Biodata Abstrak Penyelidikan

THE ACCURACY OF ULTRASOUND GUIDED TECHNIQUE FOR LUMBAR INTERVERTEBRAL DISC LEVEL LOCALISATION

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Introduction : Spinal level localisation is a very important factor in any spine surgery to ensure that the operation is performed at the correct site. C-arm image intensifier is the current practice in operating theatre for most of the spinal surgery. However, its use is related to a few problems. Ultrasound can be a good alternative. Ultrasound guided technique has gain popularity for spinal procedure especially among anaesthetist and rheumatologist.

Objectives : The aims of this study were to assess the accuracy of the L3/L4, L4/L5, L5/S1 intervertebral disc level localisation of lumbar spine using ultrasound in normal and degenerative spine.

Study design and methodology : This was a cross-sectional study of 80 participant equally divided into normal spine group and degenerative spine group. Ultrasound guided intervertebral disc localisation of L3/L4, L4/L5 and L5/S1 was performed on all participant in prone position by a single operator. A standardised steps were used and inferior edge of spinolaminar junction of the overlying vertebral was used as a sonographic landmark representing a particular disc level. A radiopaque marker was placed on each disc level identified for accuracy checking using X-ray machine or C-arm image intensifier. Radiopaque marker crossing at least 50% of the width of the intended intervertebral disc was defined as accurate.

Result : Pertinent landmark for intervertebral disc localisation were identified with ultrasound guidance in all participants with overall accuracy rate of 65.0%. No significant different in accuracy localising L3/L4 disc in normal spine (32.5%) and degenerative spine (40.0%) group. However accuracy was significantly higher in normal group (82.5%) compared to degenerative group (60.0%) at L4/L5 disc level. We had higher accuracy localising L5/S1 disc in both groups with same accuracy of 87.5%.

Conclusion : Ultrasound guidance intervertebral disc localisation is a feasible approach to localise lumbar discs using spinolaminar junction of overlying vertebra as a landmark. It can be safely performed at L5/S1 disc level in patient with or without degenerative spine disease. It can also be considered in patients without degenerative spine disease at L4/L5 disc level. However it is not recommended to localise L3/L4 disc level.

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Dr Khairil Amir Sayuti : Co supervisor

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by

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List of Nomenclatures

Nomenclature	Definition
Accuracy	Qualitative measurement of identification of intervertebral disc level that was classified into two outcomes which were “accurate” and “inaccurate”. This similar method was used in by Furness(2002) and Holmaas(2006)
Accurate	The wire (marker) crosses at least 50% of the corresponding intervertebral disc width.
Anterior dura complex	a complex of posterior vertebral cortex or intervertebral disc, posterior longitudinal ligament and anterior dura mater
Posterior dura complex	a complex of ligamentum flavum and posterior dura mater
Intervertebral disc level	The space between inferior endplate of cephalad vertebral body and superior endplate of caudal vertebral body
MRI	Magnetic resonance imaging

ABSTRAK

Ketepatan penentuan paras cakera tulang belakang lumbar dengan teknik panduan ultrasound

Pengenalan dan objektif

Penentuan paras tulang belakang merupakan faktor yang amat penting dalam mana-mana pembedahan tulang belakang untuk memastikan bahawa pembedahan dilakukan pada lokasi yang betul. Penggunaan mesin sinar-X di dalam bilik pembedahan bagi kebanyakan pembedahan tulang belakang adalah amalan masa kini. Walau bagaimanapun, penggunaannya dikaitkan dengan beberapa masalah. Kaedah ultrasound boleh menjadi alternatif yang baik. Kaedah ultrasound semakin mendapat sambutan dalam prosedur tulang belakang terutamanya oleh pakar bius dan rhematologi.

Rangka kajian dan metodologi

Ini adalah kajian keratan rentas melibatkan 80 peserta dibahagikan sama rata kepada kumpulan tulang belakang yang normal dan kumpulan tulang belakang degenerasi. Dengan panduan ultrasound, penentuan cakera tulang belakang L3/L4 , L4/ L5 dan L5/S1 telah dilakukan ke atas semua peserta dalam kedudukan meniarap oleh pengendali yang sama. Langkah-langkah yang seragam telah digunakan. Persimpangan spinolamina tulang vertebra bersebelahan di atas telah digunakan sebagai tanda sonografi untuk mewakili tahap cakera tertentu. Satu penanda ditempatkan di atas setiap peringkat cakera yang telah dikenalpasti. Ketepatan kedudukan penanda tersebut

diperiksa menggunakan mesin sinar-X. Satu-satu peringkat dianggap tepat sekiranya penanda tersebut melintasi 50 % atau lebih kelebaran cakera tulang belakang.

