Inaccurate level of intervertebral space estimated by palpation: The ultrasonic revelation

ABSTRACT

Background: Spinal cord injury resulting from spinal anesthesia is a rare, but an alarming scenario. The most likely cause is believed to be misjudged level of intervertebral space (IVS). We evaluated the accuracy of palpation method to locate IVS with the ultrasonography.

Materials and Methods: A total of 109 patients undergoing spinal anesthesia were included in this observational, double-blind study. First anesthesiologist was asked to mark IVS using palpation method. It was followed by ultrasonic assessment by another anesthesiologist who was unaware of the level estimated for the mark. We evaluated the accuracy of palpation method in sitting and lateral position as well as the impact of the anesthesiologist’s experience (Trainee/Consultant).

Statistical Analysis Used: Association between the gender, anthropometric parameters, type of anesthesiologists assessing the IVS, and the level of agreement were identified using Chi-square test. The agreement between palpation method and ultrasound assessment of IVS was analyzed using kappa statistic. \( P \leq 0.05 \) was defined as statistical significance.

Results: The IVS located by palpation method was in agreement with ultrasound location in 37.14% of the patients. There were no statistically significant differences found in terms of demographic data (sex, age, height, weight, or body mass index [BMI]) between agreement and disagreement group. The rate of errors was found to be significantly higher \( (P = 0.01) \) among the trainees (74.51%) than the consultants (51.86%). The rate of errors was not different between the sitting and lateral position. The frequency of errors was more common in cephalad direction (53.31%) compared to caudal direction (9.52%). The misidentified spaces were as high as three spaces above the intended space in caudal direction it differed by only one space.

Conclusion: The accuracy of palpation method controlled by ultrasound is 37.14% and differs by 1-3 IVS in cephalad direction (53.31%). The accuracy is affected by anesthesiologist’s experience but remains unaffected by age, sex height, BMI, and patient positioning.

Key words: Intervertebral space; palpation; ultrasonography

Introduction

Ideal site for spinal anesthesia is below conus medullaris to avoid trauma to spinal cord. The intercrystal line or Tuffier line is an imaginary line joining superior aspect of iliac crest which is known to cross the L4 vertebra or L4-L5 intervertebral disc. This is an important surface landmark to select intervertebral space (IVS) for neuraxial block. In adults, conus medullaris

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ends at the lower border of L1 vertebra. Since there are
variability in position of termination of conus medullaris,
selecting lowermost space becomes crucial for practicing
safe neuraxial anesthesia.[1]

The most common method of selecting IVS is palpation
method which is based on identification of Tuffier line.
Palpation method is shown to be least reliable method with
accuracy rate being as low as 29%.[2] In the recent years,
ultrasonography (USG) has been extensively evaluated for
practicing safe neuraxial anesthesia. It is a simple, less time
consuming, noninvasive, and easy to learn technology.

Hence in this study, ultrasound is used to evaluate the
accuracy of palpation method to estimate the level of the
IVS. In addition to that the effect of demographic parameters,
patient positioning and anesthesiologists experience were
also assessed.

Materials and Methods

This observational single arm study was approved by the
Hospital Ethics and Research Committee (Ref no. ECR/215/
Inst/Ker/2013) and registered with Clinical Trial Registry
India (CTRI/2014/09/005035). One hundred and nine
patients undergoing procedures under spinal anesthesia
were recruited in this study. Patients aged between 18 and
60 years undergoing lower abdominal or lower limb surgeries
were included in this study and written informed consent
was taken. Pregnant patients, severely obese patients with
body mass index (BMI) >35 kg/m², spine deformity, or
patients who were unable to position themselves for spinal
anesthesia were excluded from the study. Patients with
poor imaging quality were also excluded from the analysis.
Resident anesthesiologist undergoing anesthesia training
with minimum 1 year of experience was taken in the trainee
group. All consultant anesthesiologists with minimum
5 years of anesthesia experience were taken in consultant
group. Two consultant anesthesiologists having more than
5 years of experience in neuraxial ultrasound were allotted
to perform the ultrasound assessment throughout the study.
They were kept blinded about the marked IVS. Inside of the
operation theater, patient was positioned either in sitting
or lateral position. An anesthesiologist palpates, defines the
level, and keeps this level in secret. Another anesthesiologist scans with ultrasound the
marked interspace and provides his definition of level. Later
the levels estimated by palpation and identified by ultrasound
are confronted in search for agreement or disagreement.
The ultrasound assessment was done using GE Healthcare
Venue 40 software and curved array low frequency probe of
2-5 MHz, basing in parasagittal oblique view. Sacrum was
taken as a reference landmark, which appears as a horizontal
hyperechogenic line [Figure 1]. Probe was then moved
in cephalad direction to assess IVS. The hyperechogenic
pattern corresponding to the laminae of vertebra while
hypoechogenic shadow corresponding IVS forms a saw tooth
like pattern [Figure 2]. For accurate counting of interspace,
each space corresponding to the center of probe was marked
on skin. After ultrasound assessment, neuraxial block was
performed in a space unrelated to the studied space in routine
manner and surgery was continued. Anesthesiologists were
not given immediate feedback of the assessment to avoid
self-improvement. On an average, every anesthesiologist
marked IVS in maximum 4 patients.

