

## **Intraoperative oxygenation and ventilation in children – a U.K. survey of current practice**

Dr L.D. Elgie, Dr A.M. Miskovic, Dr R. Nandi

Department of Anaesthesia, Great Ormond Street Hospital, Great Ormond Street, London, U.K.

### **Introduction**

There is currently minimal evidence for intraoperative protective ventilation strategies in paediatric anaesthesia. Practice surrounding paediatric ventilation is now largely influenced by data showing benefits of lung protective ventilation in adult critical care,<sup>1</sup> which has been extrapolated to paediatric intensive care. Despite this, there is no evidence demonstrating correlation between ventilatory strategies in paediatric anaesthesia and patient outcome.<sup>2</sup>

The recent consensus of the European Society for Paediatric and Neonatal Intensive Care recommends targeting physiologic tidal volumes ( $V_T$ ) and avoiding  $V_T > 10 \text{ ml/kg}$  and although optimal fractional inspired oxygen concentration ( $FI_{O_2}$ ) cannot be recommended based on current evidence, it suggests aiming for the lowest  $FI_{O_2}$  possible.<sup>3</sup>

The detrimental effects of hyperoxia in the neonatal population are well described. There is currently debate as to whether the risks of increased reactive oxygen species (ROS) produced by hyperoxia outweigh the potential benefits of providing a high  $FI_{O_2}$  in other age groups as well.<sup>4</sup> Apart from the multisystem damage ROS can cause, a high  $FI_{O_2}$  leads to alveolar de-recruitment due to nitrogen washout and subsequent ventilation perfusion ( $\dot{V}/\dot{Q}$ ) mismatch.<sup>5</sup> The application of positive end expiratory pressure (PEEP) helps maintain functional residual capacity and reduce  $\dot{V}/\dot{Q}$  mismatch, however the optimal level of PEEP in paediatric anaesthesia is unknown.<sup>2</sup>

We surveyed paediatric anaesthetists in the U.K. to establish current practice in oxygenation and ventilatory strategies used in children of all ages (including neonates) undergoing general anaesthesia (excluding all children with congenital heart disease).

### **Methods**

An online survey link was sent via email to the U.K. based members of the Association of Paediatric Anaesthetists of Great Britain & Ireland. Consultant anaesthetists were asked to give answers in the following age groups: neonate, infant, 1-5 years, 6-12 years, 13-15 years. They were asked not to answer questions on neonates and infants if they do not routinely provide care to these age groups.

### **Results**

#### **Demographics**

221/594 U.K. based consultant members of the APAGBI responded, giving a response rate of 37.2%. 30% have been consultants for <5 years, 25% for 5-10 years and 45% for >10 years. 50% work at a University Teaching Hospital with a Tertiary Paediatric Centre, 24% at a District General Hospital, 15% at a Specialist Tertiary Paediatric Hospital and 10% at a University Teaching Hospital without a Tertiary Paediatric Centre. 1% of respondents had 2 places of work (University Teaching Hospital and Specialist Tertiary paediatric Hospital).

#### **Responses to Questions**

1. *Approximately what  $FI_{O_2}$  and which carrier gas do you routinely use for a GAS INDUCTION in the following age groups?*

Figure 1 summarises the responses to this question. It shows that 39% of anaesthetists use  $FI_{O_2}$  1 for gas inductions in neonates which is higher than other age groups. Nitrous use is lower in neonates.

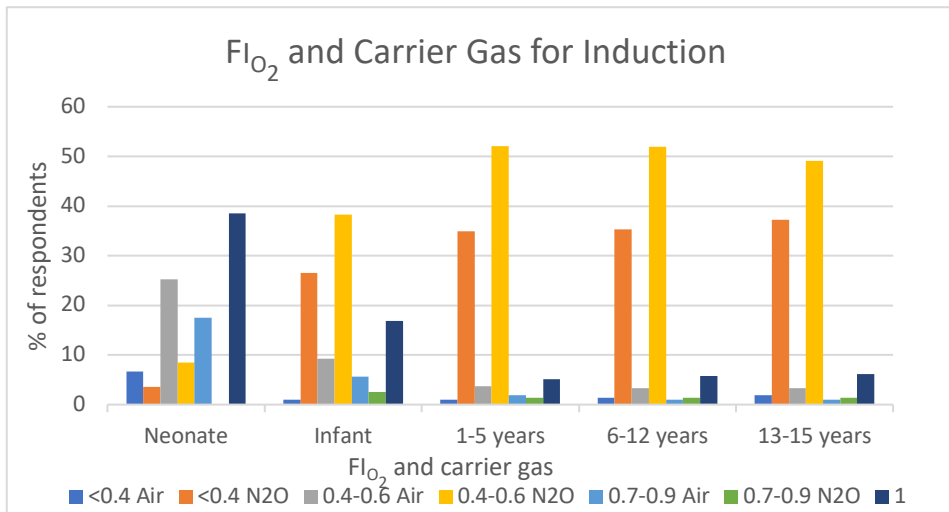


Figure 1.  $F_{I_{O_2}}$  and carrier gas used for gas induction of anaesthesia.