Keputusan

Persimpangan spinolamina sebagai tanda penting bagi penentuan cakera tulang belakang berjaya dikenal pasti dengan panduan ultrasound dalam semua peserta dengan kadar ketepatan keseluruhan sebanyak 65.0 %. Tiada perbezaan yang ketara dari segi ketepatan penentuan cakera L3/L4 di antara kumpulan tulang belakang normal (32.5 %) dan tulang belakang degenerasi (40.0%). Walau bagaimanapun ketepatan pada peringkat cakera L4/L5 adalah jauh lebih tinggi dalam kumpulan tulang belakang normal (82.5%) berbanding dengan kumpulan tulang belakang degeneratif (60.0%). Kami mempunyai ketepatan penentuan cakera yang lebih tinggi di kedua-dua kumpulan pada peringkat L5/S1 dengan ketepatan yang sama sebanyak 87.5 %.

Kesimpulan

Penentuan pringkat cakera tulang belakang dengan panduan ultrasound adalah pendekatan yang boleh dilaksanakan dengan menggunakan persimpangan spinolamina tulang vertebra bersebelahan di atas sebagai tanda. Kaedah ini dapat dilakukan dengan selamat di peringkat cakera L5 / S1 untuk pesakit dengan atau tanpa penyakit degenerasi tulang belakang. Kaedah ini juga boleh dipertimbangkan untuk digunakan pada pesakit tanpa penyakit tulang belakang degenerasi di peringkat L4/L5. Namun ia tidak digalakkan untuk menentukan peringkat cakera L3/L4.

Kata kunci : ‘Lumbar’, cakera tulang belakang, penentuan paras cakera, ‘ultrasound’, ‘sonoanatomy’

ABSTRACT

The Accuracy Of Ultrasound Guided Technique For Lumbar Intervertebral Disc Level Localisation

Introduction and objective

Spinal level localisation is a very important factor in any spine surgery to ensure that the operation is performed at the correct site. C-arm image intensifier is the current practice in operating theatre for most of the spinal surgery. However, its use is related to a few problems. Ultrasound can be a good alternative. Ultrasound guided technique has gain popularity for spinal procedure especially among anaesthetist and rheumatologist.

Study design and methodology

This was a cross-sectional study of 80 participant equally divided into normal spine group and degenerative spine group. Ultrasound guided intervertebral disc localisation of L3/L4, L4/L5 and L5/S1 was performed on all participant in prone position by a single operator. A standardised steps were used and inferior edge of spinolaminar junction of the overlying vertebral was used as a sonographic landmark representing a particular disc level. A radiopaque marker was placed on each disc level identified for accuracy checking using X-ray machine or C-arm image intensifier. Radiopaque marker crossing at least 50% of the width of the intended intervertebral disc was defined as accurate.

Result

Pertinent landmark for intervertebral disc localisation were identified with ultrasound guidance in all participants with overall accuracy rate of 65.0%. No significant different in accuracy localising L3/L4 disc in normal spine (32.5%) and degenerative spine (40.0%) group. However accuracy was significantly higher in normal group (82.5%) compared to degenerative group (60.0%) at L4/L5 disc level. We had higher accuracy localising L5/S1 disc in both groups with same accuracy of 87.5%.

Conclusion

Ultrasound guidance intervertebral disc localisation is a feasible approach to localise lumbar discs using spinolaminar junction of overlying vertebra as a landmark. It can be safely performed at L5/S1 disc level in patient with or without degenerative spine disease. It can also be considered in patients without degenerative spine disease at L4/L5 disc level. However it is not recommended to localise L3/L4 disc level.

Keywords : Lumbar, intervertebral disc, disc level localisation, ultrasound, sonoanatomy

1. Introduction

1.1. Rationale of the study

Spinal level localisation is a very important step in any spine surgery to ensure that the operation is performed at the correct site and to avoid wrong-site spine surgery. Minimally invasive surgery (MIS) is the current trend in orthopaedic surgery, many latest studies report on new methodology, implant innovation, computer assisted navigation system and usage of advance imaging modality. This transformation aims at minimising soft tissue trauma and optimising patient recovery and rehabilitation. Percutaneous spinal procedures, intradiscal electrothermal annuloplasty, endoscopic spinal surgery and mini open spinal surgery were introduced as part of minimal invasive spinal surgery to achieve long term clinical result as good as open surgery. Spinal surgery depends on correct spinal level localisation, more so with minimally invasive spinal surgery which uses very small skin incision (O'Dowd, 2007).

Perioperative C-Arm fluoroscopy has been the standard modality used in operation theatre for level localisation of spine. This is to ensure surgical incision is made on the intended level with minimal but adequate exposure which can prevent postoperative pain associated with soft tissue and bone damage. Image intensifier however may not be readily available due to breakdown or inadequate at times. It expose patients, surgeons and other theatre staffs to ionising radiation. Besides, the operation of C-Arm image intensifier needs radiographer service and of course it occupy a substantial space in the operative theatre (Tsai, 2004).