The primary aim of this study was to assess under
ultrasonographic control the accuracy of palpation method
to identify lumbar IVS. Secondary aim was to evaluate the
effect demographic parameters, patient positioning (sitting
and lateral) and anesthesiologist’s experience on the accuracy
of the palpation method.

Figure 1: Hyperechogenic line corresponding to sacrum and L5-S junction
Figure 2: Laminae of vertebrae
Statistical analysis
Sample size was estimated using nMaster (sample size software) and basing on the study of Whitty et al.\cite{1} Considering 55% agreement between IVS assessment by USG and palpation, kappa of 0.08, power of 80%, alpha error of 5% and population agreement of 0.5, we estimated that at least 101 subjects were required. We enrolled 109 to account for subjects drop out.

Data were analyzed using SPSS software, version 18 (Chicago). The demographic details of the study population were presented as proportions and means (+ standard deviation). Association between the gender, anthropometric parameters, type of anesthesiologists assessing the IVS and the level of agreement were identified using Chi-square test. The agreement between palpation method and ultrasound assessment of IVS was analyzed using kappa statistic. \( P < 0.05 \) was defined as statistical significance.

Results
A total of 109 patients (38 women and 71 men) were enrolled in the study. Four patients were excluded from the study due to poor imaging quality. Data regarding 105 patients were analyzed. The IVS located by palpation method was in agreement with ultrasound location in 37.14% (39 out of 105) of the patients [Figure 3]. The errors were more frequent in cephalad direction (53.31%) and less frequent in caudal direction (9.52%). The misidentified spaces usually differed by one space to as high as three spaces above the intended space. In caudal direction, it differed by only one space.

The demographic characteristics are presented in Table 1. Demographic and anthropometric data of patients in groups agreement and disagreement with IVS determinations based on palpation and ultrasound imaging are listed in Table 2. There were no statistically significant differences.

The other parameters likely to influence the assessment are shown in Table 3. The IVS assessment done by trainee and consultant in sitting and lateral positions and their ultrasound interpretations are shown in Tables 4-7. The rate of errors was found to be higher among the trainees (74.51%) than the consultants (51.86%). This difference was statistically significant \( (P = 0.01) \). The rate of errors 66.67% in sitting position and 58.82% in lateral position was not significantly different \( (P = 1) \).

Discussion
In our study, the accuracy of palpation method to estimate IVS was poor (37.14%) when controlled by ultrasound. The results showed that the inaccuracy of the palpation method was neither due to demographic reason nor to the patient positioning in sitting or in lateral. They also showed that the

![Figure 3: Disagreement of intervertebral space determination between the anatomical and ultrasound method. Negative values denote deviation in caudal direction and positive values in cephalad direction](image)

| Parameter | Mean (±SD) | Statistical significance |
|-----------|------------|-------------------------|
| Age (years) | 40.52 (13.23) | NS (0.18) |
| Height (cm) | 163.63 (8.55) | NS (0.44) |
| Body weight (kg) | 67.79 (11.72) | NS (0.32) |
| BMI (kg/m\(^2\)) | 25.35 (3.99) | NS (0.56) |

BMI: Body mass index; NS: Nonsignificant statistical differences; SD: Standard deviation; IVS: Intervertebral space

Table 1: Demographic data of study population

| Parameter | Agreement (n = 39) | Disagreement (n = 66) | Statistical significance |
|-----------|-------------------|----------------------|-------------------------|
| Female | 11 | 24 | NS (0.39) |
| Male | 28 | 42 | NS (0.4) |
| Sitting position | 18 | 36 | NS (0.4) |
| Lateral recumbent position | 21 | 30 | NS (0.56) |
| Consultant | 26 | 28 | P = 0.01* |
| Trainee | 13 | 38 | NS (0.39) |

*P value significant \(< 0.05\). NS: Nonsignificant statistical differences; IVS: Intervertebral space
accuracy or inaccuracy depended on the anesthesiologist’s experience.

