the fluid dynamics and physiology underpinning high flow nasal oxygen therapy.

Indications and contraindications

Historically, the principal use of high flow nasal oxygen therapy has been in neonatology, but more recently its application has extended into adult intensive care and anaesthesia. Specific areas of interest for high flow nasal oxygen therapy in anaesthesia include:

- Difficult airway management
- Pre- and apnoeic oxygenation before intubation
- Rapid sequence induction
- Awake fibreoptic intubation
- Extubation and postoperative support
- Surgical procedures involving the airway
- Obstetric and paediatric anaesthesia.

Currently there are no published guidelines describing contraindications to high flow nasal oxygen therapy. Guidance on the use of non-invasive ventilation is not

directly translatable as there are situations where high flow nasal oxygen therapy can be used effectively where non-invasive ventilation would be contraindicated (e.g. patient apnoea and shared airway surgical procedures). The authors propose contraindications to high flow nasal oxygen therapy in anaesthesia include:

- Agitated, uncooperative or non-consenting patients
- Procedural oxygenation for those with a high aspiration risk
- Complete airway obstruction
- Maxillofacial trauma
- Basal skull fracture.

Pre- and apnoeic oxygenation before intubation

Preoxygenation is the administration of 100% oxygen to a patient before the induction of anaesthesia. It denitrogenates the functional residual capacity creating an oxygen reservoir in the lungs. This provides time, after the onset of apnoea, to secure the airway (e.g. by intubation) before hypoxaemia occurs. Apnoeic oxygenation, in contrast, is the provision of supplemental oxygenation without ventilation at the airway after the induction of anaesthesia. It can be used as an adjunct to preoxygenation to extend a patient's safe apnoea time – the rate of alveolar oxygen absorption being greater than capillary carbon dioxide (CO_2) accumulation results in a pressure gradient generating a mass flow of gas from a patent pharynx to the alveoli. The Difficult Airway Society intubation guidelines recommend the use of standard nasal prongs at flows of 5–15 litres/min for apnoeic oxygenation (Frerk et al, 2015).

While conceptually high flow nasal oxygen therapy might offer advantages over traditional pre- and apnoeic oxygenation techniques, studies (*Table 2*) are ultimately inconclusive and underpowered. Moreover, areas of particular interest are situations where difficult and prolonged intubations are more prevalent, but there is a paucity of data for the provision of high flow nasal oxygen therapy in these scenarios. Nevertheless, despite the lack of robust evidence, high flow nasal oxygen therapy has gained traction and is advocated as being at least comparable to standard nasal oxygen for the intubation of the critically ill patient (Higgs et al, 2018).

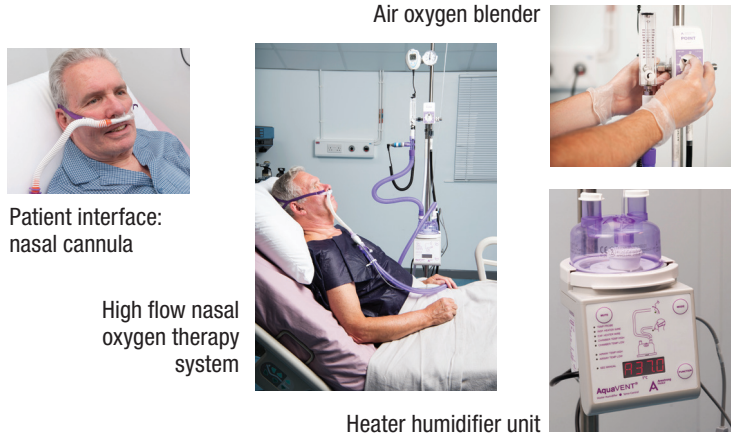

Figure 1. Components of a high flow nasal oxygen therapy system.