Ultrasound use has becoming more widespread among anaesthetist and is rapidly becoming the gold standard for regional anaesthesia and pain management. It is used for pain medicine including cervical and lumbar facet joint injection, lumbar medial branch blocks, periradicular injections, caudal and sacroiliac joints injection besides epidural and spinal anaesthesia (Griffin, 2010). Many studies had been carried out regarding ultrasound use in the mentioned indications in anaesthesia field. In spinal surgery, ultrasound is reported used for diagnosis and surgical management of lumbar disc herniation and canal stenosis after laminectomy (Montalvo, 1990).

Successful of ultrasound use is operator dependent, thus has distinct learning curve. A mixture of theoretical and practical training is required including knowledge of ultrasound and equipment and relevant anatomy.

The ideal technique for spinal-level localisation would have the following characteristics:

- Accurate
- Easy availability in the operating theatre
- Lowest-possible radiation exposure for the professional team and the patient
- Simple technique which is easily reproducible at any time during surgery
- Usable with all forms of spine surgery
- Permanently recordable
- Able to be used throughout the spine
- Able to be easily checked by non-specialist members of the team

(Nowitzke, 2008)

Ultrasound sonography for spinal level localisation seems to be a promising method as it can answer some of the above characteristic.

Ultrasound is a good option for spinal level localisation as it is versatile, without radiation exposure to the surgeons, supporting staffs and patients. It is a relatively cheaper option compare to navigation systems, CT scan and MRI for lumbar spinal level localisation. Ultrasound machine was readily available in operative theatre where this study was carried out.

1.2. Research Questions

1. What is the accuracy of localising L3/L4, L4/L5, L5/S1 intervertebral disc level using ultrasound guidance approach?
2. Is there any difference in accuracy of the L3/L4, L4/L5, L5/S1 intervertebral disc level localisation using ultrasound guidance approach comparing normal and degenerative spine?
3. Is there any different in accuracy of L3/L4, L4/L5, L5/S1 intervertebral disc level localisation using ultrasound guidance approach among the three levels.

1.3. Objectives

General

To assess the accuracy of the L3/L4, L4/L5, L5/S1 intervertebral disc level localisation of lumbar spine using ultrasound in normal and degenerative spine

Specific

1. To assess the accuracy of the L3/L4, L4/L5, L5/S1 intervertebral disc level localisation of lumbar spine in normal spine (young volunteers)
2. To assess the accuracy of the L3/L4, L4/L5, L5/S1 intervertebral disc level localisation of lumbar spine in degenerative spine
3. To compare the accuracy of each level (L3/L4, L4/L5, L5/S1 intervertebral disc) between normal spine and degenerative spine
4. To compare the accuracy between each level (L3/L4, L4/L5, L5/S1 intervertebral disc) in normal spine and degenerative spine

1.4. Research Hypothesis

There is no difference in accuracy of intervertebral disc level localisation using ultrasound in normal spine compared to degenerative spine

2. Literature reviews

2.1. Anatomy of Lumbar Spine

The lumbar spine sits in between thorax and sacrum in a spinal column. It has lordotic curvature in a normal erect posture. Lumbar spine consists of five moveable vertebrae numbered L1 to L5 from proximal to distal. These strong vertebrae are linked by inter vertebrae discs, facet joint capsule, ligaments and large spinal muscles. They are important to carry the upper body weight, protect the spinal cord and nerve roots. It provides good flexion, extension and lateral flexion but limited rotation (Moore, 2013; Sinnatamby, 2006).

A lumbar vertebra is made up of three functional parts: 1) vertebra body capable to bear weight ; 2) vertebral arch for protection of spinal cord and nerve roots ; 3) The bony processes to provide muscle attachment for more efficient muscle movement.

A typical lumbar vertebra is kidney-shaped in axial view and has triangular vertebra foramen. Long and slender transverse processes with accessory process present on each process. Posteromedially directed superior facet, anteraomedially directed inferior facet and present of maxillary process on posterior surface of each superior articular process are distinctive characteristics of the lumbar articular processes. The spinous process is short and sturdy, thick, broad and hatchet-shaped. Each neural arch is made up of two pedicles and two laminae on top of the seven processes mentioned above (Moore, 2013).

Anterior longitudinal ligament firmly attached to the periosteum of anterior vertebrae bodies but less so over the intervertebral disc. The posterior longitudinal ligament meanwhile covers the posterior surface of vertebral bodies. It attaches firmly on the disc but loosely over the vertebral bodies. Ligamentum flavum attaches to the superior lamina anteriorly and inserts to the posterior surface of inferior lamina. Each adjacent transverse process is joined by inter transverse ligament. The interspinous ligament joins the adjacent spinous processes. The tip of spinous processes from L1 to L3 are joined by supraspinatous ligament.

