Faculty of medicine
Al-Azhar University (Assiut)

Image Guidance in Pain Medicine

An Essay

Submitted for partial fullfilment of master degree
In Anaesthesia and Intensive care

By

Ali Eldorghamy Abd El ghany Koza

(M.B.,B.,CH.)

Supervised by

Prof.Dr. Ezzat Mahmoud El Saudi

Professorand head of Anaesthesia and Intensive care department
Faculty of medicine, Al-Azhar University (Assiut)

Dr. Saad El-dein Mahmoud El-khateeb

Assistant Professor of Anaesthesia and Intensive care
Faculty of medicine, Al-Azhar University (Assiut)

Faculty of medicine
Al-Azhar University (Assiut)
2014

كلية الطب
قسم التخدير والرعاية المركزة

طرق علاج الألم بواسطة أجهزة التصوير التوضيحية

رسالة توطئة للحصول على درجة الماجستير فى التخدير والرعاية المركزة

مقدمة من الطبيب

على الدرغامى عبد الغنى كوزة

طبيب مقيم بقسم التخدير والرعاية المركزة
كلية الطب،جامعة الأزهر(أسيوط)

تحت اشراف

ا.د. عزت محمود السعودى

أستاذ ورئيس قسم التخدير والرعاية المركزة
كلية الطب،جامعة الأزهر(أسيوط)

د. سعد الدين محمود الخطيب

أستاذ مساعد التخدير والرعاية المركزة
كلية الطب،جامعة الأزهر(أسيوط)

كلية الطب
جامعة الأزهر(أسيوط)

٢٠١٤

بسم الله الرحمن الرحيم

﴿ قَالُوا سُبْحَانَكَ لا عِلْمَ لَنَا إِلا مَا

عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ﴾

صدق الله العظيم

سورة البقرة آيه(٣٢)

ACKNOWLEDGEMENT

First and for most thanks to ALLAH for great help and support during this work Then I would like to express my deep gratitude to my kind teacher **Prof. Dr. Ezzat Mahmoud El Saudi** professor and head of anaesthesia and ICU department faculty of medicine AL-Azhar University(assiut) for his valuable guide,encouragement and supervision through my work.

Also I would like to express my thanks and great appreciation to **PROF.Dr. Saad El-dein Mahmoud El-khateeb** Assistant Professor of Anaesthesia and ICU faculty of medicine AL-Azhar University (assiut)for his great help, effort and kind advise and supervision on my search .

Careful acknowledgement and deepest gratitude to **my family** and specially, **my wife** for their continous support, continous help and their prayers for me to God to allow me to complete this work. Thanks to all persons who share me to complete this work

Ali Eldorghamy Abd El ghany Koza

CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	*Meaning*
AP	*Antero posterior view*
CNB	*Continuous Nerve Block*
CR	*Conventional Radiology*
CSF	*Cerebral Spinal Fluid*
CVP	*Central venous Pressure*
CT scan	*Computed Tomography*
EMG	*Electromyography*
ENS	*Electro Neuro Stimulation*
MRI	*Magnetic Resonance Imaging*
NMDA	*N-Methyl D A spartate receptors*
PNB	*Peripherally Nerve Block*
SGB	*Stellate Ganglionic Blockade*
USG	*Ultra Sonography Guidance*

INTRODUCTION

.Image Guidance including:-

1. Ultrasound

US can identify different soft tissues. Thin nerves can be visualized, which is not the case with the imaging techniques described above. US does not expose patients and personnel to radiation. Imaging can be performed continuously. The fluid injected is visualized in a real time fashion. Therefore, if the target nerve is identified, US provides the unique opportunity to assure spread of the injected solution at the site of block during administration, without radiation exposure. Because vessels are visualized, the risk of intravascular injection of local anesthetics or injury of vessels during destructive procedures is minimized. US is much less expensive than CT and may be less expensive\ than fluoroscopy. **(Kapral et al., 2008).**

A limitation of US is the poor visualization of narrow gauge needles. However, with experience, operators can infer the location of the needle from the movements of the soft tissues during needle manipulations. Some structures, such as bones, produce an US shadow behind them. This makes the identification of structures in those areas impossible. The higher the resolution of the transducer, the lower the tissue penetration of the beam. This means that deep structures cannot be visualized, or with a poor resolution **(Casati et al., 2007).**

2. Fluoroscopy

Fluoroscopy allows only the visualization of bones. Nerves and soft tissues are not visible. Vessels can be seen only when they are punctured and contrast medium is injected. Therefore, it is suitable only for target nerves that bear a dependable relationship to a bony landmark. Despite these limitations, fluoroscopy has several positive features that make it the standard method for pain procedures:(1) the whole field is visualized on the same image; (2)imaging is very rapidly obtained, which allows multiple needle repositioning in a short time; (3) in the event of intravascular injection, it will reveal rostral or caudal flow of contrast medium away from the target point (a facility that is not available from devices that produce planar images); (4) the apparatus is not excessively expensive.

