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Accuracy of Tuffier's Line Identification by Palpation Method: Cross-Sectional Comparative Study Among Obese, Pregnant and Control Groups

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Abstract

Objective: Performance of safe central neuraxial blocks requires identification of accurate vertebral interspace. This study aimed to evaluate the accuracy of palpation method by confirmation with ultrasound in high-risk groups like obesity and pregnancy.

Methods: This cross-sectional comparative study was conducted after approval from the hospital ethics committee and written informed consent from participants. Participants were enrolled into four groups: normal weight non-pregnant (N), full-term pregnant (P), obese (O) and obese full-term pregnant (PO). Tuffier's line at L4-L5 interspace was determined by palpation method and marked as P-line. Another examiner blinded to the marking done by palpation method confirmed it by ultrasound. The primary endpoint was to determine the accuracy of the palpation method, defined as true identification of Tuffier's line at the L4-L5 interspace by confirming it with ultrasound among four groups. Proportion and percentage were computed and analysed the true identification of Tuffier's line at L4-L5 by chi-square test at 0.008 adjusted level of significance for multiple comparisons.

Results: Tuffier's line identification by palpation method was confirmed by ultrasound scanning at L4-L5 interspace in 75.3% (226/300) of participants. Proportion difference of true identification of Tuffier's line at L4-L5 by palpation and ultrasound was statistically significant among the groups (p=0.0005). True identification was significantly lower in group PO [36.4%; p=0.0005<0.008] and group O [34%; p=0.0005<0.008] as compared to that in group N.

Conclusion: Palpation method was found to be the inaccurate surrogate for the L4-L5 vertebral interspace for obesity with or without pregnancy.

Keywords: Obesity, palpation method, pregnancy, Tuffier's line, ultrasound

Introduction

Central neuraxial blocks (CNB) are commonly employed anaesthetic techniques for provision of analgesia and anaesthesia. For safe and effective institution of CNB, it is essential to correctly identify the correct intervertebral level. Correct identification is required to avoid cord damage and to regulate the height of the block that is dependent on the level at which insertion is made (1, 2).

The conventional method used to identify intervertebral level for CNB is by palpation of a transverse line commonly known as 'Tuffier's line', which connects the superior aspects of the iliac crests and most of the time on an x-ray intersects the spine either at the L4-L5 interspace or at the level of the L4 vertebral body, and it is a relevant reference point to choose the intervertebral space for regional anaesthesia (3). The American Society of Regional Anesthesia recommends that anaesthesiologists should be aware of the limitations of the physical examination to determine the puncture level, especially in patients with difficult topographic anatomy like pregnancy and obesity (4, 5). Kim

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et al. (6) found that the vertebral levels were more cephalad in the parturient women than in the non-parturient women. Lin et al. (7), in their study, mentioned that patients with high body mass index (BMI) are more likely to have their lumbar intervertebral levels be identified lower than their actual level; therefore, Tuffier's line, as identified by palpation, does not seem to be a reliable landmark for proper lumbar interspace identification in these patients.

The use of pre-procedure spinal ultrasound (US) scanning can overcome difficulties in accurately identifying the vertebral interspace, and it has proven to be a valuable clinical tool to improve the accuracy of spine assessment especially in obese parturient patients (8). The UK National Institute for Health and Care Excellence (NICE) has offered guidance for the use of US to identify the epidural space (9). However, the use of US for CNB has not been accepted as a routine use in clinical practice. A survey of all registered Obstetric Anaesthetist's Association members in the UK revealed that although 73.4% of respondents were aware of the recent NICE guidance, only 8.1% of the anaesthesiologists actually used US in their practice to aid epidural placement (10).

Therefore, the question arises: should anaesthesiologists routinely use the US while performing CNB for every patient or just in the patients with difficult topographic anatomy like pregnancy and obesity? The rationale of our study is to evaluate the accuracy of palpation method in high-risk groups with altered anatomy like obesity and pregnancy when compared with normal non-pregnant patients and to determine if the use of US is justified in all female patients or only in patients with difficult topographic anatomy.