2.2. Anatomy of the intervertebral disc

Lumbar intervertebral discs strongly connect adjacent vertebral bodies. They are important for the mobility of intervertebral joints. An intervertebral disc composed of the nucleus pulpous at the centre, surrounded by annulus fibrosus. They are closely attached to the endplate of adjacent vertebral bodies.

The annulus fibrosus is made up of lamellas that are rich of strong type I collagen fibres. These lamellas are interconnected by proteoglycan aggregates, lubricant and type IV collagen. They are oriented at 35° relative to the horizontal plane in layers. Orientation of lamellas in each layers re in opposite direction to the adjacent layers. The complex structure of annulus fibrosus provide high tension strength to the intervertebral disc.

The nucleus pulposus composed of type II collagen and hydrophilic proteoglycans. The negative charge proteoglycans give hyper hydrated state of nucleus pulposus. This property allows the nucleus pulposus to be elastic and capable of withstanding high compressive strength.

The intervertebral disc ageing is a series of physiological changes at cellular and tissues levels. In nucleus pulposus, notochordal cells progressively differentiate into chondrocyte-like cells after birth. This changes affect the integrity of extracellular matrix integrity due to metabolism imbalance. This process leads to degradation of collagen and proteoglycans that subsequently results in dehydration and disorganisation of extracellular matrix. Ageing is also related to fibroblast apoptotic cell death that initiate degradation of matrix component. This results in thinner and more irregular collagen fibbers subsequently cracking and tear. The intervertebral disc thus loss its ability to absorb compressive load and transmit it to the vertebral column and loss its annular integrity. This leads to disc space narrowing and disc bulge (Antoniou, 1996; Colombier, 2014; Jarvik, 2000).

2.3. Spinolaminar junction

Lamina is a sheet of bone projecting from pedicle towards the spinous process at the midline. A pair of laminae meet and blend with one another in the midline forming the protective layer of neural arch (Bogduk, 2005). The junction between spinous process and lamina form the spinolaminar junction. It is the most medial border of a lamina. (Figure1) Morphometric anatomy of lamina from C2 to L5 vertebrae were described in a study by RongMing Xu (1999). Quantitative relation of lamina and spinolaminar junction to intervertebral disc is neglected in the literatures. However laminae or inter lamina space relation to the intervertebral disc were described in a few articles.

The L5/S1 intervertebral disc is usually located at the level of the same interlaminar space. The disc is located more proximally in relation to the interlaminar space moving in a cephalad direction (Härtl, 2012). With disc space collapse in degenerative spine, the lower edge of cephalic lamina moved caudally.

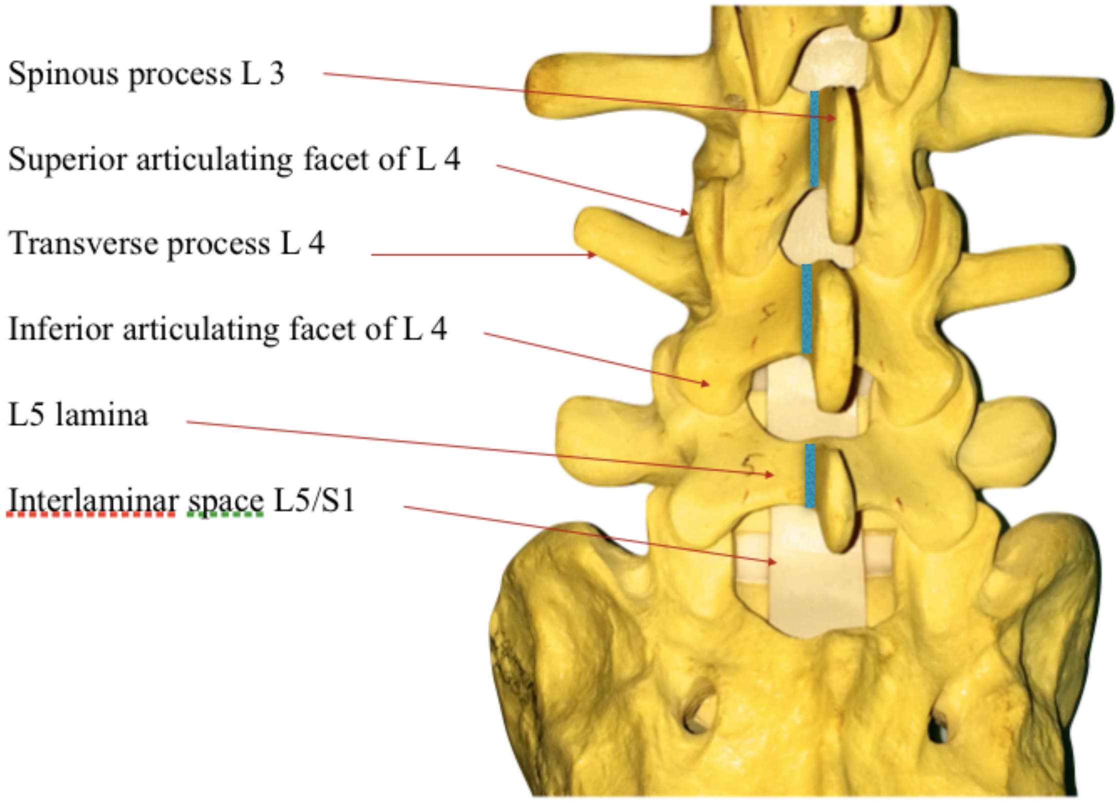
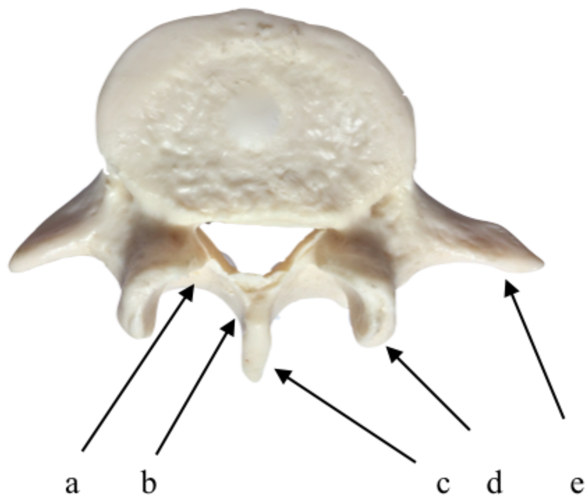