3. Computed tomography

CT provides more information than fluoroscopy. Muscles, viscera, big vessels, nerve roots, the intervertebral discs (including herniations and protrusions) and the dural sac are visualized. The opening of joints is easily displayed, which makes intraarticular puncture of difficult joints, such as the sacroiliac joints of some patients, easier than by fluoroscopy (Pulisetti and Ebraheim, 1999). A disadvantage of CT is the high cost of the apparatus and therefore of the performed procedures. Each time the needle position is checked, the patient must be rescanned. This interrupts the procedure, prolongs it and involves considerable radiation exposure. Planar image does not reveal flow of contrast medium in vessels that run out of the plane of view. Thus, although CT is a useful tool for pain physicians for selected cases, its routine use is hardly justified.

4. Magnetic resonance imaging (MRI)

Is a medical imaging technique used in radiology to visualize detailed internal structures. MRI makes use of the property of Nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body. An MRI machine uses a powerful magnetic field to align the magnetization of some atoms in the body, and radio frequency fields to systematically alter the alignment of this magnetization. This causes the nuclei to produce a rotating magnetic field detectable by the scanner—and this information is recorded to construct an image of the scanned area of the body.: Strong magnetic field gradients cause nuclei at different locations to rotate at different speeds. 3-D spatial information can be obtained by providing gradients in each direction. MRI provides good contrast between the different soft tissues of the body, which make it especially useful in imaging the brain, muscles, the heart, and cancers compared with other medical imaging techniques such as computed tomography (CT) or X-rays. Unlike CT scans or traditional X-rays, MRI uses no ionizing radiation.

Ultrasound in acute and chronic pain: why is it necessary?

Abstract

High success rates are attainable using state-of-the-art multiple electrical nerve stimulation, loss-of resistance or fluoroscopic guidance techniques in most interventional acute and chronic pain techniques. Nevertheless, ultrasound (US) guidance for regional anesthesia and pain medicine offers compelling advantages in terms of precise location of anatomical structures, controlled needle advancement and local anesthetic deposition. Accurate models are needed to define criteria for the reproducibility of US examination and nerve block. Familiarization with US imaging is quickly becoming necessary as the next step in the evolution of interventional techniques for treating pain; consistent training by competent professionals is necessary to effectively leverage on the advantages of this technology.

Introduction

The last ten years have seen a new, and renewed interest in real-time ultrasound (US) guidance for acute and chronic pain interventions. Many institutions throughout the world now consider US imaging as standard of care for many invasive anesthesia- and pain medicine-related procedures. Chief amongst the factors facilitating the paradigm shift in anesthesiology is the concurrence of technological evolution with a change in physicians' attitudes. The former allowed for better imaging capabilities at a fraction of the cost of "classical" ultrasound machines whilst reducing the form factor of devices. Concurrently, anesthesia techniques have been reaching a point where adequate patient safety does not merely pertain to major, life-threatening complications, and efficacious pain control is as important as adequate management of all other vital signs. Ultrasound guidance in chronic pain interventions has similar appeals, although pain interventionalists have been using visual (radiological) guidance for many years. For these professionals, US imaging may lead to simplification of procedures, improved safety in selected contexts, and/or a reduction in execution times. This paradigm shift does not exclusively pertain to anesthesia or pain medicine, and it is part of a larger trend also involving emergency and critical care, gradually integrating traditional semiology to quantitative and qualitative realtime assessment of pathology using US imaging. Some call this "visual medicine," and it is the future of our practice.

In this brief review, we will examine some of the advantages of US guidance and some perspectives in interventional acute and chronic pain medicine.