Rapid sequence induction

Rapid sequence induction of anaesthesia is used to prevent aspiration of gastric contents in patients who are inadequately fasted, have impaired gastric emptying or are known to have a history of gastric reflux. It is commonly used during emergency surgery. Conceptually pre- and

Table 1. High flow nasal oxygen therapy: proposed physiological effects and mechanisms of action

Physiological effect	Mechanism of action
Nasopharyngeal dead space washout	High flow nasal oxygen therapy generates a reservoir of oxygen within the nasopharyngeal cavity dead space – this results in less rebreathing of carbon dioxide (Dysart et al, 2009). There is consequently a reduction in arterial carbon dioxide concentration, respiratory effort becomes more efficient and thoraco-abdominal synchrony improves (Nillius et al, 2013)
Reduced work of breathing	High flow nasal oxygen therapy delivers heated gases with 100% relative humidity – this preconditioning means there is less metabolic demand placed on the patient to warm or humidify the gases by normal physiological mechanisms. Moreover, the high flow rates are at least equal to peak inspiratory flow – this minimizes the nasopharyngeal inspiratory resistance and decreases resistive breathing effort (Dysart et al, 2009)
Alveolar recruitment or positive end expiratory pressure effect	High flow nasal oxygen therapy is associated with the generation of positive airway pressure and the end-expiratory lung volume is greater with high flow nasal oxygen therapy than with low flow oxygen therapy. Positive pressure improves alveolar recruitment and reduces ventilation–perfusion mismatch. The positive pressure generated by high flow nasal oxygen therapy depends on: ■ flow rate ■ whether the mouth is closed or open ■ the size of the nasal cannula in relation to the nostrils and the geometry of the upper airways (Groves and Tobin, 2007; Parke et al, 2009)
Accurate inspired oxygen fraction	High gas flow rates increase the accuracy of the inspired oxygen fraction because the amounts of ambient air entrained are comparatively minimal (Sim et al, 2008)
Maintained mucociliary function	The humidified and warmed gas delivered to the patient reduces the viscosity of secretions and thus can facilitate and enhance mucociliary clearance. A reduction in the dryness of the upper airways generally improves comfort for patients (Dysart et al, 2009)

Table 2. Pre- and apnoeic oxygenation before intubation

Reference	Study type	Study design	Population	Main results and observations
Miguel-Montanes et al (2015)	Non-randomized prospective 'quasi-experimental' single centre study	Comparison of 3 minutes preoxygenation via a 15-litre non-rebreathing reservoir face mask to 60 litres/min high flow nasal oxygen therapy	101 adult patients with hypoxaemia requiring intubation on intensive care unit	■ Pulse oximetry oxygen saturation (SpO_2) higher in the high flow nasal oxygen therapy group at the end of both preoxygenation and intubation (100 *vs* 94%) ■ Fewer oxygen desaturations (<80%) with high flow nasal oxygen therapy ■ No arrhythmias or cardiac arrests observed in the high flow nasal oxygen therapy
Semler et al (2016)	Single centre randomized control trial	Preoxygenation with non-rebreathe facemask, bi-level positive airway pressure, bag valve mask or standard nasal cannulae. Then a comparison of apnoeic oxygenation with high flow nasal oxygen therapy at inspired oxygen fraction 100% and 15 litres/min during laryngoscopy to no peri-laryngoscopy supplemental oxygen therapy	150 adult patients on intensive care unit (46 further patients were excluded because of the urgency of the procedure or anticipated difficult airways)	■ No statistical difference in lowest SpO_2 (92 *vs* 90%) ■ Only five patients not intubated first time ■ 12 patients critically desaturated <80% with high flow nasal oxygen therapy *vs* 18 who received no apnoeic oxygenation
Vourc'h et al (2015)	Multicentre randomized control trial	Comparison of high flow nasal oxygen therapy to high flow face mask oxygenation during preoxygenation and apnoeic oxygenation	119 adult intensive care unit patients with hypoxaemic respiratory failure	■ No statistical difference in lowest SpO_2 (91.5 *vs* 89.5%) ■ No difference in first pass intubation ■ No difference in intubation adverse events, critical desaturation <80% or mortality

apnoeic oxygenation with high flow nasal oxygen therapy may provide additional time for airway manipulation during rapid sequence induction, which may be of use in both predicted and the unanticipated difficult airway.

