

**The role of Ultrasound-Assisted Combined Femoral and Sciatic Nerve
Block in diagnostic knee arthroscopy in intra-operative and postoperative
pain control.**

**Thesis submitted for the partial fulfilment of the Master Degree in
Anesthesia, Critical Care and Pain Management**

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List of abbreviations

2-cp: 2- chloroprocaine

ASA: American Society of Anesthesia

ASU: Ambulatory surgery unit

CSF: Cerebrospinal fluid

CSFNB: Combined sciatic-femoral nerve block

LAST: Local anesthetic systemic toxicity

LMWH: Low molecular weight heparin

NYSORA: New York society of regional anesthesia

OOP approach: Out of plane approach

PACU: Post Anesthesia Care Unit

PART maneuvers: Pressure, Alignment, Rotation and Tilt

PDPH: Post Dural puncture headache

POUR: Post operative urine retention

SAV: Short axis view

SEA: Spinal epidural abcess

TIVA: Total intravenous anesthesia

TKA: Total knee arthroplasty

TNS: Transient neurologic symptoms

U/S: Ultrasound

USA: Unilateral spinal anesthesia

Abstract

Rationale and background:

Peri-neural dexmedetomidine extends the duration of local anesthetic-induced peripheral nerve blocks in the experimental and the clinical settings. The effects of peri-neural dexmedetomidine on the pharmacodynamic profile of bupivacaine-induced femoral nerve block were not previously explored. We hypothesized that the addition of peri-neural dexmedetomidine will extend the duration of femoral nerve block in patients undergoing arthroscopic knee surgery.

Patients and methods:

This randomized, controlled double blinded study included 45 adult patients undergoing arthroscopic knee surgery. Ultrasound-guided femoral nerve block was initiated 30 min before induction of general anesthesia. Femoral nerve block was achieved with the use of 25 ml of bupivacaine 0.5% in all patients. Bupivacaine was combined with 0.5 ml normal saline (control group, n=15), 50 µg (0.5 ml) peri-neural dexmedetomidine (n=15), or 50 µg (0.5 ml) intramuscular dexmedetomidine (n=15). All patients received a standard general anaesthetic after ensuring successful femoral nerve block. The onset and duration of sensory and motor blocks, the time to first request to postoperative rescue analgesic, Richmond Agitation-Sedation Score, haemodynamic data, resting and dynamic visual analogue pain scores, were reported at predetermined time assessment points. Postoperative rescue intravenous morphine consumption over 24 hours was recorded.

Results:

The onset of sensory block was significantly shorter and its duration was extended with the use of peri-neural dexmedetomidine compared to the control and systemic route of administration. The onset of motor block was comparable in the three study groups. The duration of motor block was significantly longer in the peri-neural dexmedetomidine group. The time to first request to rescue analgesia was prolonged and total postoperative morphine consumption was reduced in the peri-neural dexmedetomidine group. Postoperative sedation was more encountered at the 30 min and two hours assessment points in the peri-neural and intramuscular dexmedetomidine groups. Statistically significant reductions in systolic blood pressure and heart rate were observed up to 45 minutes after induction of general anesthesia in all groups compared to the baseline values. However, there were no statistically significant differences in haemodynamic variables among the three study groups.

Conclusion:

The use of peri-neural dexmedetomidine as an adjuvant to bupivacaine reduces the onset and prolongs the duration of femoral nerve block in patients undergoing arthroscopic knee surgery.

Keywords: intra-operative – postoperative-PACU- CSFNB

INTRODUCTION

Arthroscopy of the knee is one of the most commonly performed orthopedic procedures worldwide. In the UK, > 50,000 operations are performed annually (9.9%/ 10,000 population) ¹. Procedure is considered to be safe and complications following arthroscopy are rare, which in the majority of cases is performed as day case surgery ¹. Anesthetic techniques should ensure minimum stress and maximum comfort for the patients and should take into consideration the risks and benefits of individual techniques. Regional and general anesthesia techniques are both acceptable anesthetic options for patients undergoing day case knee procedures ², however none of them is devoid of deleterious effects. Up-to-date, strong evidence for clinical and cost benefit of one mode of anaesthesia compared with the other has been minimal.