The primary objective of this study is to evaluate the accuracy of Tuffier's line identification by palpation method by confirming it with US examination in four groups of participants: 1) non-obese non-pregnant women 2) full-term pregnant women 3) full-term pregnant obese women and 4) obese non-pregnant women. The secondary objective is to determine the level at which the Tuffier's line determined by the palpation method intersects the lumbar spine by confirming with the aid of US in these four groups of women.

Main Points:

- Correct identification of intervertebral space while performing neuraxial anaesthesia, is required to avoid cord damage and to regulate the height of the block.
- Difficult topographic anatomy including obesity with or without pregnancy was found to be the only significant factor where palpation method was found to be inaccurate for Tuffier's line identification.
- The use of pre-procedure spinal ultrasound scanning can overcome difficulties in accurately identifying the intervertebral level in this group of population.

Methods

This cross-sectional comparative study was conducted for a period of four months from January 2018 to April 2018 at Aga Khan University Hospital, Karachi, Pakistan, after approval by the hospital ethics committee with protocol number 4592-Ane-ERC-17. Participants who fulfilled the inclusion criteria were approached for the study and were explained the purpose and conduct of the study. Those willing to participate in the study were enrolled in the study after obtaining written informed consent. The inclusion criteria were female patients/participants in the age range 18-40 years and falling into one of the four study groups: 1) Group N: non-pregnant normal weight females (BMI 20-25), 2) Group P: full-term pregnant non-obese females (37-40 weeks of gestation with BMI<30), 3) Group PO: full-term obese pregnant females (37-40 weeks of gestation with BMI 30-45); and 4) Group O: obese non-pregnant females (BMI 30-45). Exclusion criteria were any infection on the lower back, previous back surgery, refusal to participate in the study, kyphosis or scoliosis and having pain or distress in maintaining sitting position.

Enrolled participants were positioned sitting to one side of a level stretcher with the neck, back and hips flexed and feet supported by a footrest. The hips were positioned with the weight distributed evenly between both sides. An assistant stood facing the patient, helping to maintain her position, while the attending anaesthesiologist with more than ten years of anaesthesia experience in obstetric anaesthesia palpated and marked the superior aspects of the iliac crest bilaterally. The bilateral markings were then covered by taping the participant's gown onto her back.

One designated investigator who had received training in neuraxial US with experience of performing more than 30 central neuraxial USs scanned the lumbar area in the same flexed position first in the paramedian followed by the transverse approach. The designated investigator using the US was blinded to the marking done by palpation method. A Mindray portable US machine UMT-300 c29744 fitted with a 4-MHz curved array was used to determine the vertebral levels. The probe was first applied in the paramedian longitudinal plane to visualise the sacrum and the interlaminar spaces individually. The interlaminar space between L5 and the sacrum was first identified. The L5 level was marked on the skin at the midpoint of the probe by positioning the L5 lamina in the centre of the screen. However, in order that the markings would reflect the optimal needle insertion points for midline punctures, the final marking of the interspaces on the

subject's back was completed after scanning in the transverse plane. The L4 to L1 levels were identified and marked in a similar manner moving cephalad.

Upon completion of the US scanning and marking of the vertebral level from S1 (sacral line), L5, L4, L3, L2 and L1, the iliac crest markings by palpation method were uncovered, and a horizontal line connecting the two markings made from palpation method was drawn on the participants back and named as 'P-line'. The vertebral levels marked by the US and the P-line from palpation method were transcribed on a transparent sheet placed on the subject's back as shown in Figure 1, showing these markings on a transparent sheet that is placed on a white sheet of paper. The space between the two vertebrae was taken as the interspace, and the distance between any two consecutive interspaces was then divided into three equal segments and marked on the same transparent sheet as shown in Figure 2. Starting from the L5-S1 interspace and counting cephalad, 15 segments were marked and numbered sequentially from 1 (most caudal) to 15 (most cephalad). This segmental division was meant to calculate the intersection level of the P-line with respect to the upper and lower adjacent interspaces (Figure 2). The P-line intersecting segment 1, 2, 3 was calculated as interspace L5-1; P-line intersecting segments 4, 5, 6 was taken as interspace L4-L5; P-line intersecting at segments 7, 8, 9 was taken as L3-L4; P-line intersecting at segments 10, 11, 12 was taken as interspace L2-L3; and P-line intersecting segments 13, 14, 15 was taken as L2-L1 (Figure 2).

