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Original Article

Anaesthesia Section

Determination of Vertebral Structure using Ultrasound Examination at Manually Identified Midpoint of Intercristal Line in Pregnant Women at Term: A Cross-sectional Study

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ABSTRACT

Introduction: Manual palpation has traditionally been used to locate the intercristal line and corresponding vertebral level for administering subarachnoid blocks. However, ultrasound examination provides an alternative approach for accurate vertebral identification.

Aim: To determine the vertebral structure using ultrasound at the manually marked midpoint of the intercristal line in pregnant women at term.

Materials and Methods: A cross-sectional study was conducted at Government Dharmapuri Medical College Hospital (GDMCH) in Dharmapuri, Tamil Nadu, India from March 20, 2023 to April 18, 2023. It involved 100 pregnant women at term. Two independent observers estimated the vertebral space at the intercristal line – one using manual palpation and the other using ultrasound guidance. The primary outcome assessed was the determination of the vertebral structure using ultrasound examination at the manually marked midpoint of the intercristal line in pregnant women at term. The secondary outcome assessed included evaluating the accuracy of manual palpation in identifying vertebral levels compared to ultrasound examination and assessing factors such as Body Mass Index (BMI) that may influence the accuracy of vertebral level identification. One-way Analysis of Variance (ANOVA) was used to compare the mean±SD of continuous variables among more than two groups. A p-value <0.05 was considered statistically significant.

Results: The study included 100 pregnant women with a mean age of 22.91±3.74 years and a mean BMI of 25.87±3.98 kg/m^2. The ultrasonographic assessment revealed that the manually palpated intercristal line corresponded to the L4 vertebra level in 50% of cases, the L3-L4 intervertebral space level in 30%, the intended L4-L5 intervertebral space level in 15%, the L5 vertebra level in 3%, and the L3 vertebra level in 2%. Notably, the ultrasound examination showed that the manually palpated intercristal line was higher than the L4 vertebra or L4-L5 intervertebral space in 32% of the pregnant women.

Conclusion: The study indicates that ultrasound examination may offer a more accurate method for identifying vertebral structures in pregnant women at term compared to traditional manual palpation.

Keywords: Palpation, Pregnancy, Spinal anaesthesia, Ultrasonogram

INTRODUCTION

Regional anaesthesia techniques, such as spinal or epidural anaesthesia, are commonly employed for caesarean deliveries and provide excellent analgesia during labour [1]. Healthcare professionals use anatomical landmarks for the identification of the spine for diagnosis or intervention [2]. For anaesthesia, the anaesthesiologists need an exact placement of epidural/spinal catheters to ensure effective postoperative analgesia with minimised adverse effects [3]. Tuffier's line, Jacoby's line, or the intercristal line, which is the imaginary line running horizontally between the posterior iliac crest, is used as an anatomical landmark to determine vertebral levels to administer neuraxial anaesthesia. The misidentification of the vertebral levels will result in complications [4,5]. Cephalad movement of the spinal anaesthetic drug is also an important complication if there is any change in the identification of the spinal levels. The most common method to determine the spinal level is by clinically palpating of iliac crests, a method that has frequently been associated with inaccuracies [6]. This could be due to deviation of the vertebral anatomy in the association between the intercrestal line and Tuffier's line [7]. Tuffier's line is defined as the transverse line connecting the superior aspects of the iliac crests on an X-ray; it intersects the spine at the level of the L4 or the L4-L5 interspace. There is considerable error/deviation regarding the level of intersection as per the literature [8]. The variations in accurately identifying the spinal level by palpating the iliac crests may be due to anatomical differences influenced by factors like gender, height, and BMI [9].

To account for these variability introduced by palpation, ultrasound imaging has been employed to improve precision in locating anatomical landmarks for neuraxial anaesthesia [10,11]. Especially in pregnancy, ultrasound estimation is much more effective as factors like hyperlordosis, progressive pelvic rotation over the long axis of the spinal column, and maternal weight gain would interfere the estimation of spinal levels by palpation [12]. These factors also have a higher likelihood of inaccurately determining the cephalic relationship to the vertebral column.