However, the literature specifically examining the use of high flow nasal oxygen therapy during rapid sequence induction is limited. For example, a survey (Sajayan et al, 2016) explored the practice of rapid sequence induction in the UK and revealed that only 6% of respondents routinely use peri-laryngoscopy apnoeic oxygen techniques, although the authors did not differentiate between standard nasal oxygen (via nasal cannula at variable flow rates) and high flow nasal oxygen therapy. Furthermore, a randomized control trial by Mir et al (2017) of 40 patients, with an average body mass index of 26 kg/m^2, compared high flow nasal oxygen therapy to face mask preoxygenation and demonstrated no significant differences after rapid sequence induction between the two groups in terms of oxygen saturation (SpO_2), partial pressure of oxygen (PaO_2) and carbon dioxide ($PaCO_2$) in arterial blood, or pH. Despite comparable intubation grades between the groups, they reported a statistically significant increased mean apnoea time until intubation in the high flow nasal oxygen therapy group of 248 *vs* 123 seconds. The authors postulated that this was because the unblinded operator undertook a more considered laryngoscopy rather than suggesting that high flow nasal oxygen therapy prolonged the time taken to secure the airway. Notably, the authors did not provide apnoeic oxygenation by standard nasal cannula in the control group during laryngoscopy.

Awake fibreoptic intubation

Awake fibreoptic intubation is a core skill in the management of known or predicted difficult airways, and the 4th National Audit Project of the Royal College of Anaesthetists mandated that hospitals must be able to provide it (Cook et al, 2011). There is currently no gold standard technique of procedural oxygenation despite evidence that the use of high flow nasal oxygen therapy can improve oxygenation and mitigate desaturation during awake fibreoptic intubation.

In a prospective observational study Badiger et al (2015) used high flow nasal oxygen therapy during awake fibreoptic intubation in 50 patients. They had no difficulty intubating nasally despite the presence of the nasal cannulae and reported no desaturation or hypercapnia.

In a further prospective observational cohort study of 600 patients undergoing awake fibreoptic intubation (El-Boghdadly et al, 2017), high flow nasal oxygen therapy was used in 49% of all cases, although as the study progressed over time its use increased to almost 100%. Both the incidence of complications (9.2% *vs* 12.7%) and desaturations (1% *vs* 2%) were reduced in the high flow nasal oxygen therapy group without reaching statistical significance. However, the authors observed an increased incidence of over-sedation in the high flow nasal oxygen therapy group (3.4% *vs* 1%) which could be a result of increased confidence in maintaining oxygenation by the operator allowing for a deeper plane of sedation. Despite the lack of statistically significant benefit, the authors reported that high flow nasal oxygen therapy is now the standard oxygenation strategy for awake fibreoptic

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intubation in their institute. This is consistent with the recommendation of oxygenation for awake intubation with 'for example, high flow nasal oxygen therapy' made by Higgs et al (2018).

Extubation and postoperative support

Pre-oxygenation before extubation is considered standard practice, particularly in the high-risk patient. Postoperative respiratory embarrassment and hypoxaemia are clinically and financially burdensome, increasing morbidity, mortality and length of stay (Miskovic and Lumb, 2017).

High flow nasal oxygen therapy can be used immediately post-extubation to provide oxygenation as an alternative to conventional face mask methods. However, published research is dominated by the use of high flow nasal oxygen therapy for extubation on the intensive care unit (as reviewed by Papazian et al, 2016) and may not be directly translatable to anaesthesia.

Nevertheless, high flow nasal oxygen therapy interfaces are reported as being better tolerated than face masks with fewer pressure-related skin lesions, and having improved oxygenation and other physiological parameters with at least a comparable requirement for re-intubation compared to alternatives (Stéphan et al, 2015; Hernández et al, 2016).

However, there is scope for further work in this area as patient outcome data remain sparse. At best, the evidence suggests that high flow nasal oxygen therapy is not inferior to standard oxygen delivery methods and theoretically may confer some advantages.

Surgical procedures involving the airway

Prolonged apnoeic oxygenation with high flow nasal oxygen therapy has shown promise during maintenance of anaesthesia for shared airway procedures, including laryngo-tracheal surgery and fibreoptic bronchoscopy. An educational article claimed that high flow nasal oxygen therapy has the potential advantage of avoiding the risks associated with jet ventilation and can provide superior gas exchange to low flow techniques (Pearson and McGuire, 2017). However, in the absence of ventilation one of the limitations of apnoeic oxygenation with high flow nasal oxygen therapy is that it leads to an increase in $PaCO_2$ and respiratory acidosis (Nekhendzy, 2017).