Central neuroaxial anesthesia had been introduced to practice for more than 60 years ³, has become an established and routine part of every anesthetist's practice. Two decades ago, spinal anesthesia was not the preferred anesthetic technique among day case patients due to two main constraints. First, complications associated with spinal anesthesia ⁴, though most of complications associated with spinal anesthesia are mild, transient and self-limited, however rare serious complications can still occur and can be considered disastrous specially among patients in whom general anesthesia do not impose an increased risk for morbidity and mortality (ASA I). Secondly, fear from delayed discharge for patients in the ambulatory setting due to widespread of local anesthetics. Nowadays, central neuroaxial anesthesia are more frequently used in the ambulatory setting, due to development in needle designs (pencil point, smaller gauges), spinal techniques aiming for limiting widespread of local anesthetics (selective spinal), and better understanding of pharmacological and clinical behaviors of local anesthetics ⁵. Nair and colleagues ⁶ systematically reviewed spinal bupivacaine anesthesia among patients undergoing ambulatory knee arthroscopy and demonstrated that 4-5 mg of hyperbaric bupivacaine can effectively produce spinal anaesthesia for knee arthroscopy with unilateral positioning (Unilateral spinal anesthesia) and was associated with favorable intra and postoperative conditions. Such finding was further confirmed in a prospective randomized trial involving 80 patients undergoing ambulatory knee arthroscopy ⁷.

Peripheral nerve block is another attractive option for regional anesthesia in patients undergoing ambulatory knee arthroscopy; however regional nerve block anesthesia had been less commonly used and less successful in surgery on the lower extremity, due to anatomical difficulties⁸, also drug toxicity and inadvertent injury to adjacent structures are another deleterious effects of peripheral nerve block. The introduction of ultrasound (U/S) to the field of peripheral nerve blocks and widespread availability of ultrasound guidance over the past 20 years^{9 10} had dramatically expanded the popularity of peripheral nerve blocks among anesthesiologists². U/S guided peripheral nerve block allows higher success rates and fewer complications associated with peripheral nerve blocks¹¹⁻¹³. Femoral nerve block are well validated for knee surgery¹⁴, the value of adding sciatic nerve block to femoral nerve block had been questioned in patients subjected for total knee arthroplasty (TKA) with controversial results¹⁵⁻¹⁷ in regard to functional recovery and major outcome variables. However, negative trials appreciated reduced pain severity on the day of surgery when sciatic nerve block was added to femoral nerve block¹⁵. Postoperative pain is one of the major factors associated with unplanned admission in the ambulatory setting¹⁸. Thus, logically the addition of single shot sciatic nerve block to single shot femoral nerve block using ultrasound guidance will be an ideal regional anesthetic option for patients undergoing day case knee surgery.

Numerous evidences are emerging in support of regional (central neuroaxial + peripheral nerve block) over general anaesthesia, in terms of postoperative analgesia^{19 20}, deep venous thrombosis²¹, myocardial events²², pulmonary complications²³ and even on cancer recurrence²⁴. However, very few evidences are available in support of a regional technique over another. Thus, the question is as follows: Is central neuroaxial anesthesia superior to peripheral nerve block in patients undergoing knee arthroscopy? In the current trial we will investigate safety and efficacy of unilateral spinal anesthesia using hyperbaric bupivacaine 0.5% + fentanyl versus U/S guided combined sciatic and femoral nerve block, in patients scheduled for elective knee arthroscopy.

REVIEW OF LITERATURE

Evidence in regional anesthesia is rapidly growing. It is hard to review all relevant studies, and therefore meta-analyses are very helpful to categorize the available evidence. Although the popularity of meta-analyses has increased dramatically over the last two decades, interpretation of meta-analyses can lead to deceptive results²⁵ compared to clinical practice and experience. In the current review we will discuss relevant knowledge according to best available evidence. The following topics will be discussed:

- **Physical principals and basics of U/S scanning.**
- **Clinical considerations for spinal anesthesia**
- **Clinical considerations for U/S guided combined sciatic and femoral nerve block (CSFNB).**
- **Evidence regarding spinal anesthesia and combined sciatic and femoral nerve block in anesthesia.**

➤ **Physical Principals and basics of U/S scanning:**

The term ultrasound (U/S) refers to sound with a frequency above that which can be detected by the human ear (20 Hz and 20 kHz), whereas the frequencies of sound waves used for diagnostic applications in medicine are of the order of one thousand times higher than this, with a range between 1 and 10MHz. Ultrasound imaging relies on the so-called pulse echo principle, which involves emitting a short burst of ultrasound and then listening for the returning “echo” after the sound has been reflected off appropriate surfaces. This is exactly the mechanism which has been employed by bats for millions of years to navigate their way around dark caves and to catch flying insects. Human interest in navigation using sound waves was significantly enhanced (if not initially inspired) by the sinking of the Titanic, which occurred when the ship collided with an iceberg in April 1912. Within a few years, ships were widely equipped with SONAR (Sound Navigation and Ranging) devices, which emit sound waves beneath the surface of the sea, and detect echoes from large objects within a radius of several miles. The technology advanced considerably during both world wars as it was utilized to detect submarines and mines ²⁶.

