Equipment and monitoring in paediatric anaesthesia

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Abstract

Advances in paediatric anaesthetic equipment and monitoring continue to be made. While the mainstay of airway intubating equipment currently is the direct laryngoscope, video laryngoscopes and endoscopes are increasing in their use. These continue to evolve, generating better quality pictures, with more sophisticated yet easier to use equipment. Vascular access in paediatric anaesthesia can be challenging with an increasing number of patients presenting with difficult intravenous access. Ultrasound has become an integral piece of equipment in the management of these children. As the population increases in weight, so the management of the obese paediatric patient is now a reality. This requires thought and careful planning of their perioperative care. Newer techniques such as high-flow nasal oxygen are useful both to prevent hypoxia at induction, but also to facilitate open airway surgery. Neurological monitoring in the form of near infrared spectroscopy and bispectral index are discussed with evidence relevant to paediatric practice. This article will discuss all of these devices and techniques with particular emphasis on paediatric anaesthetic practice.

Keywords Airway; bispectral index; NIRS; obesity; paediatric anaesthesia; vascular access

Royal College of Anaesthetists CPD Matrix: 2A02, 2A03, 2A04, 3D00, 3A13

Learning objectives

After reading this article, you should be able to:

- name different laryngoscopes used in paediatric practice
- name video laryngoscopes and endoscopes available for paediatric anaesthesia
- discuss the role of ultrasound in vascular access
- discuss the perioperative management of the obese paediatric patient
- understand the principles of NIRS and BIS

Equipment

Airway

The paediatric airway can pose a challenge to the anaesthetist. There are distinct anatomical variations which change as the patient grows, as well as the possibility of abnormalities of the airway associated with particular syndromes which can render mask ventilation and intubation increasingly difficulty.

Laryngoscopes: because of the anatomical differences between babies and older children traditional laryngoscopy techniques are also different between these groups. Traditional laryngoscopy has been undertaken using a straight blade for the pre-term and infant, graduating to a larger curved blade as the child gets older. The technique used to gain a view of the larynx also may change as the patient gets older, with the tip of the straight blade at the arytenoids to obtain a direct view of the larynx, and tip of the curved blades into the vallecula to lift the epiglottis out of the field of vision exposing the vocal cords.

One of the most commonly used straight blades is the Miller blade; this is a straight, narrow-bladed instrument, which is useful in those with small oral cavities. There are other blades of varying shapes available that may improve the view attained on laryngoscopy, either as a first-line or back-up laryngoscope and these should not be a forgotten. The Cardiff blade is designed to have the proximal 6 cm straight and the distal 4 cm curved to allow an improved view with minimal mouth opening and minimal mucosal damage. This has been shown to gain a faster view on laryngoscopy than the Millar 1 and a better view than the Macintosh 2 blade in children (see Figures 1 and 2).[1] The Seward and Robert Shaw laryngoscopes are alternative blades that are primarily straight though with curved tips, which may be beneficial to a trained user, but perform less well in untrained hands.[2] The Macintosh blades are the most common curved blade traditional laryngoscopes; these are available in a number of different sizes and lengths.

Videolaryngoscopes: videolaryngoscopes and flexible intubation video laryngoscopes are now frequently used for difficult airway management in children. A number of videolaryngoscopes suitable for children include:

- Storz C-MAC Video Laryngoscope (Karl Storz GmBH & Co KG, Tuttlingen, Germany)
- McGrath MAC Enhanced Direct Laryngoscope (Aircraft Medical Limited, Edinburgh, UK)
- Airtraq™ (Prodol Meditec SA, Vizcaya, Spain)
- Pentax Airway Scope™ AWS-S200 (Pentax, Tokyo, Japan)
- Glidescope (Verathon Medical, Bothell, WA, USA)
- TruView PCD™ (Truphatek, Netanya, Israel)
- Bullard Elite™ laryngoscope (Olympus America, Center Valley, PA, USA).

These products have been discussed previously in this journal.

One of the newer advances in paediatric airway management is the Storz FIVE (Flexible Intubating Video Endoscopes). These are part of the C-MAC system allowing clear pixel-less images to be generated (Figure 3).

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Please cite this article in press as: Seddon D, McLeod M, Equipment and monitoring in paediatric anaesthesia, Anaesthesia and intensive care medicine (2018), https://doi.org/10.1016/j.mpaic.2018.05.001

Figure 1 Lateral and end views of the Cardiff and Macintosh 2 laryngoscope blades.

