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Applications of Electronic Instrumentation in the Management of Paediatric Airway Emergencies: A Life-Saving Technology

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Editorial

The paediatric airway has significant differences when compared to the adult, especially with respect to its anatomical dimensions and physiological range of movements, which predisposes it to more frequent airway obstruction. The aerodynamics of paediatric ventilation is based on Poiseuille's law and Reynold's number, which infer that rapid deterioration from a mild obstruction onto life threatening airway compromise, may be heralded by a slight decrease in airway diameter just by a few millimeters [1]. It is observed that children mostly present with stridor when nearly 75% of their airway is compromised and this creates a serious challenge for ENT surgeons and anaesthesiologists who need to access & secure the airway in a race against time scenario.

Improved airway endoscopic technology along with precise ventilation monitoring tools used in present day clinical practice, have ably assisted in saving many children's lives. These newer electronic equipments have comforted the airway experts who previously had dreaded "can't intubate, can't ventilate" situations, where they had to either attempt blind intubations or perform emergency cricothyroidotomy/ tracheostomy with high risk of cardio-respiratory failure.

The spectrum of paediatric airway emergencies

It is paramount to have an intricate knowledge of the paediatric airway anatomy for a comprehensive evaluation of the respiratory distress situation and to provide an appropriate remedy for the same. Video endoscopy helps to guide the anaesthetist & surgeon to visualize the larynx overcoming abnormalities like craniofacial dysmorphism, bulky base of tongue, retrognathia, compressive neck tumours, abscesses etc. Intubation in such children is a difficult task needing a far lateral approach rather than a midline access, in which case the video guidance is of immense help [2]. Airway endoscopy can reveal a diaspora of pathologies, including structural abnormalities in the laryngo-tracheo-bronchial tract, foreign bodies and functional compromise due to infection, inflammation or extrinsic compression.

Paediatric airway endoscopy

Rapid technological advancements have brought in high definition electronic video cameras systems, which are incorporated into the endoscopes to provide high speed kymographic real-time image recording during surgery [1]. The latest tip-chip HD cameras with xenon light scopes capture magnified crystal-clear images of the airway to study the intricate mucosal lesions, extent of stenotic segments, altered respiratory wave patterns, abnormal pulsations, extrinsic compressions etc apart from their conventional use for locating foriegn bodies in the tracheobronchial tree.

Paediatric anaesthesia monitoring

A child's pulmonary capacity & ventilatory compliance is lower than adults and especially in a compromised airway situation, the paediatric anaesthetist needs to rely upon the electronic display panel of the anaesthetic monitors to quickly take appropriate decisions to keep control of the airway, while the ENT surgeon performs the airway surgery.

The latest ventilators include an electronic calibration panel for pulse oximetry, capnography, non-invasive Blood pressure (BP), respiratory flow volume loop, temperature, Electrocardiogram (ECG), gas uptake record, Bispectral index (BIS) and positive pressure support. The calibrations on the panel do remain stable & reliable while there is a secure airway with an endotracheal tube insitu, but it is a challenge to regulate the ventilation in an emergency situation with compromised airway [3].

Ventilating bronchoscopy is a classic example where anaesthesia is provided via the airway endoscope, with both the surgeon & anaesthetist sharing a compromised airway, working in tandem to achieve an optimal plane of anaesthesia in accordance with the surgical findings [3]. This is an ideal setting where electronic gadgetry and surgical skills mingle into play, wherein the endoscopic findings and anaesthetic parameters complement each other.

Pearls & pitfalls of electronic gadgetry

The video stack system provides the opportunity to record the intra-operative findings, take snapshots at different levels of endoscopy & discuss the findings with evidence especially with the anxious parents soon after the procedure. It is very helpful as a communication tool, since the entire operating team can witness the findings & especially the anaesthetist can be fully involved in the proceedings. Serial imaging helps to maintain a medical database record for patients' prognosis & for medico-legal purposes. Videos have been used for training & educational purposes and for sharing experience in scientific podiums with peers, which is important in the present realm of evidence based clinical practice [1,2,4]. Newer non-endotracheal ventilatory techniques like jet ventilation, intermittent apnoeic technique and THRIVE twin-stream system, are highly dependent on electronic calibrations and have been successful in providing a full view for the surgeon with complete access to the airway while the anaesthesia is delivered in a controlled fashion [3].

Electronic technology has its drawbacks, since a technical snag in the video image or ventilation system at a crucial moment of the surgery can lead to serious eventualities. Limitations of video image is the lack of depth perception and 3D orientation which a surgeon would prefer to have similar to when scoping end-on under direct vision. The learning curve is steep for hand-eye coordination especially in emergency situations for junior surgeons [5].

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Limitation for the capnography and flow loops in display panel is the variable sensitivity of the sensor probes and its response reflecting with a lag period lasting few seconds to minutes, during which values may indicate the loss of airway control. Also there may be false positives or negatives, due to delinked circuits or apparent failure of probes to respond [2,3]. It is vital for the surgical team to test and confirm that these electronic equipments are fully serviced and certified up to safety standards.

Conclusion

Digital airway endoscopy under controlled anaesthetic ventilation has evolved into a unique sub-specialty with a diverse range of diagnostic & therapeutic indications in paediatric practice. The future is towards improving the video resolution of the endoscopes, multi-angle lens compatibility, wireless image capturing and incorporation of intra-operative 3D navigation systems. Dedicated paediatric ventilation monitors with sensitive probes for accurate monitoring are also evolving to optimally support the airway. Thereby, electronic technology has definitely proved to be a life-saver in paediatric airway emergencies, by enhancing the diagnostic capability for the surgeon and providing precise monitoring control for the anaesthetist-a crucial symbiosis in a critical scenario.

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