Patel and Nouraei (2015) published a well-conducted case series: the original THRIVE (transnasal humidified rapid-insufflation ventilatory exchange) study which demonstrated extended apnoea times using high flow nasal oxygen therapy in patients with difficult airways receiving general anaesthesia for hypopharyngeal or laryngotracheal surgery. Patients were pre-oxygenated using high flow nasal oxygen therapy and then apnoeic oxygenation was provided for an extended period until either the airway was secured, jet ventilation was commenced or spontaneous ventilation returned. They achieved apnoea times of 5–65 minutes with no oxygen desaturations greater than 90% and reported mean rates of end tidal carbon dioxide ($ETCO_2$) rises of 0.15 kPa/min.

Subsequent not dissimilar studies, summarized in *Table 3*, achieved comparable apnoea times with high flow nasal oxygen therapy, with To et al (2017) concurring with Patel and Nouraei (2015) that patients with a high body mass index may be more predisposed to rapid desaturation with high flow nasal oxygen therapy than patients with a normal body mass index. They recommended careful planning to minimize surgical time in obese patients and those with complex stenosis.

These studies also explored CO_2 accumulation in greater detail with Gustafsson et al (2017) reporting comparable rates to Patel and Nouraei (2015) of mean $ETCO_2$ rise (at 0.12 kPa/min). However, their rate of mean $PaCO_2$ rise was disproportionately greater at 0.24 kPa/min. This finding is broadly consistent with data provided by Lyons and Callaghan (2017) showing a mean $ETCO_2$ rise of 0.17 kPa/min compared to a mean rise in $PvCO_2$ (partial pressure of carbon dioxide in venous blood) of 0.21 kPa/min. This suggests that anaesthetists should be aware that capnography at the end of the procedure underestimates carbon dioxide accumulation in blood.

Interestingly, in contrast to the aforementioned studies, a retrospective observational study by Booth et al (2017) examined the use of high flow nasal oxygen therapy while maintaining spontaneous ventilation. This included 26 adult patients with airway compromise or respiratory distress (16 stridulous, 10 dyspnoeic) undergoing airway surgery. Anaesthesia was induced and maintained in a protocolised fashion using a propofol infusion (Marsh TCI model) and patients were allowed to breath for themselves. Median oxygen saturations were 100% (range 97–100%) during induction, with spontaneous ventilation maintained in all patients and there were no episodes of complete airway obstruction. They achieved a median duration of spontaneous ventilation of 44 minutes (range 18–100 minutes) including the staged induction period (ranging from 14 to 26 minutes). They measured the $ETCO_2$ at the end of the period of spontaneous ventilation using a supraglottic airway or endotracheal tube and compared this to baseline levels recorded via a face mask at the start. Over this period, there was an $ETCO_2$ rise of 0.03 kPa/min which is unsurprisingly less than that reported with apnoeic techniques. Moreover, they achieved an extended use time of 56 minutes in seven patients with a body mass index >35 kg/m^2. This contrasts with the shorter apnoea times that Patel and Nouraei (2015) achieved in THRIVE and may reflect the significance of spontaneous ventilation with high flow nasal oxygen therapy particularly in the obese population.

Table 3. Studies using high flow nasal oxygen therapy as an apnoeic oxygenation technique for surgical procedures involving the airway