Figure 1: Above picture showed posterior view of Spinolaminar junction (shaded blue colour) of L3/L4 , L4/L5, L5/S1 respectively. Right Picture showed axial view of L5 vertebra:

a) lamina
b) spinolaminar junction
c) spinous process
d) superior articulating facet
e) transverse process



2.4. Ultrasound

Since Dr. Karl Theo Dussik who was an Austrian neurologist first apply ultrasound as a medical diagnostic tool to image the brain 50 years ago, ultrasound has become one of the most widely used imaging technologies in medicine. It is popularly adopted due to the advantages of portability, free of radiation risk, and relatively inexpensive when compared with magnetic resonance, computed tomography and other modalities.

There are several modes of ultrasound used in medical imaging depends on the purpose of imaging including A-mode (amplitude mode), B-mode (brightness mode), C-mode, M-mode (motion mode), doppler mode, pulse inversion mode and harmonic mode. Modern medical ultrasonography is primarily performed using pulse-echo approach with B-mode display.

Ultrasonography uses a transducer that transmits pulse or sound wave through body tissues, sound wave was reflected back to the transducer as echo signals as it traverse along a straight line through body tissues. The echo signals were detected by the same transducer, subsequently processed and combined to produce image. Ultrasound produces sound wave with frequencies above upper auditory limit of 20kHz. Medical ultrasound commonly uses sound wave between 2-15MHz.

The short ultrasound pulse traverses in a straight path, hence it is often referred to as an ultrasound beam. 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. Lateral direction waves are rapidly attenuated in tissue, thus it does not play direct role in B-mode imaging. For imaging purposes, we are mostly interested in the echoes reflected back to the transducer, which usually constitute only a small fraction of the ultrasound pulse. The remainder of the pulse continues along the beam line to greater tissue depths, scattered or transformed to heat. Ultrasound attenuation by tissue is approximately proportional to both the total path length and the ultrasound frequency. Longer path lengths and higher frequencies result in greater attenuation.

Acoustic impedance, is the amount of echo returned after hitting a tissue interface. It is determined by density of the particular tissue property. For example, air-containing organs such as the lung have the lowest acoustic impedance, while bone have very high-acoustic impedance. Acoustic impedance increase in a sequence from air, lung, fat, liver, blood, kidney, muscle to bone. The intensity of a reflected echo is proportional to the acoustic impedance gradient between two adjacent mediums. When an incident ultrasound beam reaches a smooth interface between two tissues with different angle at 90°, almost all of the generated echo will be reflected back to the transducer. This phenomenon is called specular reflection. Vice versa, if the angle of incidence with the specular boundary less than 90°, the echo will not return to the transducer, but rather be reflected at an angle equal to the angle of incidence, which will potentially miss the transducer and not be detected (Chan, 2011; Hangiandreou, 2003).

2.5. Ultrasonography of Lumbar spine

Spinal sonography is a valuable diagnostic imaging modality used in neonate and infants. It is a useful tool to detect congenital anomalies such as cord thetering, tight film terminalale, syringomyelia, spinal lipoma dermal sinuses, riastematomyelia and caudal a genesis as well as birth trauma to spinal cord and spinal neoplasm. Ultrasonography provides clear panoramic view of spine and its contents in neonates thus allow diagnostic accuracy as good as MRI in certain cases. Acoustic window is wide as predominantly cartilaginous spinal arches allows transmission of ultrasound beam. As the baby grows, acoustic window become narrower due to ossification of spinal arches. Certain technique like paramedic scan still allow segmental view of spinal canal and its contents (Tomà, 2005).