The accuracy of palpation method to assess IVS is shown to be in between 29% and 64%.[2-7] Our findings are consistent with the finding of Schlotterbeck et al. who observed the accuracy of palpation method to be 36.4% in pregnant patients. The gold standard techniques to assess IVS are computerized tomography (CT), magnetic resonance imaging (MRI), X-ray, and fluroscopy. However, the limitations of these techniques (CT, MRI) are patient’s need to lie in supine unflexed position and risk of radiation. In clinical practice, the IVS is palpated...
after the patient is positioned appropriately by flexing hip and neck. Hence these methods (CT, MRI) can lead to bias when the accuracy is compared with palpation. The advantage of ultrasound technique is being a bedside technique and the assessment can be done in the same flexed position given for spinal anesthesia. Hence, the bias of displacement of marker as seen with CT and MRI can be eliminated. The accuracy of ultrasound assessment when compared to other various techniques has been reported as 68-76% but with appropriate training and experience it can enhanced up to 90%. The ultrasound estimation usually differs from CT and MRI by one space unlike in palpation where errors can be up to 4 spaces. Identifying interspinous spaces is reported to be relatively easier than estimating epidural depth and optimal needle insertion point. Relevant anatomical structures for lumbar puncture can be identified quickly in emergency setting. Hence, spinal ultrasound can form an important tool for practicing safe neuraxial anesthesia and for assessment of accuracy of the palpation method in this study.

In our study, patient positioning has not improved accuracy. Theoretically sitting position should improve the accuracy. In sitting position, it is easier to eliminate the effect of lumbar lordosis. It is easy to determine the intercristal line in this position as it gives good grip by palpating both iliac crests. The distribution of body weight is even in sitting position as it gives good grip by palpating both iliac crests. In lateral position, the axis of pelvic brim is uneven surface. In lateral position, the axis of pelvic brim is lordosis. It is easy to determine the intercristal line in this position as it gives good grip by palpating both iliac crests.

There is difference in the opinion about the space corresponding the intercristal line. As per traditional teaching, the intercristal line crosses the body of L4 or the L4-L5 interspace. This forms an important landmark while giving spinal anesthesia. However, this landmark is shown to be influenced by age, sex, pregnancy, height, BMI of the patient as well as imaging methods used to identify the space. In pregnant patients, it shown to vary in range of L1-L2 to L4-L5 spinal segments while in tall males it crosses L2-L3 spaces. The position of conus medullaris varies from T12-upper to L3-upper segments and elderly females tend to have low conus. Use of atraumatic spinal needle is not completely risk free. The position of cones medullaris in relation to vertebral column does not change after spinal flexion and hence does not offer any protection against spinal cord damage.

In our study, we have not evaluated for lumbosacral anomaly (lumbarization of sacrum and sacralization of lumbar vertebra). The incidence of these anomalies is around 6% and can be easily missed by ultrasound. Spine radiograph combined with MRI is a gold standard technique to diagnose and to count lumbosacral vertebral anomalies. Kim et al. have shown that despite the transitional vertebrae there seems to be margin of safety of two IVS and these authors consider that counting up from lumbosacral junction is fairly valid approach to select the interspace for spinal anesthesia.

Although neurological complications with spinal anesthesia is rare, but there are some disturbing evidence of grievous spinal injury and likely medico legal malpractice. In addition to liberal attitude of anesthesiologist for selecting lumbar IVS, use of atraumatic spinal needle has been cited as a cause of damage to spinal cord. It is not uncommon to anesthesiologist to select most easily palpated lumbar interspace to improve the success rate. Anesthesiologist may tempt to prefer L2-L3 space in order to reduce the dose of spinal anesthetic drug but in this space if more cephalad needle is directed more likely are the chances of needle trauma. Geaves reported a case of serious spinal injury caused by misidentification of the L2-L3 IVS in a patient receiving heparin. Atraumatic needles (pencil point) carries more risk as free flow of cerebrospinal fluid comes after needle is well advanced in the subarachnoid space.

In our study, anesthesiologist’s experience has improved accuracy. These findings were consistent with Larisa et al. who noticed accuracy improves significantly with experienced anesthesiologist’s with professional experience of 10 years. Broadbent, Schlotterbeck and Whitty et al. reported that accuracy is unaffected by level of experience. However in all of these studies, the years of anesthesia experience studied varied widely. As per Broadbent et al., the experience may not improve the accuracy as there is no element for self-correction in the professional training because of lack of radiographic confirmation. Even in experienced hand, errors have occurred 3-4 spaces above the space they believed in and it was a common finding in our study also. This highlights the need of the ultrasound as a modality to confirm IVS for every anesthesiologist’s irrespective of years of experience.

