Evaluation of Ultra-sound in Guidance of Arterial Puncture for Arterial Blood Gas Analysis in Respiratory ICU

Thesis of

A Systematic Review-Meta-Analysis for Partial Fulfillment of Master Degree in Chest Diseases

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List of Abbreviations

ABG	**:**	Arterial-blood gas
CNS	**:**	Central nervous system
CO2	**:**	Carbon dioxide
COPD	**:**	Chronic obstructive pulmonary disease
CT	**:**	Computed Tomography
DKA	**:**	Diabetic ketoacidosis
EBUS	**:**	Endobronchial Ultrasound
IVUS	**:**	Intravascular Ultrasound
MRI	**:**	Magnetic Resonance Imaging
pH	**:**	potential of hydrogen
VBG	**:**	Venous blood gas
KHz	**:**	Kilohertz

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Introduction

Arterial blood gas analysis is an essential part of diagnosing and managing a patient's oxygenation status and acid-base balance. Improper sampling may result in fallacious results and inappropriate management. Additionally, poor sampling technique may increase the rate of complications. Arterial puncture is also painful, particularly when more than one attempt is required ***(Giner et al., 1996).***

Arterial blood gas sampling may even prove difficult when pulse is imperceptible due to edema, obesity, hematoma and shock, which are not infrequent in respiratory ICUs.

Vascular ultrasound can be used to evaluate arteries or veins in nearly any part of the body, including blood vessels in the neck, abdomen, arms and legs. Two dimensional ultrasound improves the success, efficiency and safety of central venous cannulation at both peripheral and central puncture sites ***(Karakitsos et al., 2006).***

Ultrasound can be assumed to facilitate invasive arterial procedures as arterial puncture for arterial blood gas analysis, for better success and shorter procedure time ***(Lamperti et al., 2012)*.**

Aim of the Work

Is to evaluate the use of ultrasound in ABG sampling in patients admitted to respiratory ICUs.

Ultrasound

Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing. Ultrasound is not different from 'normal' (audible) sound in its physical properties, except in that humans cannot hear it. This limit varies from person to person and is approximately 20 kilohertz (20,000 hertz) in healthy, young adults. Ultrasound devices operate with frequencies from 20 kHz up to several gigahertzes. Ultrasonic devices are used to detect objects and measure distances. Ultrasound imaging or sonography is often used in medicine. In the nondestructive testing of products and structures, ultrasound is used to detect invisible flaws. Industrially, ultrasound is used for cleaning, mixing, and to accelerate chemical processes. Animals such as bats and porpoises use ultrasound for locating prey and obstacles. Scientist are also studying ultrasound using graphene diaphragms as a method of communication ***(Novelline and Robert, 1997).***

History:

Acoustics, the science of sound, starts as far back as Pythagoras in the 6th century BC, who wrote on the

mathematical properties of stringed instruments. Echolocation in bats was discovered by Lazzaro Spallanzani in 1794, when he demonstrated that bats hunted and navigated by inaudible sound and not vision. Francis Galton in 1893 invented the Galton whistle, an adjustable whistle which produced ultrasound, which he used to measure the hearing range of humans and other animals, demonstrating that many animals could hear sounds above the hearing range of humans. The first technological application of ultrasound was an attempt to detect submarines by Paul Langevin in 1917. The piezoelectric effect, discovered by Jacques and Pierre Curie in 1880, was useful in transducers to generate and detect ultrasonic waves in air and water ***(Wileyand Sons, 2012).***

Perception:

Humans

The upper frequency limit in humans (approximately 20 kHz) is due to limitations of the middle ear. Auditory sensation can occur if high-intensity ultrasound is fed directly into the human skull and reaches the cochlea through bone conduction, without passing through the middle ear ***(Takeda et al., 1992).***

Animals

Bats use a variety of ultrasonic ranging (echolocation) techniques to detect their prey. They can detect frequencies beyond 100 kHz, possibly up to 200 kHz. Many insects have good ultrasonic hearing and most of these are nocturnal insects listening for echolocating bats. This includes many groups of moths, beetles, praying mantids and lacewings. Upon hearing a bat, some insects will make evasive manoeuvres to escape being caught. Ultrasonic frequencies trigger a reflex action in the noctuid moth that cause it to drop slightly in its flight to evade attack. Tiger moths also emit clicks which may disturb bats' echolocation, but may also in other cases evade being eaten by advertising the fact that they are poisonous by emitting sound ***(Tougaard et al., 2003).***

Dogs and cats' hearing range extends into the ultrasound; the top end of a dog's hearing range is about 45 kHz, while a cat's is 64 kHz. The wild ancestors of cats and dogs evolved this higher hearing range to hear high-frequency sounds made by their preferred prey, small rodents. A dog whistle is a whistle that emits ultrasound, used for training and calling dogs. The frequency of most dog whistles is within the range of 23 to 54 kHz ***(George, 2010).***

History of Ultrasound in medicine:

Although discovered 12 years before the X-ray(1883), the ultrasound is a much later found application in medicine the first practical application of ultrasound is recorded during the World War I in detecting of submarines. The application of ultrasound in medicine began in fifties of last century. First was introduced in the obstetrics, and after that in all the fields of the medicine (the general abdominal diagnostics, the diagnostics in the field of the pelvis, cardiology, ophthalmology and orthopedics and so on.

The use of ultrasound in medicine began during and shortly after the 2nd World War in various centres around the world. The work of Dr. Karl Theodore Dussik in Austria in 1942 on transmission ultrasound investigation of the brain was the first published work on medical ultrasonics. From the mid-1960s onwards, the advent of commercially available systems allowed the wider dissemination of the art. Rapid technological advances in electronics and piezoelectric materials provided further improvements from bistable to greyscale images and from still images to real-time moving images. The technical advances at this time led to a rapid growth in the