Klaus Galiano et al used ultrasound imaging for real-time monitoring of facet joints injection in the lumbar spine. He successfully given the injection in all 18 patients, verified by CT scan (Galiano, 2007). Ultrasound guided procedures in anaesthesia is well established with many published studies in recent years. They use ultrasound for lumbar plexus block (Kirchmair, 2001), lumbar facet nerve block (Jung, 2012), periradicular injections (Galiano, 2005).

The application of ultrasound imaging to diagnose and treat bone and joints problem has increase tremendously over the past decades. It serves as an alternative modality to fluoroscopy for examining the spine inflammatory and degenerative disorder besides guiding injections into epidural space and facet joints especially in office-based practise (Darrieutort-Laffite, 2014; Ha, 2010)

2.6. Techniques for lumbar spine level localisation

Fluoroscopic technique is the current method of spinal level localisation. Localising spinal level with lateral projection fluoroscopy is adopted by many spine surgeon. Anteroposterior direction C-Arm projection to localise the intended disc is also being used. Some authors while remain using C-Arm fluoroscopy as the method of localising level of intervertebral disc, they proposed a more simple, non-invasive and cheaper technique using additional surgical tool to help minimising surgical exposure of the intended structure or level. Tsai *et al* described placing a circular oven rack with 1.5 cm spaced parallel wires on the surgical field while the patient in prone position. They made multiple parallel skin markers along the wires followed by taking preoperative posteroanterior lumbosacral plain radiograph. A small incision was made correctly on the intended disc level by counting the lines marked earlier (Tsai, 2004).

Adrian Nowitzke *et al* introduced computer-assisted image guidance for thoracolumbar-level localisation which is as accurate as current method. However, not all centres has access to image guidance systems. Other more accurate modalities include magnetic resonance image and CT system but they are both more expensive and not readily available in most centres (Nowitzke, 2008).

Intraoperative CT has the advantage to evaluate spinal anatomy, correct surgical path, and assess instrument placement despite accurately localise spinal level. New-generation CT machines has tip accuracy within 1 mm that is capable of producing precise surgical planning and intraoperative targeting (Gu, 2013). Both CT scan and C-arm fluoroscopy exposed the patient and surgeon to radiation. They are also more expensive and not readily available in many centres (Jung, 2012).

2.7. Lumbar intervertebral disc level localisation with ultrasound

Ultrasonography of lumbar spine is a common research topic in recent years especially by anaesthetist, pain physician and rheumatologist. G. Furness et al publised a study showing ultrasound accurately identify intervertebral level in up to 71% of cases compared to using palpation method that could only identified up to 27% of cases. This study involved 50 patients, ultrasound imaging was performed to identify L2/L3, L3/L4, and L4/L5. The levels was marked with pellets and compared with X-ray of the lumbar spine (Furness, 2002)

However, usage of ultrasonography at lumbar spine is not without its limitation. In a study of paravertebral ultrasound guided posterior lumbar plexus block, failure to examine the intended levels was related to obesity due to thick subcutaneous tissue lead to heavy sound wave reflection and low tissue penetration (Kirchmair, 2001). Patients with lumbar spine disorder are frequently associated with overweight and obesity, these patients have thick layers of adipose tissue which is an obstacle for ultrasound wave penetration. Thus a lower frequency transducer ranged from two to nine MHz is commonly used in published studies. Curve transducer give further advantage of increasing field of view especially deeper structures.

2.8. Sonoanatomy and landmark

Successful of ultrasound imaging usage for diagnosis and intervention procedure is operator dependent and need a comprehensive training. On the other hand, ultrasound interpretation of lumbar spine and interspaces for anatomical purposes is relatively simple (Watson, 2003). Some author even suggest that basic sonographic physics, imaging, and interpretation can be effectively taught to medical students during a short training session (Yoo, 2004). Ultrasonography shows different echogenicity for different structures. Bony structures produce hyper echoic (white) areas followed by underneath sound attenuation (black). Epidural fat produce hyper echoic area followed by disc produces medium echogenicity. Dural space and muscles produce hypo echoic areas.

There are several ultrasonographic view described in literatures for assessment of lumbar spine. (Figure 2)

2.8.1.Longitudinal median view

This approach enable visualisation of spinous process and vertebral levels. The ultrasound transducer is placed in vertical position along the spinous process, start from sacrum and move in cephalic direction in a longitudinal direction. Sonography shows layers of tissue represented by different echogenicity starting from skin, subcutaneous tissue, thin line of hyper echoic thoracolumbar fascia and finally a series of hyper echoic line with upward convexity and posterior acoustic shadow representing spinous process. The L5 spinous process appears smaller and pointed, spinous processes become flatter and wider from L4 to L1. Sacrum is a useful landmark to count vertebral level. It appears as a continuous hyper echoic line until the upper edge of sacrum. L5/S1 level is identified between this long hyper echoic line and L5 spinous process. Interspinous ligament is viewed as hyper echoic structure with parallel fibrils between each spinous process.