2. *Approximately what  $F_{I_{O_2}}$  and which carrier gas do you routinely use during MAINTENANCE OF ANAESTHESIA in the following age groups?*

Figure 2 shows that a lower  $F_{I_{O_2}}$  is used for maintenance of anaesthesia in neonates. Air is the preferred carrier gas in all age groups. Table 1 shows that nitrous is more popular with anaesthetists who have been consultants for more than 10 years.

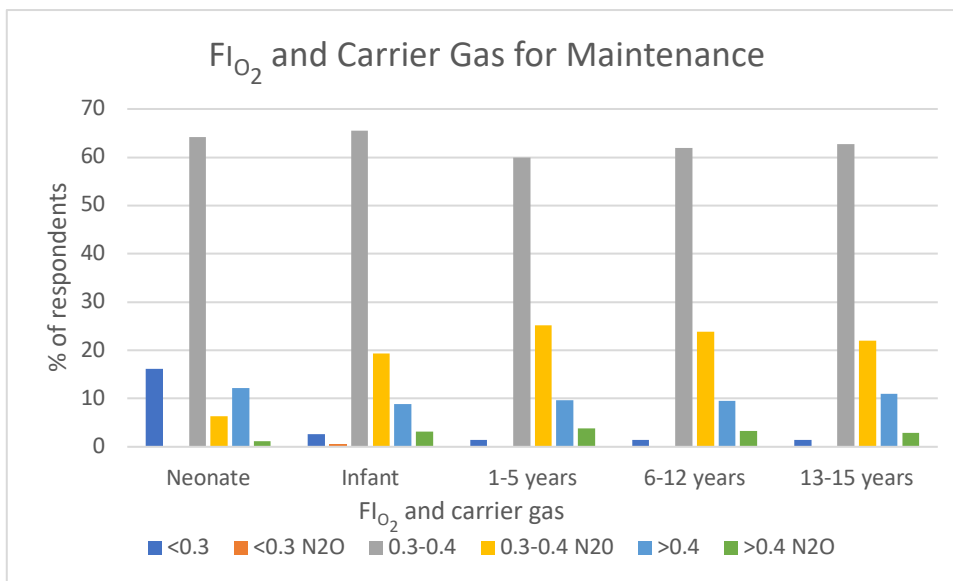


Figure 2.  $F_{I_{O_2}}$  and carrier gas used for maintenance of anaesthesia.

Age Group	Number of years practising as a Consultant		
	< 5 years	5-10 years	>10 years
Neonates	3%	4%	8%
Infants	16%	14%	25%
1-5 years	21%	25%	35%
6-12 years	21%	25%	35%
13-15 years	18%	23%	30%

Table 1. The percentage of consultants who use nitrous during maintenance of anaesthesia.

### 3. When extubating, what $FiO_2$ do you set?

Figure 3 shows that approximately 60% of respondents use a  $FiO_2$  of 1 for extubation apart from in neonates, where 49% use a  $FiO_2$  of 1. For neonates 4% use a  $FiO_2$  of <0.4, which is marginally higher than in other age groups (1.8-2.5%).

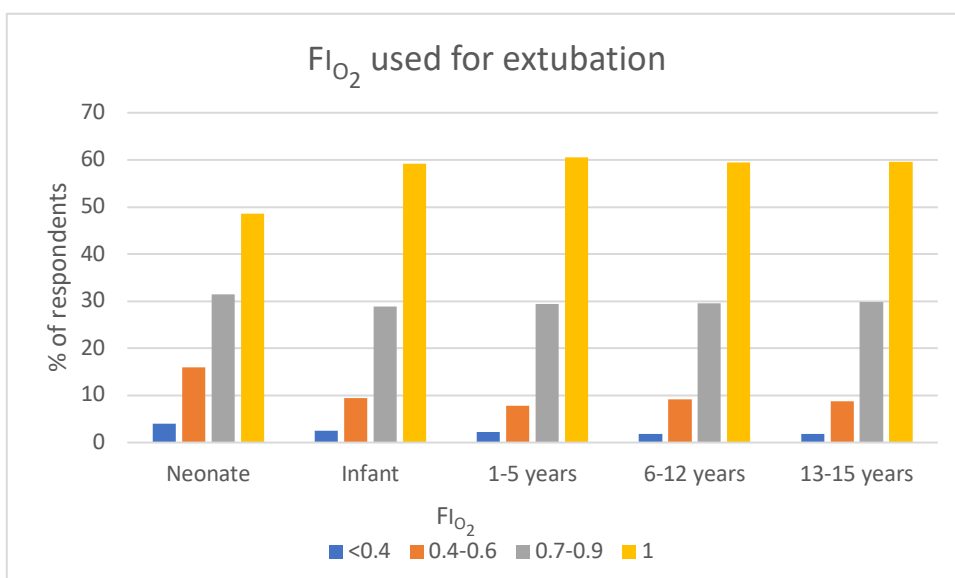


Figure 3.  $FiO_2$  used for extubation.

