Pediatric Sedation for MRI

An Essay

Submitted for partial fulfillment of Master Degree in Anesthesiology

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2018

Acknowledgment

*First and foremost, I feel always indebted to **ALLAH**, the Most Kind and Most Merciful.*

*I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Hala Gomaa Salama,** Professor of Anesthesiology, Intensive Care and Pain Management - Faculty of Medicine - Ain Shams University for her keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

*I am also delighted to express my deepest gratitude and thanks to **Dr. Rami Mounir Wahba,** Professor of Anesthesiology, Intensive Care and Pain Management, Faculty of Medicine, Ain Shams University, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

*I am deeply thankful to **Dr. Ahmed Mohamed Moubarak,** Professor of Anesthesiology, Intensive Care and Pain Management, Ain Shams University, for his great help, active participation and guidance.*

I would like to express my hearty thanks to all my family for their support till this work was completed.

Last but not least my sincere thanks and appreciation to all patients participated in this study.

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List of Abbreviations

Abb.	Full term
AAP	*American Academy of Pediatric*
AAPCOD	*American Academy of Paediatrics Committee on Drugs*
ASA	*American society of anesthesiologists*
CNS	*Central nervous system*
CoA	*Coenzyme A*
CSF	*Cerebrospinal fluid*
CT	*Computed tomography*
DPT	*Demerol, phenergan, thorazine*
ECG	*Electrocardiogram*
EMS	*Emergency medical services*
Hcy	*Homocysteine*
IM	*Intramuscular*
IV	*Intravenous*
KG	*Kilogram*
Min	*Minute*
Mm	*Millimeter*
MRI	*Magnetic resonance imaging*
NAPS	*Nurse-administered propofol sedation*
PACU	*Post anesthesia care unite*
PSA	*Procedural sedation and analgesia*
RBBB	*Right bundle branch block*
RF	*Radio frequency*
S/G	*Sedation or general anesthesia*
spo2	*Saturation of Peripheral Oxygen*
UK	*United Kingdom*
USA	*United States of America*
V/Q	*Ventilation/perfusion*

Introduction

According to the American Society of Anesthesiologists (ASA), sedation is defined as:

Minimal Sedation (Anxiolysis) is a drug-induced state during which an individual responds normally to verbal commands. Although cognitive function and coordination may be impaired, ventilatory and cardiovascular functions are unaffected, Moderate Sedation / Analgesia ("Conscious Sedation") is a drug-induced depression of consciousness during which an individual responds purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained, And Deep Sedation / Analgesia is a drug-induced depression of consciousness during which an individual cannot be easily aroused but responds purposefully following repeated or painful stimulation. The ability to independently maintain ventilatory function may be impaired. The individual may require assistance in maintaining a patent airway, and spontaneous ventilation may be inadequate Cardiovascular function is usually maintained ***(ASA House of Delegates, 2014).***

The main goals of pediatric sedation vary according to the imaging procedure, but generally encompass anxiety relief, pain control and control of excessive movement ***(Cravero and Blike, 2004).***

The American Academy of Pediatric (AAP) defines the goals of sedation in the pediatric patient for diagnostic and therapeutic procedures as follows: to guard the patient’s safety and welfare; to minimize physical discomfort and pain; to control anxiety, minimize psychological trauma and maximize the potential for amnesia; to control behavior and/or movement to allow for the safe completion of the procedure; and to return the patient to a state in which safe discharge from medical supervision, as determined by recognized criteria is possible ***(Cote et al., 2006).***

The target level or depth of sedation will vary according to the imaging procedure (and modality), as well as the individual patient characteristics. For CT scanning, for instance, modern multislice scanners allow for rapid image acquisition; therefore, moderate sedation can be employed. However, some children need to be asleep in order to tolerate complex or prolonged investigations such as MRI and nuclear medicine imaging, which may involve the child keeping still for up to 1 hour. MRI can be particularly frightening because it is noisy and involves lying still in an enclosed space ***(Arlachov et al., 2010).***

Image acquisition after the administration of the radioactive tracer becomes essential in nuclear medicine techniques in order to avoid unnecessary repeat studies and the additional radiation burden. Careful planning of sedation is particularly important for these modalities ***(Malviya et al., 2000).***

Rates of failure can be decreased dramatically when sedation is provided by a dedicated team, by implementing clear protocols and when experienced anaesthesiologists themselves provide the sedation ***(Crock et al., 2003).***

