Effectiveness of Various Ultrasonographic Utilizations in Pediatric Anesthesia

An Essay

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بسم الله الرحمن الرحيم

قالوا

سبحانك لا علم لنا
إلا ما علمتنا إنك أنت
العليم الحكيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

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Mohamed Ahmed Kandeel

Contents

List of Abbreviations

λ	:	Wave length
ρ	:	density
A M	:	Air mucosa
ASIS	:	Anterior superior iliac spine
CA	:	Carotid artery
CT	:	Computed tomography
CXR	:	Chest X ray
D	:	Depth
Db	:	Decibels
EJV	:	External jugular vein
ETT	:	Endotracheal tube
F	:	Frequency
FA	:	Femoral artery
FV	:	Femoral vein
HLHS	:	Hypoplastic left heart syndrome
Hz	:	Hertz
h	:	Amplitude
IJV	:	Internal jugular vein
IV	:	Intravenous
IP	:	In plane
LA	:	Local anesthesia
OOP	:	Out of plane
PB	:	Pelvic prim
PFA	:	Profunda femoral artery
PIV	:	Peripheral intravenous
R	:	Fraction of energy
Sart	:	Sartorius muscle
SCV	:	Subclavian vein

List of Abbreviations (Cont.)

TAP	:	Transversus Abdominis Plane
TGC	:	Time gain compensation
T	:	Time
US	:	Ultrasound
USG	:	US Guided
V	:	Velocity
Z	:	Acoustic impedance

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AIM OF THE WORK

To study the effectiveness of ultrasound imaging in pediatric an - esthesia; for vascular access, regional anesthesia and confirmation of the diameter of endotracheal tube.

Introduction

The technology and clinical understanding of anatomical sonography has evolved greatly over the past decade. Studies have shown that direct visualization of the distribution of local anesthetics with high frequency probes can improve the quality and avoid the complications of upper & lower extremity nerve blocks and neuroaxial techniques. Ultrasound guidance enables the anesthetist to secure an accurate needle position and to monitor the distribution of the local anesthetic in real time. The advantages over conventional guidance techniques, such as nerve stimulation and loss of resistance procedures, are significant**.** Direct ultrasonographic visualization significantly improves the outcome of most techniques in peripheral regional anesthesia. With the help of high resolution ultrasonography, the anesthetist can directly visualize relevant nerve structures for upper and lower extremity nerve blocks at all levels. Such direct visualization improves the quality of nerve blocks and avoids complications. ***(Marhofer et al, 2012).***

The use of ultrasound seems to enhance not only the traditional brachial and lumbosacral plexus blocks but also the common techniques used in invasive pain therapy, such as stellate ganglion and facet nerve blocks. Further studies are needed to establish whether ultrasonography can improve neuroaxial techniques. Promising results have also been obtained in children, in whom most types of block are performed under sedation or general anesthesia ***(Marhofer et al, 2012).***

Ultrasound is widely available, decreases the complications of pediatric vascular access, and is a useful training tool. Scrupulous attention to ultrasound technique and knowledge of normal (and common variations) anatomy is essential to avoid complications. Ultrasound is particularly useful for assisting access the internal jugular and femoral veins in all age groups and the subclavian vein in infants. A small footprint hockey stick probe of frequency 7-10 MHz is adequate for most children, but higher frequency probes are useful for smaller veins and difficult cases. Developments in ultrasound technology including three and four dimensional probes are likely to improve vessel resolution and successful cannulation in children ***(Sigaut, et al, 2009).***

It is often difficult to determine the correct size of endotracheal tubes needed for intubating pediatric patients. Although age and height based formulas are used routinely in anesthesiologic practice, the results are often incorrect and patients must be re intubated, which is associated with a higher risk of air leak or damage to the laryngeal structures ***(Schramm et al, 2012).***

Chapter I

Physical Principles of Ultrasound

1- Main principles:

Ultrasound is no more than high pitched sound. This does not mean louder; it means having a frequency that is above human hearing. Conventionally this is defined as being above 20,000 cycles per second, or 20 kHz. There are a number of aspects to note:

- Sound travels in straight lines (rectilinear propagation).
- the sound beam is a thin pencil shape.
- A single ultrasound pulse can result in many echoes being generated.
- It is possible to tell the depth of the reflectors from their arrival time.
- In general, the echoes get smaller as the depth increases.

(Evans , 2008).

The distance (D) from the source to the wall can be estimated (depth) if we measure the time that elapses between the noise leaving us and the echo being received. If the speed at which the sound travels is c, then the time T is simply: $T= 2D/c$. The speed of sound in different soft tissues is remarkably similar. In fact, all scanners are programmed in the factory to assume a value of 1540 m/sec, which is a good overall average for soft tissue **(Evans , 2008).**

2- Wavelength and Frequency:

Ultrasound is a form of acoustic energy defined as the longitudinal progression of pressure changes. These pressure changes consist of areas of compression and relaxation of particles in a given medium. For simplicity, anultrasound wave is often modeled as a sine wave. Each ultrasound wave is defined by a specific wavelength (λ) measured in units of distance, amplitude (h) measured in decibels (dB), and frequency (f) measured in hertz (Hz) or cycles per second. Ultrasound is defined as a frequency of more than 20,000 Hz. Current transducers used for ultrasonography guided regional anesthesia generate waves in the 3 to 13 MHz range (or 30,000 to 130,000 Hz) ***(Brown, 2010).***

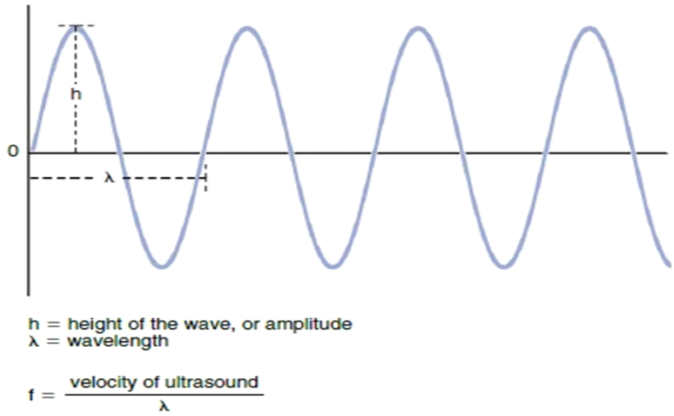

Fig.(1): Ultrasound wave basics ***(Brown, 2010)***.

3- Ultrasound transducer:

Each ultrasound transducer is required to create a source of energy that when applied to the skin safely penetrates the tissues, and receive any energy reflected back to the transducer from the tissues. To generate the ultrasound energy, an electrical current is applied to the crystal component within the transducer face. The current is then converted to mechanical (ultrasound) energy and transmitted to the tissues at very high (megahertz) frequencies. The ultrasound energy produced then travels through the tissues as pulsed, longitudinal, mechanical waves originating from the point the transducer contacts the skin ***(Pollard, 2012)***.

Frequency is a key property of each transducer, as it largely determines what ultrasound screen image representation is possible for any given footprint.They are broadly categorized as high, mid, and low frequency transducers. Transducers typically characterized as 'high frequency' usually operate above10 MHz and arebest suited to visualize structures less than 3 cm from the surface of the skin. With increasing depth, structures are less readily visualized due to attenuation of the emitted and returning ultrasound energy. These transducers are commonly selected for examinations of superficial structures such as the brachial plexus, peripheral