Ultrasound has been used to image the human body for over half a century. Dr. Karl Theo Dussik, an Austrian neurologist, was the first to apply ultrasound as a medical diagnostic tool to image the brain, and over the following decade simple (A-mode) systems were developed that could detect midline shift in head injury and the presence of foreign bodies in the orbit ²⁷. Today, ultrasound (US) is one of the most widely used imaging technologies in medicine. It is portable, free of radiation risk, and relatively inexpensive when compared with other imaging modalities, such as magnetic resonance and computed tomography.

I. Basic principal of U/S:

Modern medical US is performed primarily using a pulse-echo approach with a brightness- mode (B-mode) display. The basic principles of B-mode imaging involve transmitting small pulses of ultrasound echo from a transducer into body. As the ultrasound waves penetrate body tissues of different acoustic impedances along the path of transmission, some are reflected back to the transducer (echo signals) and some continue to penetrate deeper. The echo signals returned from

many sequential pulses are processed and combined to generate an image. Thus, an ultrasound transducer works both as a speaker (generating sound waves) and a microphone (receiving sound waves). The direction of Ultrasound propagation along the beam line is called the axial direction, and the direction in the image plane perpendicular to axial is called the lateral direction ²⁸. Usually only a small fraction of the ultrasound pulse returns as a reflected echo after reaching a body tissue interface, while the remainder of the pulse continues along the beam line to greater tissue depths.

II. Generation of U/S Pulses:

Ultrasound transducers (or probes) contain multiple piezoelectric crystals which are interconnected electronically and vibrate in response to an applied electric current. This phenomenon called the piezoelectric effect was originally described by the Curie brothers in 1880 when they subjected a cut piece of quartz to mechanical stress generating an electric charge on the surface ²⁹. Later, they also demonstrated the reverse piezoelectric effect, i.e., electricity application to the quartz resulting in quartz vibration ³⁰. These vibrating mechanical sound waves create alternating areas of compression and rarefaction when propagating through body tissues. Sound waves can be described in terms of their frequency (measured in cycles per second or hertz), wavelength (measured in millimeter), and amplitude (measured in decibel).

III. U/S Wavelength & frequency:

The wavelength and frequency of US are inversely related, i.e., ultrasound of high frequency has a short wavelength and vice versa. Proper selection of transducer frequency is an important concept for providing optimal image resolution in diagnostic and procedural US. High-frequency ultrasound waves (short wavelength) generate images of high axial resolution. Increasing the number of waves of compression and rarefaction for a given distance can more accurately discriminate between two separate structures along the axial plane of wave propagation. However, high-frequency waves are more attenuated than lower frequency waves for a given distance; thus, they are suitable for imaging mainly superficial structures ²⁹. Conversely, low-frequency waves (long wavelength) offer images of lower resolution but can penetrate to deeper structures due to a lower degree of attenuation.

IV. U/S and tissue interaction:

As US waves travel through tissues, they are partly transmitted to deeper structures, partly reflected back to the transducer as echoes, partly scattered, and partly transformed to heat. For imaging purposes, we are mostly interested in the echoes reflected back to the transducer. The amount of echo returned after hitting a tissue interface is determined by a tissue property called acoustic impedance. This is an intrinsic physical property of a medium defined as the density of the medium times the velocity of US wave propagation in the medium. Air-containing organs (such as the lung) have the lowest acoustic impedance, while dense organs such as bone have very high- acoustic impedance (table 1) ³¹.

Table 1: Acoustic impedances of different body tissues and organs ³¹.

Body Tissue	Acoustic impedances (10^6 Rayls)
Air	0.0004
Lung	0.18
Fat	1.34
Liver	1.65
Blood	1.65
Kidney	1.63
Muscle	1.71
Bone	7.8

V. Reflection, refraction, scattering & attenuation:

The intensity of a reflected echo is proportional to the difference (or mismatch) in acoustic impedances between two mediums. If two tissues have identical acoustic impedance, no echo is generated. Interfaces between soft tissues of similar acoustic impedances usually generate low-intensity echoes. Conversely interfaces between soft tissue and bone or the lung generate very strong echoes due to a large acoustic impedance gradient ³¹.

When an ultrasound pulse encounters a large, smooth interface of two body tissues with different acoustic impedances, the sound energy is reflected back to the transducer. This type of reflection is called specular reflection, and the echo intensity generated is proportional to the acoustic

impedance gradient between the two mediums (Figure 1). If the U/S beam reaches the linear interface at 90° , almost all of the generated echo will travel back to the transducer. However, if the angle of incidence with the specular boundary is less than 90° , the echo will not return to the transducer, but rather be reflected at an angle equal to the angle of incidence. The returning echo will potentially miss the transducer and not be detected.