Table 2 summarises the responses to the remaining survey questions.

Though lung protective ventilation is commonly practised in adult anaesthesia, specific tidal volumes ( $V_T$ ) are not targeted by 42% of respondents when anaesthetising neonates and 27% when anaesthetising infants. In the older age groups only 16-18% do not target a  $V_T$ .

Pressure controlled ventilation is the preferred mode of ventilation (62%-84% in different age groups) and over 70% of respondents set a positive end expiratory pressure (PEEP) of 4-5cmH<sub>2</sub>O. Uncuffed endotracheal tubes are preferred in neonates and infants and cuffed tubes are preferred in children aged 6 years and above. Regarding assessment ventilation adequacy, end tidal carbon dioxide ( $FE_{CO_2}$ ) monitoring is most commonly used in all ages, though less in neonates. Several anaesthetists commented on the inaccuracy of  $FE_{CO_2}$  in neonates. Chest expansion is used more frequently in smaller children,  $V_T$  is used more in older children.

Free text responses for measuring ventilation adequacy included oxygen saturations, overall clinical picture, capnography waveform, transcutaneous carbon dioxide monitoring, capillary or venous gases and other ventilation parameters (e.g. minute ventilation and compliance).

Question		Neonate	Infant	1-5 years	6-12 years	13-15 years
4. When mechanically ventilating, presuming circuit compliance is taken into account, what $V_T$ in $mls.kg^{-1}$ do you target?	No $V_T$ target	42%	27%	18%	16%	17%
	$\leq 8$	46%	59%	68%	70%	71%
	$> 8$	12%	14%	14%	14%	12%
5. When mechanically ventilating through an endotracheal tube, what level of intraoperative PEEP do you set? ( $cmH_2O$ )	0	2%	2%	3%	3%	3%
	2-3	5%	5%	5%	5%	5%
	4-5	73%	80%	84%	83%	81%
	$< 5$	6%	6%	5%	5%	6%
	$\geq 5$	8%	5%	1%	1%	2%
	6-8	5%	1%	1%	2%	2%
	10	1%	0%	0%	0%	0%
6. When intubating a patient what type of ETT do you routinely use?	Cuffed	23%	45%	52%	91%	99%
	Uncuffed	77%	55%	48%	9%	1%
7. When mechanically ventilating through an ETT what mode of ventilation do you use?	PCV	84%	80%	76%	71%	62%
	VCV	2%	2%	5%	7%	13%
	PCVG	14%	18%	19%	22%	25%
8. How do you assess adequacy of ventilation (without the presence of an arterial line to measure gas exchange)?	$FE_{CO_2}$	92%	98%	99%	99%	99%
	Chest expansion	88%	73%	65%	65%	58%
	$V_T$	69%	76%	81%	81%	82%
	Other	26%	12%	10%	10%	10%

Table 2. Summary of survey responses to questions 4-8.

## **Conclusions**

This survey gives an idea of how paediatric anaesthetists in the U.K. are managing the oxygenation and ventilation of their patients. The lack of available evidence for paediatric protective ventilation is apparent from the varying practice of paediatric anaesthetists.

## **References**

1. Acute Respiratory Distress Syndrome Network. Ventilation with Lower Tidal Volumes as Compared with Traditional Tidal Volumes for Acute Lung Injury and the Acute Respiratory Distress Syndrome. *N Engl J Med.* 2000 May;342(18):1301-1308.
2. Kneyber MCJ. Intraoperative mechanical ventilation for the pediatric patient. *Best Pract Res Clin Anaesthesiol.* 2015 Sep;29(3):371-9.
3. Kneyber MCJ, de Luca D, Calderini E et al. Recommendations for mechanical ventilation of critically ill children from the Paediatric Mechanical Ventilation Consensus Conference (PEMVECC). *Intensive Care Med.* 2017 Dec;43(12):1764-1780.
4. Habre W. et al. Perioperative use of oxygen: variabilities across age. *Br J Anaesth.* 2014 Dec; 113: 26-36.
5. Trachsel D, Svendsen J, Erb TO, von Ungern-Sternberg BS. Effects of anaesthesia on paediatric lung function. *Br J Anaesth.* 2016 Aug;117(2):151-63.