The present study aimed to determine the vertebral structure using ultrasound examination at the manually marked midpoint of the intercristal line in pregnant women at term. This study was undertaken as there were not many studies done in the south Indian population, whose body habitus vary considerably when compared with other population groups.

MATERIALS AND METHODS

A cross-sectional study was conducted at Government Dharmapuri Medical College Hospital (GDMCH) in Dharmapuri, Tamil Nadu, India from March 20, 2023 to April 18, 2023. Ethical approval was obtained from the institutional review board (Ref: IEC: GDMC/02/2022). Informed written consent was obtained before the study started, and confidentiality was maintained

throughout. Clinical Trial Registry of India registration was also done (CTRI/2023/02/049815).

Inclusion criteria: Term pregnant women over 18 years, classified as American Society of Anaesthesiologists (ASA) Physical Status Risk I or II [14], were included in the study.

Exclusion criteria: Term pregnant women who were unable to maintain the required position or had a spinal deformity were excluded from the study.

Sample size calculation: The sample size was calculated using a proportion of correct vertebral level of 14% [13], with an absolute precision of 6.96%, a 95% confidence level, and a population size of 3000. Using the formula, authors determined a sample size of 95.

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)}$$

n′ = Sample size

N = Total population size

Z = Confidence level

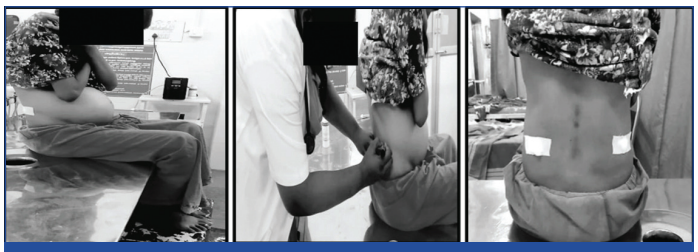
P = Estimated proportion of the population

d = Margin of error

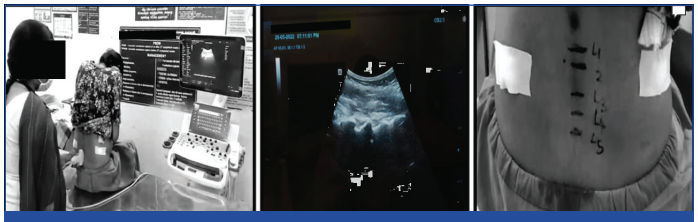
Taking a 5% attrition rate into account, five subjects were added to allow for potential loss to follow-up or non participation. The final sample size was 100.

Study Procedure

With the patient placed in the sitting position, with the neck, hip, and back flexed and the foot placed comfortably positioned on a footrest, two independent mutually blinded observers made the observations in the study. The observer who performed manual palpation had a standard five years of experience [Table/Fig-1], while the other who performed an ultrasound-guided estimation had undergone two weeks of training in interpreting ultrasound of the spine [Table/Fig-2]. The first observer conducted manual palpation and marked the midpoint of the intercristal line. The second observer performed the ultrasound scanning at the manually marked midpoint of the intercristal line and identified the vertebral level at that point [Table/Fig-3]. Additionally, to these findings, the height, weight, and pre-pregnant BMI of each study participant were recorded.

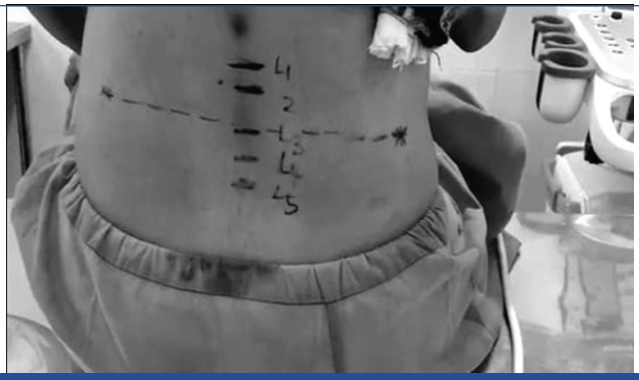


[Table/Fig-1]: Manual marking for the intercristal line.