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The accuracy of palpation method when controlled by ultrasound is “poor” and differs by 1-3 IVS particularly in cephalad direction. The accuracy is affected by anesthesia experience but remains unaffected by age, sex height, BMI and patient positioning.

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Conflicts of interest
There are no conflicts of interest.

References
1. Saifuddin A, Burnett SJ, White J. The variation of position of the conus medullaris in an adult population. A magnetic resonance imaging study. Spine (Phila Pa 1976) 1998;23:1452-6.
2. Broadbent CR, Maxwell WB, Ferrie R, Wilson DJ, Gawne-Cain M, Russell R. Ability of anaesthetists to identify a marked lumbar interspace. Anesthesia 2000;55:1122-6.
3. Whitty R, Moore M, Macarthur A. Identification of the lumbar interspinous spaces: Palpation versus ultrasound. Anesth Analg 2008;106:538-40.
4. Schlotterbeck H, Schaeffer R, Dow WA, Touret Y, Bailey S, Diemunsch P. Ultrasonicographic control of the puncture level for lumbar neuraxial block in obstetric anesthesia. Br J Anesth 2008;100:230-4.
5. Duniec L, Nowakowski P, Kosson D, Lazowski T. Anatomical landmarks based assessment of intravertebral space level for lumbar puncture is misleading in more than 30%. Anaesthesiologie Intensive Ther 2013;45:1-6.
6. Locks Gde F, Almeida MC, Pereira AA. Use of the ultrasound to determine the level of lumbar puncture in pregnant women. Rev Bras Anestesiol 2010;60:13-9.
7. Furness G, Reilly MP, Kuchi S. An evaluation of ultrasound imaging for identification of lumbar intervertebral level. Anesthesia 2002;57:277-80.
8. Halpern SH, Banerjee A, Stocche R, Glance P. The use of ultrasound for lumbar spinal process identification: A pilot study. Can J Anesth 2010;57:817-22.
9. Watson MJ, Evans S, Thorp JM. Could ultrasonography be used by an anesthetist to identify a specified lumbar interspace before spinal anesthesia? Br J Anesth 2003;90:509-11.
10. Margarido CB, Arzola C, Baliki M, Carvalho JC. Anaesthesiologists’ learning curves for ultrasound assessment of the lumbar spine. Can J Anesth 2010;57:120-6.
11. Ferre RM, Sweeney TW. Emergency physicians can easily obtain ultrasound images of anatomical landmarks relevant to lumbar puncture. Am J Emerg Med 2007;25:291-6.
12. Thavasothy M. The reproducibility of the iliac crest as a marker of lumbar spinal level. Anesthesiology 1997;82:811.
13. Margarido CB, Mikhail R, Arzola C, Baliki M, Carvalho JC. The intercristal line determined by palpation is not a reliable anatomical landmark for neuraxial anesthesia. Can J Anesth 2011;58:262-6.
14. Rahman M, Vaziri Bozorg SM, Ghasemi Esfe AR, Moritza A, Khalilzadeh O, Pedarzadeh E, et al. Evaluating the reliability of anatomic landmarks in safe lumbar puncture using magnetic resonance imaging: Does sex matter? Int J Biomed Imaging 2011;2011:868632.
15. Chakraverty R, Pynsent P, Isaacs K. Which spinal levels are identified by palpation of the iliac crests and the posterior superior iliac spines? J Anat 2007;210:232-6.
16. Pysyk CL, Persaud D, Bryson GL, Lui A. Ultrasound assessment of the vertebral level of the palpated intercristal (Tuffier’s) line. Can J Anesth 2010;57:46-9.
17. Fettes PD, Leslie K, McNab S, Smith PJ. Effect of spinal flexion on the conus medullaris: A case series using magnetic resonance imaging. Anesthesiology 2006;105:251-3.
18. Kim JT, Bahk HJ, Sung J. Influence of age and sex on the position of the conus medullaris and Tuffier’s line in adults. Anesthesiology 2003;99:1359-63.
19. Reynolds F. Damage to the conus medullaris following spinal anesthesia. Anesthesiology 2001;56:238-47.
20. Bahk HJ, Ko H. Damage to the conus medullaris following spinal anesthesia: 2. Anesthesiology 2001;56:813-4.
21. Greaves JD. Serious spinal cord injury due to haematomyelia caused by spinal anesthesia in a patient treated with low-dose heparin. Anesthesia 1997;52:150-4.