Anatomical accuracy

Interventional techniques for acute pain treatment have traditionally relied upon a combination of external anatomical references (palpable landmarks) and, in some cases, functional guidance in the form of elicitation of paresthesiae, electrical nerve stimulation (ENS) or loss-of-resistance (LOR) techniques. We have demonstrated that when the combination of anatomical and functional location is completely realized – i.e., when two or more of the motorresponses attributable to a nerve plexus are sought for at the same anatomical region – the success rate of peripheral nerve blockade (PNB) is maximized, and is around 94% in a general population of patients undergoing orthopedic surgery of the upper and lower limb **(Fanelli et al., 1999).**

With single stimulation, the failure rate of PNB can be up mto 4 times higher in most blocks **(Rodriguez et al., 2004).**

Although often “taken for granted” due to the reproducibility of LOR techniques, epidural catheter placement using such guidance is not always successful. Data are scarce on the overall incidence of dural puncture (a surrogate of “failed guidance”), but in labor patients this may be estimated to be no less than 1.5% – probably much higher if we consider the inevitable under-reporting **(Choi et al., 2003).**

Success of regional nerve blocks for regional anesthesia and analgesia techniques is multifactorial in determination; however, accurate positioning of the injection needle is a condicio sine qua non.

To this end, real-time imaging of needle and target structures represents the ideal standard for interventional procedures, and the inevitable evolution of multiple stimulation in PNB, by which functional mapping was used to more accurately locate nerves. The advantages of US imaging are immediate: accurate localization of most neural structures of interest, together with “relevant” blood vessels and other sensitive structures (e.g., pleura, peritoneum, vertebrae, kidney; Fig. 1). Even when the actual target of the procedure cannot be directly imaged, as may be the case with the dura mater for epidural catheterization or the roots of the lumbar plexus, surrogate landmarks (e.g., the ligamentum flavum or the aponeurosis of the ileo-psoasmuscle) and their distance from the skin may be measured in vivo, thus reducing the chance of erroneous interpretation of traditional functional guidance. Once target structures have been identified, either directly or using surrogate landmarks in cases where current technology does not grant direct images, needle advancement can also be monitored to reduce the need for painful redirections or the risk of inadvertent puncture (Fig. 2). Randomized controlled trials have demonstrated the feasibility of US-guided PNB in most clinical settings (Marhofer and Chan, 2007); several studies also report positive results, especially in terms of risk of dural puncture and need for needle reinsertions, when adding US exploration of vertebral anatomy immediately before, or during the performance of epidural catheterization for labor analgesia **(Grau et al., 2002).**

When using traditional functional guidance at its gold standard (i.e., multiple ENS in the case of PNB and LOR with water for epidural), advantages in terms of success rate are difficult to formalize, since current success rates are already very high; US guidance, however, does make a difference in cases where traditional techniques may fail due to anatomical variations**(Kapral et al., 2008).**

Additionally, US imaging ensures reliable diagnostic and therapeutic blocks of sensory branches such as the lateral femoral cutaneous (Hurdle et al., 2007), saphenous/infrapatellar **(Lundblad et al., 2006),** ilioinguinal/iliohypogastric (Eichenberger et al., 2006b) and occipital nerves (Eichenberger et al., 2006a). The real novelty, however, is not in the possibility of enhanced success rates by themselves. Rather, US guidance allows for constant monitoring and avoidance of sensitive structures, including nerves themselves: although current knowledge and technology do not allow a clear definition of what an intraneural injection looks like (Chan et al., 2007a), the mere ability to see the nerve and needle has the potential improved safety. The same can be said for epidural catheterization procedures: real-time visualization of the needle is seldom possible in adults, but skin-to-target distances may be correctly measured **(Grau et al., 2002; Kim et al., 2008).**

Similar to epidural procedures, many interventions for spinal pain are commonly performed using fluoroscopic guidance and bony landmarks as surrogate targets. Although ultrasounds may not penetrate adult, mineralized bone, similar bone contour landmarks may be identified in US imaging, with the additional advantage of being able to identify and avoid blood vessels. A recent, masterful review by Gofeld details many of the most common techniques, along with data from the literature **(Gofeld, 2008).**

Of note, evidence shows that US guidance is an adequate replacement for fluoroscopy in lumbar vertebral procedures and celiac plexus blocks. Ultrasound imaging in these and other settings has several advantages, including a reduction in radiological burden for patients and operators and a reduction in personnel requirements (fluoroscopy technicians). Given the simplicity of the techniques, it is not unconceivable that as professionals progress along the learning curve, operative times may also be reduced.