[Table/Fig-2]: USG estimation of vertebral levels.

Outcome studied: The primary outcome assessed was the determination of the vertebral structure using ultrasound examination at the manually marked midpoint of the intercristal line in pregnant women at term. The secondary outcome assessed included evaluating the accuracy of manual palpation in identifying vertebral levels compared to ultrasound examination and assessing factors such as BMI that may influence the accuracy of vertebral level identification.



[Table/Fig-3]: Vertebral level at intercristal line..

STATISTICAL ANALYSIS

Descriptive analysis was performed using frequency and proportion for categorical variables. Continuous variables were presented as mean±SD. One-way ANOVA was utilised to compare the mean±SD of continuous variables among more than two groups. A p-value <0.05 was considered statistically significant. Statistical analysis was conducted using RStudio Desktop Version 2023.03.0+386.

RESULTS

A total of 100 subjects were included in the final analysis. The mean age was 22.91±3.74 years in the study population. The mean gestational age (weeks) was 38.91±1.11 in the study population. The minimum gestational age was 37 weeks, and the maximum was 41 weeks. The mean pre-pregnant weight (kg) was 51.82±9.50 in the study population. The minimum pre-pregnant weight was 33 kg, and the maximum was 76 kg [Table/Fig-4].

Demographic parameters	Summary
Age (years)	22.91±3.74 (Range 17.00 to 39.00)
Height (cm)	154.22±5.17 (Range 142.00 to 165.00)
Weight (kg)	61.56±10.09 (Range 41.00 to 86.00)
BMI (kg/m^2)	25.87±3.98 (Range 18.43 to 38.41)
Maternal parameters	
Gestational age (weeks)	38.91±1.11 (Range 37.00 to 41.00)
Prepregnant weight (kg)	51.82±9.50 (Range 33.00 to 76.00)

[Table/Fig-4]: Demographic parameters in the study population (N=100).

Ultrasound examination revealed that the manually palpated midpoint of the intercristal line corresponded to the L4 vertebra level in 50% of patients, the L3-L4 intervertebral space level in 30%, the L4-L5 intervertebral space level in 15%, the L5 vertebra level in 3%, and the L3 vertebra level in 2% of patients. The manually drawn intercristal line was above the level of the L4 vertebra or the L4-L5 intervertebral space in 32% of patients. However, manual palpation assessment showed disagreement with the ultrasound findings, with the intercristal line being identified at the L3 vertebra level in 26% of patients and the L3-L4 intervertebral space level in 66% of patients [Table/Fig-5].

Vertebral level	Assessed by USG n (%)	Manual assessment n (%)
L3	2 (2)	26 (26)
L3-L4	30 (30)	66 (66)
L4	50 (50)	8 (8)
L4-L5	15 (15)	-
L5	3 (3)	-

[Table/Fig-5]: Vertebral levels at the Intercristal line as assessed by USG (N=100).
L1, L2,L3,L4,L5- Vertebral levels

The mean difference in BMI (kg/m^2) across different vertebral levels was statistically not significant (p-value = 0.3771) [Table/Fig-6].