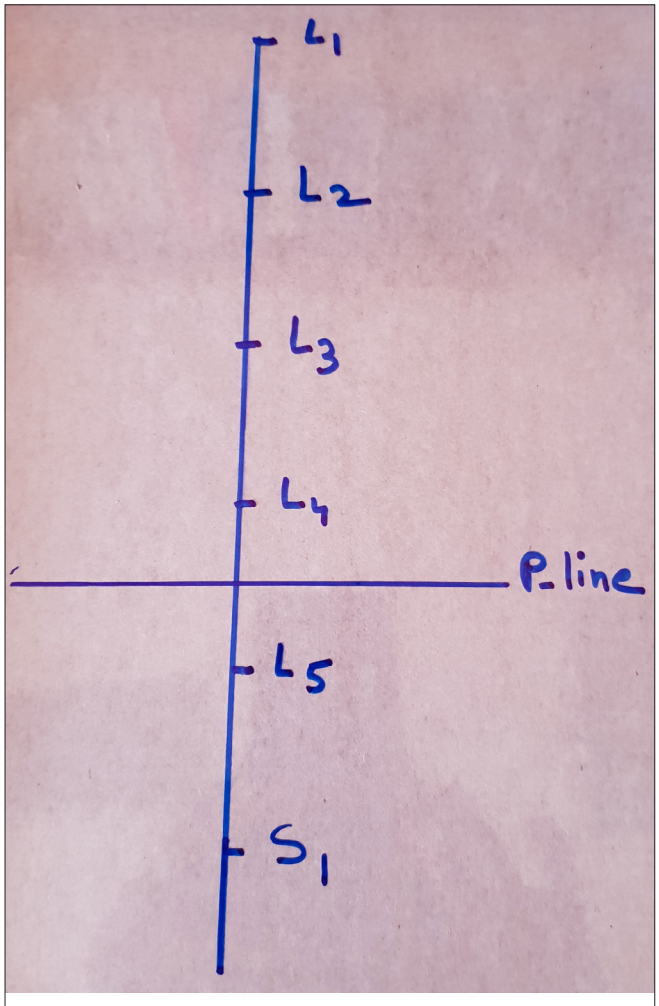

Figure 1. The vertebral levels and the P-line were transcribed on a transparent sheet placed on participant's back

The primary endpoint was to evaluate if Tuffier's line identification by palpation method (P-line) intersects the spine at the L4-L5 interspace (segments 4, 5, 6) by confirming it with US examination in four groups of patients.

Statistical analysis

Sample size calculation is based on a pilot study in which proportion difference in Tuffier's line among the four groups mentioned above was 30%. Based on the pilot study, 200 patients (50 in each group) were needed to detect the 30%