However, the safe practice of sedation is not inevitable. Sedation is often difficult and always demanding, with potentially devastating adverse effects. Because most of the literature focuses on only a particular aspect of sedation (such as the effectiveness of an agent in the expanding array of sedatives), a comprehensive review of sedation of children in radiology is essential ***(Keira et al., 2012).***

Chapter 1
ANATOMY AND PHYSIOLOGY

Definitions

Table (1): Pediatric age groups

Pediatric Subpopulation	Approximate Age Range
Newborn	**birth to 1 month of age**
Infant	**1 month to 2 years of age**
Child	**2 to 12 years of age**
Adolescent	**12-21 years of age**

(Rudolph, 2002)

Anatomy of the upper respiratory tract

The respiratory tract begins at the tips of the nostrils (alae nasi), which are kept open by soft cartilage. Around the nostrils are the alar nasalis muscles which cause the nostrils to flare open during states of respiratory distress, and can reduce nasal airway resistance by up to 25% ***(Carlo et al., 1983).***

The nasal cartilage encloses the anterior nasal cavity called the nasal vestibule. The cells of the nasal vestibule are the same as skin and contain small hairs, vibrissae, which can help stop debris such as dust from entering. There is a large vascular capillary network in the anterior vestibule, commonly called Little's area, which is a common site of nosebleeds in children. A midline nasal septum divides the nasal cavity into two. On the lateral walls lie three curved turbinate bones called conchae, which direct airflow. Air passing through the nasal cavity is warmed and humidified and prevents the airways from drying out. Ventilator humidifiers do the same thing when the nose is bypassed by an orotracheal tube. This is the beginning of the nasopharynx, the site where nasopharyngeal aspirates are taken. The cells in this area are ciliated respiratory epithelial cells, rather than squamous cells, and move any particulate matter towards the oropharynx where it can be swallowed. It is notable that the lacrimal ducts drain into the nasal conchae and the Eustachian tube, that equalizes pressure in the middle ear. The adenoids are located near this region of the nasopharynx, and during viral upper respiratory tract infections adenoidal hypertrophy can block the Eustachian tube in some infants and children which can lead to otitis media with effusion ***(Pearl et al., 1998).***

The naso- and oropharynx lead to the pharnyx where the epiglottis protects the laryngeal opening from the tracheal aspiration of food and liquids. During swallowing, the epiglottis moves down to close off the larynx. In epiglottitis, the epiglottis becomes very red and inflamed, swallowing becomes too painful, and the child drools ***(Manoukian et al., 1998).***

The larynx is a complex structure that contains 'C'-shaped rings of cartilage vocal cords and muscles.The vocal cords and the space between them are commonly referred to as the glottis. Any abnormalities in this area will cause a variety of sounds, the most common being stridor. Below the vocal cords are the windpipe or trachea, which is part of the lower respiratory tract ***(Wright et al., 1998).***