2.8.2.Transverse view

This view enable visualisation of posterior vertebra structures, from spinous process at the midline, laminae, facet joints and transverse process laterally. The props is placed at the midline along spinous processes in transverse orientation. Spinous process appears as a convex hyper echoic line with posterior acoustic shadow. Laminae is seen as two horizontal hyper echoic line with posterior acoustic shadow at both sides of spinous process and deep to it. Facet joints is seen as hypo echoic zone between two hyper echoic structure representing inter articulating facets. Transverse processes are visible as two hyper echoic line with posterior acoustic shadow lateral to facet joints. To visualise spinal canal and its content at the intervertebral level, the transducer is placed in between two adjacent spinous process. It is bounded by two parallel hyper echoic lines. Epidural fat and dura mater complex are identified as the more superficial hyper echoic line in between two adjacent acoustic shadows of spinous process. The deeper hyper echoic line correspond to the posterior longitudinal ligament and posterior cortex of vertebral body.

2.8.3.Longitudinal paramedian view

Positioning the transducer vertically 1-2cm lateral to spinous process and directing ultrasound beam obliquely towards midline allows visualisation of spinal canal. The spinal canal is seen as a pace bounded by anterior hyper echoic line (a complex of posterior vertebral cortex and anterior longitudinal ligament) and posterior hyper echoic line (a complex of ligamentum flavum and dura mater)

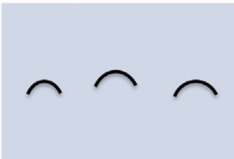
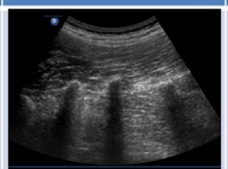
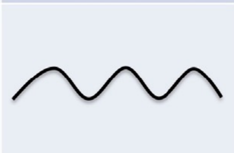
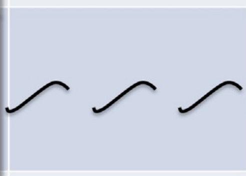
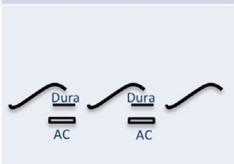
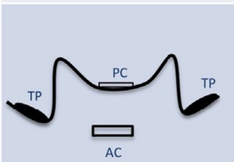
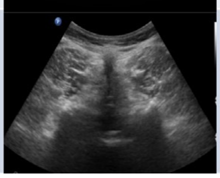
2.8.4.Longitudinal view through facet joint

The objective of this view is to visualise the facet joint which is especially useful in facet joint injection. The transducer is placed vertically 3-4cm from the spinous process. It shows the facet joints as a series of lumps. Every lump is domed by the inferior articular process of the above vertebra overlying the superior interarticular process (of the vertebra below it) which is largely concealed by acoustic window of the overlying inferior articular process. The facet joint capsule is identified as a thin echo-free line surrounding the joint. The L4/L5 and L5/S1 facet joints are closer to each other compare to the subsequent facet joints proximally.

2.8.5.Longitudinal view through transverse process

This view enable clear visualisation of transverse process and counting of vertebral level. The transducer is placed vertically 6-7cm away from spinous process. Erector spine muscle overlying transverse processes is visualised as hypo echoic striated mass. The transverse processes appear as rounded hyper echoic lines with upward convexity and posterior acoustic window. L5 vertebra is characterised by wider and longer transverse process. Inter transverse ligament is visible as isoechoic and fibrillar structure with parallel edges. Psoas muscles seen as striated mass siting deep to transverse process and inter transverse ligament (Darrieutort-Laffite, 2014).

Figure 2 : This tables shows various sonographic approach to lumbar spine, corresponding transducer position, pattern for recognition, sonographic view and the explanations

View	Probe orientation	Pattern recognition image	Ultrasound view	Notes
Paramedian Sagittal Transverse Process View				The "trident sign" represents finger-like shadowing behind the transverse processes.
Paramedian Sagittal Articular Process View				"Camel humps" represent continuous hyperechoic bone,due to vertebrae being connected by articular processes.
Paramedian Sagittal Laminar View				"Sawtooth" or "Horse Heads" represent the laminaes,the hiperechoic bone is not continuos and the interlaminar space allows visualization of the posterior and anterior complex.
Paramedian Sagittal Oblique View				Slight medial tilt optimizes the view of the posterior and anterior complexes.The dura is seen as a thin hyperechoic line.
Tranverse Interlaminar view				The articular processes/facet joints and transverse processes (TP) are visible.Tilting the probe will highlight the posterior (PC) and anterior(AC) complexes.