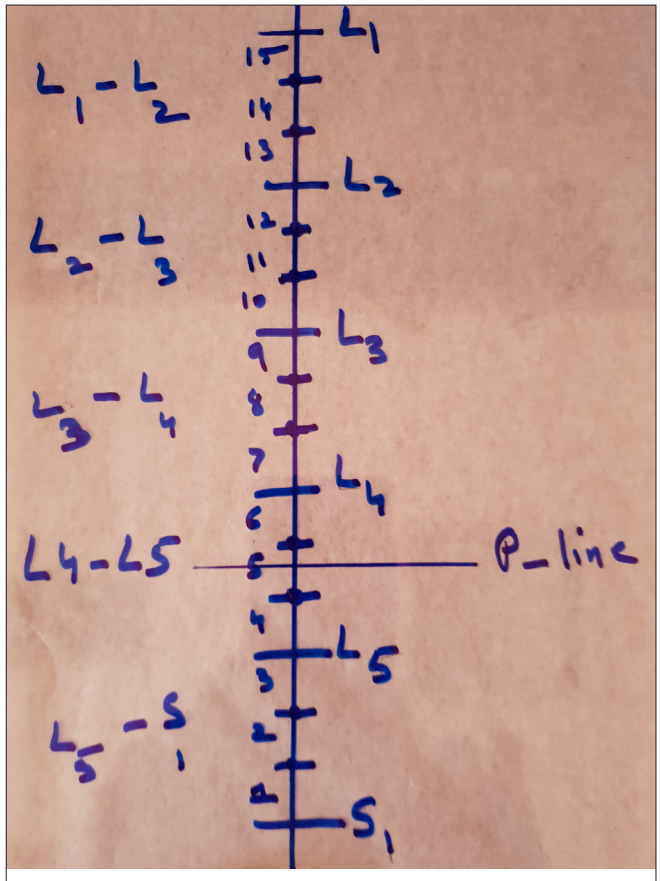

Figure 2. The space between the two vertebrae was taken as the interspace and marked on the transparent sheet and the distance between any two consecutive interspaces was then divided into three equal segments from 1 to 15 (caudal to cephalic)

difference with 80% power and 5% type I error. All statistical analysis was performed using IBM Statistical Packages for Social Science version 19 (IBM SPSS Corp.; Armonk, NY, USA). Demographic data were recorded in the form of height, weight, BMI, gravidity, gestational age and co-morbidities. Mean and the standard deviation were estimated for numeric observation, and mean was compared by analysis of variance. Frequency and percentage were computed and analysed the rate of Tuffier's line at L4-L5 by chi-square test. P-value ≤0.05 was considered as significant. However, as there were four groups and six comparisons were needed to be performed by chi-square, the p-value was adjusted to 0.008.

Results

A total of 316 women fulfilling the inclusion criteria were approached for a period of four months from January 2018 to April 2018, out of which 14 declined and 2 were dropped because of protocol violation. Therefore, 300 participants completed the study. The enrolled participants were placed in four groups according to BMI and current pregnancy status. The calculated sample size was 50 in each group; however, we managed to enrol more patients than the estimated sample size in each group. A total of 81 women were enrolled in group P, 53 in group PO, 87 in group O and 79 in group N. The overall mean age of the women was

Table 1. Patients' demographics and co-morbid conditions (n=300)

Variables	Pregnant Obese (PO) n=53	Obese Non-pregnant (O) n=87	Pregnant Non-obese (P) n=81	Non-obese Non-pregnant (n) n=79
Age (Years)	31.19±4.35	33.57±7.17	30.27±4.42	29.57±6.04
Height (cm)	154.66±4.06	154.71±5.77	157.07±4.95	156.82±4.93
Weight (kg)	83.02±8.62	87.72±7.86	68.99±8.11	59.85±7.94
BMI (kg m^{-2})	34.31±3.25	36.01±2.37	27.46±2.31	23.71±2.39
Co-morbid conditions				
PIH	11 (20.8%)	0 (0%)	5 (6.2%)	0 (0%)
Asthma	0 (0%)	1 (1.1%)	1 (1.2%)	2 (2.5%)
Anaemia	3 (5.7%)	2 (2.3%)	13 (16%)	6 (7.6%)
Hypothyroidism	1 (1.9%)	8 (9.2%)	1 (1.2%)	1 (1.3%)
GDM	16 (30.2%)	0 (0%)	6 (7.4%)	0 (0%)
Hypertension	2 (3.8%)	12 (13.8%)	1 (1.2%)	1 (1.3%)
GDM	1 (1.9%)	12 (13.7%)	0 (0%)	3 (3.8%)
Others	0 (0%)	2 (2.3%)	0 (0%)	2 (2.5%)

Data are presented as mean±SD and n (%). PIH: pregnancy induced hypertension; GDM: gestational diabetic mellitus

Table 2. Comparison of Tuffier's line location by palpation method after confirmation with ultrasound in four groups of participants (n=300)

Tuffier's line by palpation method confirmed by ultrasound	Pregnant Obese (PO) n=53	Non- pregnant Obese (O) n=87	Pregnant Non- obese (P) n=81	Non- pregnant Non-obese (N) n=79	p
Matched with L4-L5 (Segments 4, 5, 6)	31 (58.5%)	53 (60.9%)	67 (82.7%)	75 (94.9%)*†	0.0005
Not matched with L4-L5	22 (41.55%)	34 (39.1%)	14 (17.3%)	4 (5.1%)	0.0005
Intervertebral spaces other than L4-L5					-
L5-S1 (segments 1, 2, 3)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	
L3-L4 (segments 7, 8, 9)	8 (15.1%)	3 (3.4%)	2 (2.4%)	3 (3.8%)	
L3L2 (segments 10, 11, 12)	10 (18.9%)	25 (28.7%)	7 (8.6%)	1 (1.3%)	
L2-L1 (segments 13, 14, 15)	4 (7.5%)	6 (6.9%)	5 (6.2%)	0 (0%)	