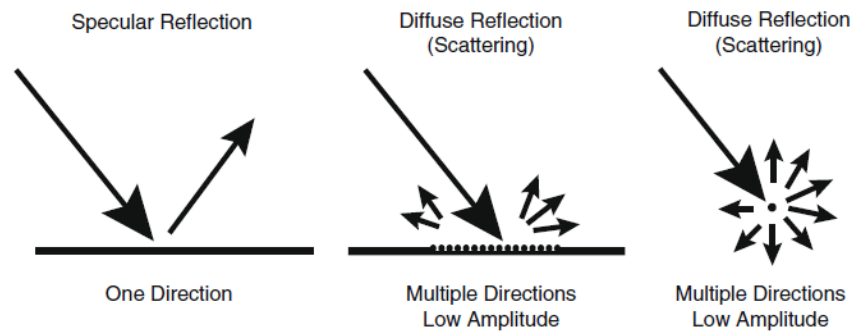


Figure 1: Different types of U/S tissue reflection ³¹.

Refraction refers to a change in the direction of sound transmission after hitting an interface of two tissues with different speeds of sound transmission. In this instance, because the sound frequency is constant, the wavelength has to change to accommodate the difference in the speed of sound transmission in the two tissues. This results in a redirection of the sound pulse as it passes through the interface. Refraction is one of the important causes of incorrect localization of a structure on an ultrasound image. Because the speed of sound is low in fat (approximately 1,450 m/s) and high in soft tissues (approximately 1,540 m/s), refraction artifacts are most prominent at fat/soft tissue interfaces. The most widely recognized refraction artifact occurs at the junction of the rectus abdominus muscle and abdominal wall fat. The end result is duplication of deep abdominal and pelvic structures seen when scanning through the abdominal midline (figure 2) ³².

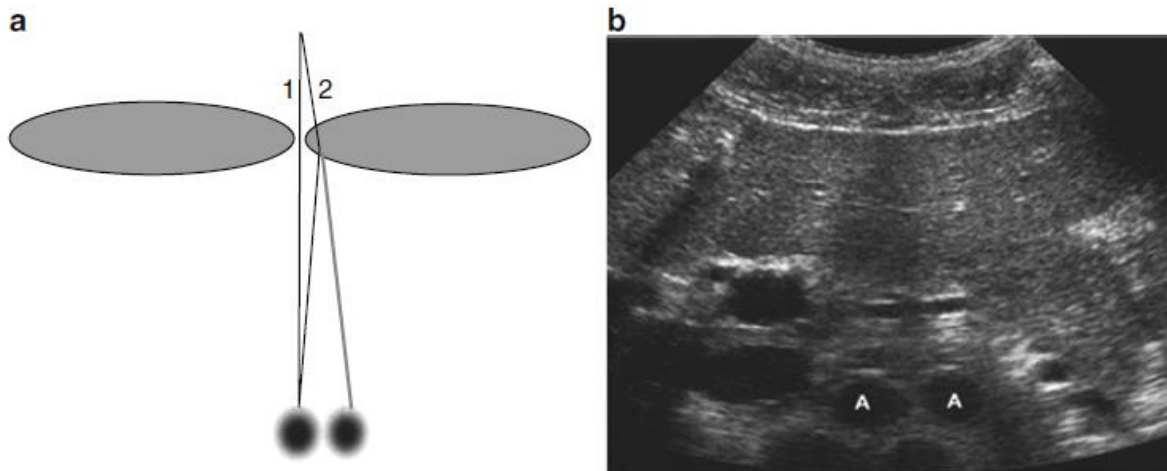


Figure 2: Refraction artifact. Diagram (a) illustrates how sound beam refraction results in duplication artifact. (b) Transverse midline view of the upper abdomen showing duplication of the aorta (A) secondary to rectus muscle refraction³².

If the ultrasound pulse encounters reflectors whose dimensions are smaller than the ultrasound wavelength, or when the pulse encounters a rough, irregular tissue interface, scattering occurs. In this case, echoes reflected through a wide range of angles result in reduction in echo intensity. However, the positive result of scattering is the return of some echo to the transducer regardless of the angle of the incident pulse. Most biologic tissues appear in U/S images as though they are filled with tiny scattering structures. The speckle signal that provides the visible texture in organs like the liver or muscle is a result of interface between multiple scattered echoes produced within the volume of the incident ultrasound pulse²⁸.

As U/S pulses travel through tissue, their intensity is reduced or attenuated. This attenuation is the result of reflection and scattering and also of friction losses. These losses result from the induced oscillatory tissue motion produced by the pulse, which causes conversion of energy from the original mechanical form into heat. This energy loss to localized heating is referred to as absorption and is the most important contributor to US attenuation. Longer path length and higher frequency waves result in greater attenuation. Attenuation also varies among body tissues, with the highest degree in bone, less in muscle and solid organs, and lowest in blood for any given frequency (figure 3)²⁸.