Reference	Study type	Study design	Population	Main results and observations
Patel and Nouraei (2015)	Single centre prospective case series	■ Preoxygenation with high flow nasal oxygen therapy 100% O_2 at 70 litres/min for 10 minutes ■ Apnoeic oxygenation at 70 litres/min until the airway was secured, jet ventilation commenced, or spontaneous ventilation resumed	■ 25 patients ■ Hypopharyngeal or laryngotracheal surgery ■ 12 obese patients ■ Body mass index range 18–52 kg/m^2 ■ ASA 1–4 (median 3) ■ Nine stridulous patients ■ Predicted difficult airways – median Mallampati grade 3	■ Mean apnoea times 17 minutes ■ No SpO_2 desaturations <90% ■ Rate mean $ETCO_2$ increase 0.15 kPa/min ■ Mean $ETCO_2$ 7.8 kPa ■ Median intubation grade was 3
Gustafsson et al (2017)	Single centre prospective randomized trial	■ Preoxygenation with high flow nasal oxygen therapy 100% O_2 at 40 litres/min for at least 3 minutes ■ Apnoeic oxygenation at flows of 70 litres/min	■ 30 patients ■ Laryngoscopic surgical procedures ■ Body mass index <30 kg/m^2 ■ ASA 1–2	■ Mean apnoea time 22.5 minutes ■ No SpO_2 desaturations <91% ■ Rate $PaCO_2$ increase 0.24 kPa/min ■ Rate mean $ETCO_2$ increase 0.12 kPa/min ■ End procedure mean $ETCO_2$ 7.4 kPa ■ Mean pH decline 7.44 to 7.14 over 30 minutes ■ No malignant arrhythmias
Lyons and Callaghan (2017)	Single centre prospective case series	■ Preoxygenation with high flow nasal oxygen therapy 100% O_2 at 80 litres/min for 3 minutes ■ Apnoeic oxygenation at flows of 80 litres/min ■ Supraglottic airway device placed at end of procedure	■ 28 patients ■ Laryngotracheal surgical procedures ■ Median Mallampati grade 1 ■ Mean body mass index 24.8 kg/m^2	■ Median apnoea times 19 minutes ■ Four patients desaturated to SpO_2 85–90% with one improving with increased flows of 120 litres/min ■ Rate mean $PvCO_2$ increase 0.21 kPa/min ■ Rate mean $ETCO_2$ increase 0.17 kPa/min ■ End procedure mean $ETCO_2$ 8.47 kPa ■ Mean venous pH 7.23 (at 15 minutes)
To et al (2017)	Single centre case series	■ Preoxygenation with high flow nasal oxygen therapy ■ Apnoeic oxygenation at flows of 70 litres/min	■ 17 patients with subglottic stenosis	■ Median apnoea time 18 minutes ■ Rate $ETCO_2$ increase 0.17 kPa/min ■ End procedure median $ETCO_2$ 7.4 kPa ■ Two patients desaturated to 80% after 25 minutes apnoea – one with a body mass index of 35 kg/m^2 and difficult surgical access ■ Surgeons reported improved surgical access

ASA = American Society of Anesthiologists class; $ETCO_2$ = end tidal carbon dioxide; $PaCO_2$ = partial pressure of carbon dioxide in arterial blood; $PvCO_2$ = partial pressure of carbon dioxide in venous blood; SpO_2 = pulse oximetry oxygen saturation

Obstetric anaesthesia

Difficult intubation is more frequent in the obstetric population with failed intubation rates quoted as high as 1 in 390 (Kinsella et al, 2015). The gravid uterus results in a reduced functional residual capacity and increased metabolic rate, thus predisposing the mother to rapid desaturation and hypoxaemia.

The joint Obstetric Anaesthetists Association and Difficult Airway Society obstetric intubation guidelines (Mushambi et al, 2015) state that nasal oxygen should be considered at 5 litres/min during pre-oxygenation. At the time of publication high flow nasal oxygen therapy was recognized as an option but not openly advocated because of a clear lack of evidence in the obstetric population – this remains the case.

Paediatric anaesthesia

Children are less able to tolerate apnoea than adults, experiencing a greater rapidity in oxygen desaturation and hypoxaemia because of the higher basal metabolic rates of oxygen consumption, reduced functional residual capacity and a higher closing capacity (Jagannathan and Burjek, 2017).

Unanticipated difficulty managing a paediatric airway can result in adverse outcomes and oxygen desaturation during attempted intubation can result in the need to revert to face mask ventilation. Both repeated instrumentations to facilitate intubation and paediatric face mask ventilation are associated with airway complications (Fiadjoe et al, 2016).

KEY POINTS

- High flow nasal oxygen therapy provides humidified and heated controlled inspired oxygen/air mixtures and is an alternative to traditional means of perioperative oxygenation.
- While there is growing evidence in the literature highlighting its potential utility there are no published guidelines describing its indications and contraindications.
- Despite there being no large randomized control trials there is an increasing body of opinion advocating its use – particularly during intubation of the critically ill, for awake fibreoptic intubation, and oxygenation during short surgical procedures involving the airway.