Pair wise comparison: adjusted p-value=0.05/6=0.008. [PO vs. O: p=0.776; PO vs. P: p=0.002; PO vs. N: p=0.0005*]. [O vs. P: p=0.002; P vs. N: p=0.0005†]. [P vs. N: p=0.014].

† * significant. L4-L5 was confirmed by ultrasound method.

31.21±5.95 years (range: 19-48). Participant's demographics and co-morbid conditions in each group are shown in Table 1.

Tuffier's line identification by palpation method (P-line) was confirmed by US scanning at L4-L5 interspace (segments 4, 5, 6) in 75.3% (226/300) of participants. However, in 24.6% (74) of participants, US scanning did not correspond to the L4-L5 interspace by palpation method. The US scanning revealed that P-line was located above the L5-S1 interspace in 100% (300) of participants. The P-line was found at L2-L1 in 15 (5%) participants, at L3-L2 in 43 (14.3%) participants and at L3-L4 in 16 (5.3%) participants (Table 2).

Proportion difference of true identification by palpation method of Tuffier's line at L4-L5 was statistically significant among the groups (p=0.0005). It was observed that proportion difference in true identification of Tuffier's line was significantly lower in group PO as compared to that in group N [36.4%; p=0.0005<0.008 adjusted p-value], and proportion difference was also observed between group N and group O [34%; p=0.0005<0.008 adjusted p-value]. However, the proportion difference of true identification was not statistically significant among groups PO, P and O as shown in Table 2. It was also not a statistically significant difference between group P and group N at p=0.014 (p>0.0008).

Discussion

Based on the review of the literature, this is the first study to evaluate the agreement between US and palpation method to identify Tuffier's line at L4-L5 interspace in participants with difficult and normal topographic anatomy. The results of this study showed that identification of Tuffier's line at L4-L5 by palpation method as confirmed by the US was highest among normal weight non-pregnant participants (94.9%) compared to groups having difficult topographic anatomy; including pregnant participants (82.7%), obese participants (60.9%) and pregnant obese participants (58.5%). When compared with the normal weight non-pregnant patient, the only statistically significant difference in the proportion of disagreement between palpation and US method to identify Tuffier's line was found in obese participants with or without pregnancy. Previous studies using radiography have also shown Tuffier's line to coincide with the L4 spinous process or the L4-L5 interspace in majority of non-pregnant patients (11, 12).

In contrast, pregnancy and obesity is associated with higher placement of Tuffier's line (13, 14). In addition, these special groups of patients are clinically important while performing neuraxial block because they are at increased risk of technical difficulty, as identification of Tuffier's line by palpation method requires palpation through the variable amount of fat (15). This study confirmed that palpation method as confirmed by the US was less accurate in obese participants with or without pregnancy. However, it did not show a statistically significant difference in identification of Tuffier's line between palpation and US method in pregnant normal weight women compared to non-pregnant normal weight women. This is in contrast to previous studies in pregnant patients (13, 14). The possible reason could be high average BMI of pregnant patients of 30 plus in these studies as compared to an average BMI of 27 among pregnant females in this study (13, 14). In addition, the sample size in the previous studies was insufficient to provide an accurate measure of correlation among BMI; and the disparity between clinical estimates and the US determined levels and the statistical significance in these studies was considered at p-value≤0.05 (13, 14).

However, in this study, because of the comparison of four groups, six comparisons were performed by chi-square; therefore, the p-value was adjusted to 0.008 to control the inflation of type I error, which could be the reason of not having a statistically significant difference in pregnant participants.