Adapted from (Ortega-Romero, 2013)

2.8.6. Wrong site surgery

The term wrong site surgery is defined as " a concept encompassing such actions as operating on wrong person, the wrong organ or limb, or the wrong vertebral level." It can cause devastating outcome to the patient and surgeon, thus AAOS in 1997 had recommended surgeons to put their initials on the operation site (Canale, 2005). "Sign Your Site" was introduced in 1998 followed by "Sign, Mark and Radiograph (SMaX)" program introduced by the North American Spine Society (NASS) in 2001. Subsequently, Joint Commission on Accreditation of Healthcare Organisation (JCAHO) introduced the "Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery" in 2003 (Longo, 2012). Wrong site surgery represent 5.6% of all medical errors in an AAOS member survey where 5% of the wrong anatomical location involved spine (Wong, 2009).

In spine surgery, Wrong-site Spine Surgery (WSSS) include wrong-level surgery (incorrect vertebra or spinal motion segment) and wrong-side surgery while the surgeon performing a decompression, resection, or reconstructive procedure on an unintended anatomical location along the spinal axis. Matsumoto et al reported wrong level spine surgery contributed by minimally invasive and endoscopic spine surgery because of unrecognised movement of the tubular retractor (Palumbo, 2013)

A questionnaire study on the prevalence of wrong level surgery involving 415 spine surgeons with mean duration of practice of more than 10 years showed prevalence of 1 in 3110 procedures. However, the prevalence could be higher in reality as the response rate of the questionnaire is only 12%. The majority of the error occurred in the lumbar spine surgery (71%) compared to cervical (21%) and thoracic (8%) segment as lumbar surgery is the most common site for spine surgery (Mody, 1976).

Lumbar disc surgery is one of the commonest procedure in spine surgery (Tsai, 2004). Fluoroscopy is the most common method of intraoperative imaging modality used for spinal level localisation but this does not always guarantee the correct level of surgery due to a few factors. These include congenital spine variation, inadequate radiological exposure or incorrect identification of the levels, inadequate visualisation because of large body size or operating table limitation as well as the absence of an expected lesion at the operating level (Longo, 2012).

3. Methodology

3.1. Study design

This is a cross sectional study.

3.2. Study period

Data was collected over a period of six months from March to August 2014.

3.3. Reference population

Malysian population

3.4. Source population

Kelantan population

3.5. Study samples

Young volunteers and patient with clinical and radiographic evidence of degenerative spine.

3.6. Sampling methods

Purposive sampling

3.7. Calculation of Sample Size

Furness reported 71% accuracy in identifying lumbar intervertebral level (Furness, 2002). In this study, age of participant ranges from 20 to 82 year old which may include normal and degenerative spine.

Base on our assumption, accuracy would be higher in normal spine compare to degenerative spine

We assume in normal spine, accuracy is 15% higher ==> 85%

We assume in degenerative spine, accuracy is 15% lower ==> 55%

Using PS sample size software

Type 1 error - 0.05

Type II error - 0.8

P0 - degenerative group --> 0.55

P1 - normal group--> 0.85

--> n = 35 each group

Total sample size = 35x2 + 10% estimated dropout rate

= 77

adjustment to 78

Estimated required sample size is

Normal group = 39

Degenerative group = 39

3.8. Study criteria

3.8.1. Inclusion Criteria

Recruitment of group 1 subjects will be via flyer (Appendix A) asking for young healthy volunteer age 18-25 year old while group B will be via requisition of patient age 50 year old or greater radiology evidence of clinical and radiographic (plain radiograph and/or MRI) degenerative spine.

3.8.2. Exclusion Criteria

- Pregnancy
- History of undergoing spine surgery
- Spine deformity
    - Spinal scoliosis with major lumbar curve
    - Spondylolysthesis (Meyerding grade more than grade II)
    - Severe disc height reduction less than 2mm
- Transition vertebra

3.9. Research Ethical Approval

Ethical approval was obtained from Human Research Ethics committee, Universiti Sains Malaysia on 25th March 2014 (Reference number : USM/JEPeM/ 280.3(11))

(Appendix B)

3.10. Research tools

3.10.1. Patient performa

(please refer to Appendix C)

3.10.2. Equipments

3.10.2.1. First ultrasound machine. (Figure 3)

Brand : Mindray

Model : M5 ultrasound system

System Version : X8.1G.XM.6Q

Configuration :

- Pulse Wave Doppler
- Convex array transducer 3C5s (2.5/3.5/5.0/H5.0/H6.0MHz)
- B-mode

Date of last service and calibration : 5 March 2014

Location : General operative theatre

Figure 3: First ultrasound machine used in this study, on the right is the curvilinear transducer 3C5s