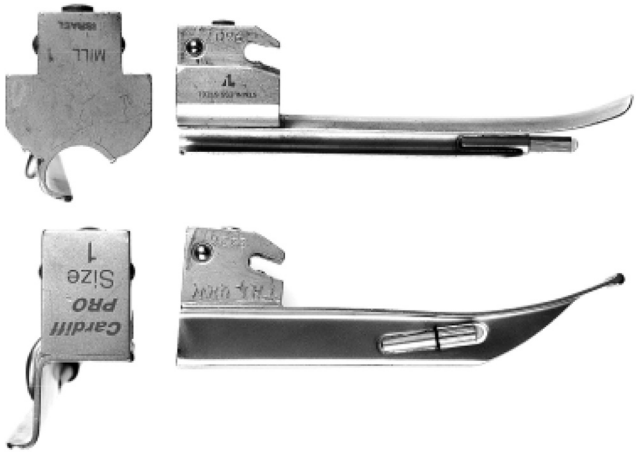

Figure 2 Lateral and end views of the Cardiff and Miller 1 laryngoscope blades.

Single-use fiberscopes: these are a cost effective alternative to reusable fiberscopes for use in centres with less than 200 fiberoptic intubations per year.[3] These devices are compatible to the reusable scopes except when used in patients with acutely compromised airways.[4]

Endotracheal tubes (ETTs): historically, uncuffed endotracheal tubes were used in children. Information about the size and shape of the larynx and trachea from MRI studies have shown that the tracheal structure maybe elliptical in nature rather than round.[5] This information suggests that cuffed tubes may be of benefit. Low-pressure, cuffed endotracheal tubes reduce risks of airway oedema. There are higher rates of perioperative laryngospasm in children in whom an uncuffed endotracheal tube was used compared with a cuffed endotracheal tube.[6] Care should be taken not to overinflate the cuff, for instance if a smaller sized ETT was chosen. Accurate cuff measurements are important to avoid potential pressure injuries, particularly during longer cases.

A recent Cochrane review noted no difference in rates of post extubation stridor between the patients who were intubated with cuffed or uncuffed tubes. There was some evidence that those patients intubated with cuffed tubes had lower rates of tube changes, and less anaesthetic gas use, resulting in lower cost, however this evidence was of low quality.[7] There may be many benefits of cuffed tubes including accuracy of measured gases and delivered tidal volumes, and reduced environmental pollution because of gas flows and leaks, and these may outweigh the cost and smaller internal diameter of these tubes. The UK Resuscitation council has recommend that cuffed tubes be used in all patients except neonates, on the proviso that the person intubating uses the appropriate tube size, cuff inflation pressure and monitors the tube position.[8]

Supraglottic airway devices (SGADs) are commonly used in routine paediatric anaesthesia, but they also have a role in difficult airway management, either as rescue devices following failed intubation and/or mask ventilation, or as conduits to facilitate fiberoptic intubation. There are many different types of first and second generation supraglottic devices available with different features. Overall leak pressures with SGADs in the paediatric population are lower than in adults, however still at pressures that enable positive pressure ventilation.[9]

Research around SGADs has concentrated on leak pressures, ease of insertion, and complications of use between the different devices available. A recent network meta-analyses looked at 65 randomized clinical trials with 5823 participants, involving 16 types of supraglottic airway device. The review concluded that the LMA-Proseal may be the best supraglottic airway device for children as it has a high oropharyngeal leak pressure and a low risk of insertion. The authors mention the i-gel as it has a high oropharyngeal leak pressure and low risk of blood staining; however, its risk of failure was higher and so the recommendation from this review was that this be evaluated on a patient basis prior to its use.[10]

Vascular access

Venous access in children can be divided into temporary vessel cannulation and long-term access. Both of these forms can be challenging due to factors including vessel size, abnormal vasculature, prior cannulation attempts and adiposity. Historically identification of appropriate vessels was done on an anatomical basis, based on where the vein or artery should be. A number of devices are available to assist in vein visualization with varying amounts of supporting evidence.

Near-infrared devices: these use the principle that infrared light penetrates skin deeper and is more readily absorbed by haemoglobin than visible light. These devices are often used on premature neonates; however, they are available for use in older children and adults (Figure 4). Evidence has yet to determine improvement in cannulation success with these devices when compared to standard techniques or ultrasound guidance.

Ultrasound works on the basis that ultrasonic waves can be transmitted from a probe, will be reflected off the tissues, and received back by the same probe. The time taken for the sound waves to travel from the probe and back reflect the depth of the tissue interface. The type of probe used will give different near and far picture quality based on the arrangement of the piezoelectric crystals within it, which are used to generate the

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