In paediatrics, high flow nasal oxygen therapy has been used for many years in paediatric intensive care for awake, spontaneously breathing children with respiratory failure and for ventilator weaning, typically using flows of 2 litres/kg/min and 1 litre/kg/min for neonates and infants respectively (Milési et al, 2014). However, the use of high flow nasal oxygen therapy during anaesthesia is less well established.

Humphreys et al (2017a) conducted a study on 48 healthy children (0–10 years old) presenting for elective surgery. After induction of anaesthesia and onset of apnoea all patients had 3 minutes of face mask ventilation using 100% oxygen. The control arm had supplementary oxygen removed and a jaw thrust applied only; the intervention arm received a weight-guided flow rate of 1–2 litres/kg/min of high flow nasal oxygen therapy at 100% FiO_2. Time taken to desaturate to 92% was measured. The intervention group SpO_2 was maintained at 97% or more with apnoea times more than twice those expected by age: 192 seconds in the <6-month age group, up to 430 seconds in the 6–10-year-old group. Transcutaneous CO_2 clearance in both groups demonstrated similar rates of CO_2 accumulation at 2.4 mmHg/min.

Riva et al (2018) compared apnoea times using high flow nasal oxygen therapy at 2 litres/kg/min (30% or 100% FiO_2) to low flow nasal cannula oxygen at 0.2 litres/kg/min. They randomized 60 healthy children (aged <6 years) after the induction of anaesthesia and onset of apnoea. Their apnoea times were recorded until either desaturation to 95%, transcutaneous CO_2 >65 mmHg or 10 minutes duration. High flow nasal oxygen therapy at 30% FiO_2 achieved shorter apnoea times than 100% FiO_2 because the patients desaturated to 95%, whereas the endpoint in the 100% FiO_2 groups was primarily the result of transcutaneous CO_2 rises. There was no statistical difference between the low flow nasal cannula and high flow nasal oxygen therapy 100% FiO_2 groups with median apnoea times of 6.9 and 7.6 minutes respectively. No patients in the 100% FiO_2 high flow nasal oxygen therapy arm desaturated to <95% and more achieved apnoea times of 10 minutes than the low flow group. Their mean rate of transcutaneous CO_2 increase was 4.13 mmHg/min. The greater rate of CO_2 accumulation than that seen by Humphreys et al (2017a) may reflect the increased basal metabolic rate in the younger cohort. It is clear there is a greater rate of CO_2 accumulation than in adult studies (Patel and Nouraei, 2015; Gustafsson et al, 2017).

A further series by Humphreys et al (2017b) successfully demonstrated the use of 100% FiO_2 age-adjusted flow high flow nasal oxygen therapy in 20 children aged 5 days to 11 years for a variety of indications including airway surgery, flexible bronchoscopy, predicted difficult airway and comorbid apnoea risk. Across the series, the average SpO_2 was 96% and the lowest was 77%. One patient required rescue oxygenation.

Conclusions

Despite there being no large multicentre randomized control trials high flow nasal oxygen therapy appears to have established a toehold in anaesthetic practice with numerous publications highlighting its feasibility, practicality and safety. The most convincing evidence of its advantage over alternative techniques is the provision of apnoeic oxygenation during short surgical or other shared airway procedures. However, the full utility, indications and contraindications of high flow nasal oxygen therapy are not yet completely understood with little in the literature detailing its current usage in day-to-day practice.

Difficult Airway Society tracheal intubation guidelines advocate the use of high flow nasal oxygen therapy as an alternative to conventional oxygenation techniques at best (Higgs et al, 2018). This reflects the current evidence base being limited to small studies, with many exhibiting control group bias, that may not be transferable to all patient groups.

Although best clinical practice is ideally informed by robust randomized control trials, it may prove difficult to achieve in all cases – as it seems implausible to conduct such studies, for example, with the unanticipated difficult airway. In that scenario the evidence base is more likely to come from the scrutiny of databases and registers. It is still early days in the development of high flow nasal oxygen therapy within anaesthesia and time will tell whether it gains further traction and establishes its use in routine practice. **BJHM**

Figure 1 *is reproduced with permission of Armstrong Medical Ltd. Conflict of interest: Dr D Kotwinski, Dr L Paton and Dr R Langford received an honorarium payment from Armstrong Medical Ltd for writing a user guide for the peri-operative insufflatory nasal therapy airway system.*

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