One systematic review on lumbar neuraxial US for spinal and epidural anaesthesia included 31 clinical trials and 1 meta-analysis (16). Five studies from this review examining the agreement between US and palpation of surface landmarks in identifying given intervertebral space showed an agreement range varying from 14% to 64% (3, 14, 17-19). This range of agreement is lower than found in this study. The possible reason could be the anatomical variation of spine among different races; as previous studies have found differences in vertebra-specific distributions of vertebral dimensions and ratios among different populations (20). Anatomical variation among different races have also been found in the level of conus medullaris, as it has been reported to be at L2 or L2-L3 in 32% of Africans as compared to 20% of Europeans (18). Ethnic differences exist in the body fat deposition that might affect the identification of intervertebral level by palpation methods among different ethnic groups (20).

As the study on Tuffier's line identification has never been performed on South Asian population, the results of this study might be different from previous studies done on study population from different ethnic groups.

The other reason could be the experience of the anaesthesiologist of more than 10 years in obstetric anaesthesia performing the palpation method. Duniec et al. (3) also show this in their study where the only statistically significant correlation was found between the length of professional training versus agreement in clinical and US-guided identification. Identification carried out by physicians with long professional experience was commonly consistent with US-guided determina-

tions. However, this study still confirms the finding of previous studies (3, 18) that patient population having difficult topographic anatomy like obese or obese pregnant patients are clinically important for image guidance by the US for CNB, as they are at increased risk for technical difficulty and inaccurate identification of Tuffier's line by palpation method.

With all the available literature on the US, there are no study data that demonstrate that the US-guided method increases the safety of lumbar puncture. A systematic review on lumbar neuraxial US for spinal and epidural anaesthesia has concluded that given the very low baseline incidence (usually less than 1 in 100,000) of spinal cord injury due to unintended intracord injection, it is not feasible to design prospective studies to conclusively prove that the US improves safety (16).

The study by Windisch et al. (21) revealed that accuracy of the palpation method to identify Tuffier's line depends on the right bedding and the orientation of the given landmarks and recommended that palpation method will stay as the most important tool to identify the correct intervertebral space when performing CNB. Therefore, US-assisted CNB is not designed to replace the conventional surface landmark-guided technique, which is simple and effective in the majority of patients. Rather, it is an advanced tool to be used when the technical difficulty is anticipated or when increased precision is desired. It is recommended that anaesthesiologist should acquire technical skills to attain the desired level of competence with the US-assisted approach to CNB and incorporate the use of US in their clinical practice in technically difficult cases.

One limitation of this study is the application of the results to patients of all genders because of anatomical variation. As adult females have more percentage body fat for equivalent BMIs and different fat distribution with greater waist to hip ratios, the finding of the study of the statistically significant correlation between obesity and disagreement in clinical and US identification may not be applicable to male patients. The second limitation of this study is not taking into consideration the presence of lumbosacral transitional vertebrae (either a sacralised L5 or a lumbarised S1). This may have affected the accuracy of determination of vertebral levels; however, recognition is difficult without the use of radiography (22).

The strength of this study is a large sample size and comparing the three groups with difficult topographic anatomy with a control group of patients with p-value adjusted to 0.008. In addition, this is the first study done on this topic in South Asian population with results different from studies done in Caucasian population. This can be an avenue for future larger studies targeting anatomical variation of Tuffier's line identification among different population.

Conclusion

Difficult topographic anatomy including obesity with or without pregnancy was found to be the only significant factor where palpation method was found to be the inaccurate surrogate for the L4-L5 vertebral interspace. In this population, the palpated Tuffier's line most frequently intersects the spine just below the L2-L3 vertebral interspace. Therefore, use of US can be a valuable aid in identification of intervertebral level in this group of the population while performing neuraxial anaesthesia, particularly the spinal and combined spinal-epidural techniques.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Aga Khan University Hospital (Protocol number 4592-Ane-ERC-17).

Informed Consent: Written informed consent was obtained from participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – S.I., M.M.; Design – S.I., M.M.; Supervision – S.I., M.M.; Resources – S.I., M.M.; Data Collection and/or Processing – S.I., M.M.; Analysis and/or Interpretation – S.I., M.M.; Literature Search – S.I., M.M.; Writing Manuscript – S.I., M.M.; Critical Review – S.I.

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