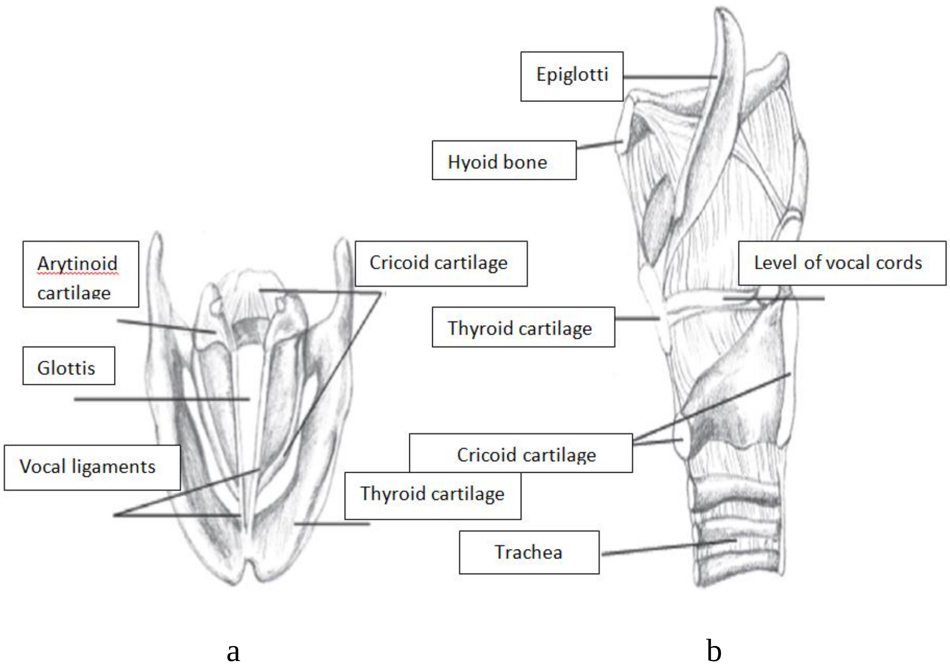

Figure (1): (a) Larynx showing cricoid and thyroid cartilages and level of vocal cords. (b) Vocal cords ***(Janica et al., 2013).***

Anatomy of the lower respiratory tract

The trachea bifurcates at the carina to become the right and left main bronchi. The angles are slightly different, with the left main bronchi coming off at a more acute angle. Thus any inhaled foreign bodies tend to go down the right main bronchus. These bronchi then divide repeatedly into secondary and tertiary bronchi until finally dividing into the terminal bronchioles, respiratory bronchioles and eventually alveoli ***(Wright et al., 1998).***

The lung itself is covered by a pleural membrane which consists of the visceral and parietal pleura, with a small fluid-filled space in between. The visceral pleura covers the lung itself, while the parietal pleura is attached to the inner walls of the thorax. Infection and/or inflammation within the lung tissue can lead to accumulation of fluid or pus in this pleural space, respectively called a pleural effusion and empyema. The work of breathing is done by the diaphragm and the intercostal muscles, located between the ribs. In poorly controlled respiratory conditions such as asthma, the diaphragm works much harder than usual and can deform the chest wall, as the muscle fibres attach to the lower part of the rib cage. This chronic deformity of the chest wall is called Harrison’s sulci ***(Wright et al., 1998).***

Surface anatomical landmarks

The ability to describe surface locations on the chest is important, and is usually described in terms of ribs or intercostal spaces and vertical lines drawn from anatomical landmarks. The second rib is located first by feeling for the sternal angle, then moving laterally. Other ribs can then be identified by counting downwards. The important vertical lines are the midclavicular and midaxillary. The midclavicular line passes straight down from the middle of the clavicle and the midaxillary line passes straight down from the axilla, when looking at the patient side on. In pneumothorax, needle thoracocentesis is performed by inserting a butterfly needle or venflon into the second intercostals space in the midclavicular line. Emergency chest drains are inserted into the fifth intercostal space in the midaxillary line ***(Wright et al., 1998).***

Changes in anatomy with age

In infancy, the narrowest point of the upper airway is the cricoid ring, rather than the vocal cords as in older children. Endotracheal intubation requires placing a suitably sized tube so as not to damage the vocal cords, whilst ensuring that any air leak is minimal. In younger children and infants the cricoid ring provides a seal, whereas in older children an endotracheal tube with an inflatable cuff is used. When the endotracheal tube passes through the vocal cords and is in the correct position, the cuff is inflated which creates a seal against the trachea and prevents air leak. An important consideration in airway resistance is the change that occurs when the diameter is reduced due to mucus or inflammation. Poiseuille's law states that airway resistance is inversely proportional to the fourth power of the airway radius.Thus a 1 mm change in airway diameter in an older child will have little effect on resistance compared to that of a newborn or infant ***(Balfour-Lynn and Davies. 2006).***

Physiology of the respiratory system

The function of the lung is to oxygenate the blood and remove carbon dioxide. Air at sea level contains 21% oxygen, with inert nitrogen making up the remainder. In order for the oxygen to be delivered to the blood, flow of air into the lung must occur. To accomplish this, a pressure gradient must be created between the terminal respiratory unit and the outside air. By contraction mainly of the diaphragm, against a thoracic cavity held rigid by the rib cage, a negative intrathoracic pressure is generated and flow of air occurs. The anatomical 'dead space' consists of the terminal bronchioles, bronchi, trachea and upper airway. Although air passes through this dead space, no gas exchange occurs. Similarly, the tubes from a ventilator to the patient, including the endotracheal tube, extend this dead space. In neonatal ventilation, endotracheal tubes are kept as short as safely possible to reduce dead space.During inspiration, the negative pressure exerts a force against the extrathoracic trachea and larynx, which instead of the rib cage