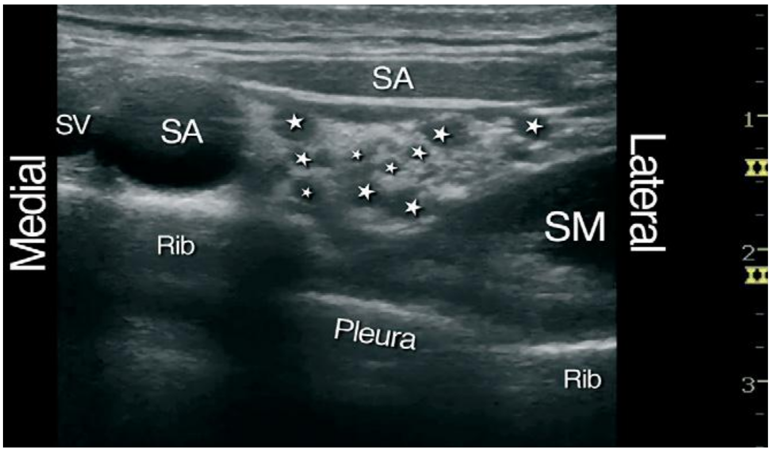

Fig. 1. Oblique coronal ultrasound scan of the supraclavicular region. Ultrasound imaging allows for both direct localization of target structures and avoidance of complications. SV and SA, subclavian vein and artery; SA and SM, scalenus anterior and medius muscles. Brachial plexus divisions are indicated by stars.

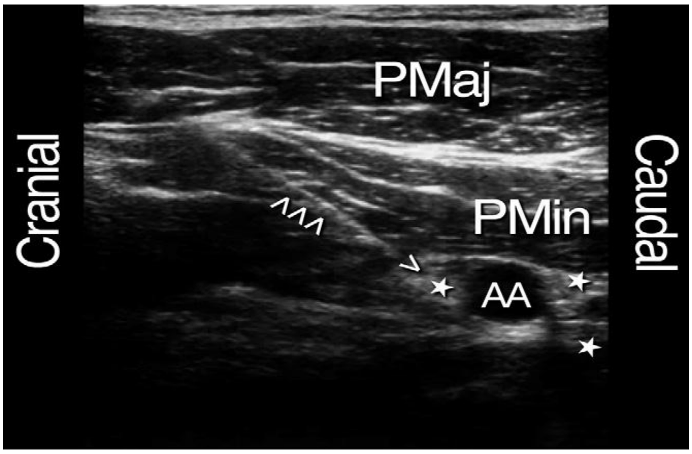

Fig. 2. Parasagittal scan of the infraclavicular region. The needle, highlighted by carets, is safely and precisely advanced towards the lateral cord of the brachial plexus, with a minimum of redirections. Stars indicate the approximate position of the brachial plexus cords. PMaj, pectoralis major muscle; Pmin, pectoralis minor muscle; AA, axillary artery.

Pharmaceutical accuracy

Placing the needle in the right position is only part of a successful nerve block. Local from a needle or catheter may be observed and assessed for adequate spread around the nerve in real-time guidance, in all cases where direct needle visualization is possible (Fig. 3).

Few studies have been published on what constitutes "adequate" spread and, inductively, the minimum dose required for PNB. We have assessed the minimum effective dose of 0.5% ropivacaine for surgical anesthesia of the femoral nerve, achieving a 40% reduction with US guidance **(Casati et al., 2007).**

Although suggestive of the potential improvement in anesthetic delivery, this preliminary study had several limitations, including a lack of ultrasound defined (as opposed to statistically-defined) endpoints for the estimation of the effective dose. Willschke et al. have demonstrated that visual determination of the effective dose is possible for ilioinguinal/iliohypogastric block in children, by terminating the injection when both nerves were seen "surrounded by the local anesthetic" in a short-axis view **(Willschke et al., 2005).**

Future investigations will include quantitative analysis of the bi-dimensional ultrasound images, coupled with volume data from 3D ultrasound technology, to model local anesthetic diffusion along nerve sheath and its relationship with block effectiveness.

The quest for the "right dose" of local anesthetic is not only a matter of safety and/or pharmacoeconomics. Liposomal formulations of local anesthetic are in their preclinical evaluation phases **(Grant et al., 2004; Cereda et al., 2006).**

These drug formulations, which release the active local anesthetic in a controlled fashion over hours to days after administration, may be attractive for