Parameter	Vertebral Level					p-value (ANOVA)
	L3 (N=2)	L3-L4 (N=30)	L4 (N=50)	L4-L5 (N=15)	L5 (N=3)	
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	
BMI (kg/m^2)	31.60±9.63	25.67±3.65	25.80±4.29	25.73±2.90	25.67±1.62	0.3771

[Table/Fig-6]: Comparison of BMI (kg/m2) with vertebral levels assessed by USG.
L1, L2, L3, L4, L5- Vertebral levels

DISCUSSION

Studies have demonstrated that the clinical estimation of vertebral levels through manual palpation of anatomical landmarks is often inaccurate when compared to advanced imaging modalities such as Magnetic Resonance Imaging (MRI), radiography, and ultrasound examination [15,16]. These imaging techniques provide direct visualisation of the vertebral structures and can reveal discrepancies between the clinically palpated level and the actual vertebral anatomy [17]. A comparative study conducted by Kim SH et al., investigated the position of the intercrestal line in pregnant versus non pregnant women when placed in the lateral decubitus position. Their findings revealed that the intercrestal line traversed at a higher vertebral level in pregnant individuals compared to their non pregnant counterparts. Specifically, the non pregnant group exhibited a mean intrercrestal position corresponding to the L4 vertebra (6.4±0.9 vertebral levels), whereas pregnant women demonstrated a lower mean level around L3 (3.0±1.0 vertebral levels). This difference between the two cohorts was statistically significant (p-value<0.05), indicating that pregnancy status substantially influences the anatomical landmark of the intercrestal line relative to the vertebral column when patients are positioned laterally [18].

Another study with ultrasound in non pregnant patients reported that the level of the intercristal line palpated clinically corresponded to the L3-L4 level in 73% of cases as evaluated by USG [11]. A study conducted by Whitty R et al., reported that the vertebral level identified clinically was at least one interspace higher than the level located by ultrasound in 32% of the patients [19]. Present study showed similar results with the manually drawn intercristal line being above the level of the L4 vertebra or L4-5 intervertebral space in 32% of patients. Shiraishi N and Matsumura G conducted a radiograph study of non pregnant females in the sitting position with flexion of the spine and found none with an intercristal line level above L4. This difference was due to increased lumbar lordosis in pregnancy and also difficulty in flexion of the spine during pregnancy [20]. The projection of the intercristal line is directly related to pelvic lordosis [21].

In individuals presenting with severe oedema and obesity, palpation techniques may be hindered, potentially leading to inaccuracies in clinical assessment. Present study also found that BMI was not significantly associated with the disparity between the vertebral levels determined by ultrasound examination. The mean difference in BMI (kg/m^2) in vertebral level was statistically not significant in the current study, which was consistent with a study by Lee AJ et al., [13]. Malik M and Ismail S showed that obesity with or without pregnancy was found to be a significant factor in which the palpatory method was found to be an inaccurate estimate for the L4-L5 vertebral interspace [22].

Kim SH et al., demonstrated that based on MRI, the tip of the conus medullaris is positioned between the T12 body and female L2 body, and Tuffier's line was between L3-L4 and L5-S1 in female patients. While MRI may offer superior accuracy, ultrasound guidance still presents a practical, real-time, and comparatively cost-effective alternative to manual palpation for precisely identifying the intended intervertebral space in pregnant women at term [18].

In summary, this study highlights the discrepancies between manual palpation and ultrasound guidance in determining the L4-L5 intervertebral space, emphasising the importance of ultrasound assistance to improve accuracy and safety during epidural placements. While advanced imaging modalities like MRI may provide even greater precision, ultrasound remains a valuable tool for real-time vertebral level identification, minimising risks associated with inaccurate epidural needle placement in the obstetric population.

Limitation(s)

The study was conducted in a single centre, which may limit the generalisability of the findings. Additionally, the potential for observer bias, particularly in the manual palpation technique, and the limited training for ultrasound assessment could influence the accuracy of the results. Further research addressing these limitations would further strengthen the evidence and clinical applicability of the findings.

CONCLUSION(S)

Ultrasound findings showed that the manually palpated intervertebral space was higher than the L4 spine or L4-L5 interspace in 32% of pregnant women. Incorrect estimation of the vertebral level carries the risk of neural damage. To ensure patient safety, routine use of preprocedure USG is recommended in pregnant women to assess the vertebral level before a subarachnoid block.

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