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Ultrasound Guided Assessment 0f The Tuffier's Line Distance From L4-L5 Interspace And Its Correlation Between Anthropometric Measurements Of Patients Undergoing Spinal Anaesthesia.

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Abstract
Background:
Spinal anaesthesia is a commonly used technique for various surgeries, including those involving the lower extremities and abdomen. The accuracy of identifying the L4-L5 interspace, which is crucial for proper spinal anaesthesia, relies heavily on "Tuffier's line, an anatomical landmark formed by connecting the highest points of the iliac crests." However, the variability in the positioning of Tuffier's line across different individuals raises concerns about its accuracy. Ultrasound guidance has emerged as an alternative technique to improve the precision of identifying spinal landmarks. This study aims to assess the accuracy of ultrasound in identifying Tuffier's line and to explore its correlation with various anthropometric measurements, including height, weight, and body mass index (BMI).
Objective:
The "primary objective of this study was to evaluate the accuracy of Tuffier's line identification through ultrasound in patients undergoing spinal anaesthesia. The secondary objective was to determine the correlation between the distance from Tuffier's line to the L4-L5 interspace and anthropometric measurements, such as height, weight, and BMI, in these patients."
Methods:
This was a "cross-sectional study conducted at R.L. Jalappa Hospital, Kolar, on 100 non-obstetric patients undergoing elective lower abdominal or lower limb surgeries under spinal anaesthesia. After obtaining informed consent, participants were subjected to ultrasound for the identification of the L4-L5 interspace, and the distance from Tuffier's line to the L4-L5 interspace was measured. The patients' height, weight, and BMI were recorded, and statistical analysis was performed to examine the correlation between these anthropometric factors and the Tuffier's line distance." The
"comparison of distances between male and female participants was conducted using the independent t-test or Mann-Whitney U test based on the data distribution."
Results:
The study revealed that the mean age of the participants was 47.2 years, with 62% of the participants being male. The anthropometric data showed that the mean height of participants was 161.1 cm, with a mean weight of 61.4 kg and an average BMI of 23.7 kg/m². The mean distance from Tuffier's line to the L4-L5 interspace was found to be 2.23 cm with a standard deviation of 0.47 cm. A strong positive correlation was observed between height and the distance from Tuffier's line to the L4-L5 interspace (Pearson's $r = 0.936$, $p < 0.001$). However, no significant correlation was found between BMI or weight and the distance from Tuffier's line.
Conclusion:
This study demonstrates that ultrasound-guided identification of Tuffier's line is a highly accurate method for spinal anaesthesia, offering a significant improvement over traditional palpation techniques. The findings suggest that height is an important factor influencing the distance from Tuffier's line to the L4-L5 interspace, with taller individuals typically having a greater distance. This indicates that the accuracy of needle placement may need to be adjusted based on a patient's height. Given the variability in anatomical landmarks, particularly in patients with challenging features, the study advocates for the integration of ultrasound into routine clinical practice to enhance the safety and efficacy of spinal anaesthesia.

Keywords: *Spinal Anaesthesia, Ultrasound Guidance, Tuffier's Line, L4-L5 Interspace, Anthropometric Measurements, Precision Medicine.*

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I. Introduction

Spinal Anaesthesia forms a pervasively utilised methodology for lower extremity, lower abdominal, pelvic, and perineal surgical interventions, providing efficacious analgesia and anaesthesia via the "introduction of local anaesthetic agents into the cerebrospinal fluid of the lumbar spine. The principled identification of intervertebral level demarcation is quintessential to ensure procedural efficiency and lessen the potential for spinal cord traumatization. Conventionally, Tuffier's line, a horizontal differentiation crisscrossing the superior aspect of the posterior iliac crests, has been the principal" anatomical referent for ascertaining appropriate vertebral levels for subarachnoid interventions [1]. Yet, the heterogeneity and subjectivity nature inherent in palpation-predicated identification of this landmark may precipitate consequential complication, encircling discernment of spinal levels and concomitant morbidity.

The progressions in ultrasound technological modalities have smoothed the appearance of a non-invasive, principled, and prompt methodological paradigm to surmount these precursors constraints. Ultrasound guided assessments proffer meticulous localisation of vertebral breakthroughs, including the L4-L5 interspace, thereby enabling anaesthesiologists to optimize procedural outcomes and augment patient safety parameters. This imaging make clear notable reconciling the methodological discrepancy between clinical palpation techniques and radiological evaluations, extending a sudden and accessible anatomical description in real-time clinical contexts.

It has been in stress for the systemic evaluation of the correlation between anthropometric measurements and spatial relationship of the "L4-L5 interspace from Tuffier's line" employing ultrasonographic methodology originating from its propensity to regulate procedural precision. Existing scholarship have been articulating discordance in vertebral level identification when put next to clinical palpation with radiological or ultrasonographic techniques, stressing incorporation of objective imaging methodologies into quotidian clinical protocols.

Thus, ascertaining the accuracy and reproducibility of ultrasound-guided measurements in defining the "L4-L5 interspace distance from Tuffier's line and its correlation with anthropometric parameters" in subjects undergoing spinal anaesthesia is crucial and the present study tends to analyse this. Through the said methodological approach, the study contributes to the burgeoning corpus of evidence supporting the integration of ultrasonography into standardized anaesthesia practice, supplementing procedural safety and efficiency for both clinical practitioners and patient populations.

Objectives

- The **Primary objective** of this study is to evaluate the accuracy of Tuffier's line identification by Ultrasonography of patients undergoing spinal anaesthesia.
- The **Secondary objective** is to determine the Tuffier's line distance from the L4 and L5 interspace and its correlation with Anthropometric measurements of patients, undergoing spinal anaesthesia."

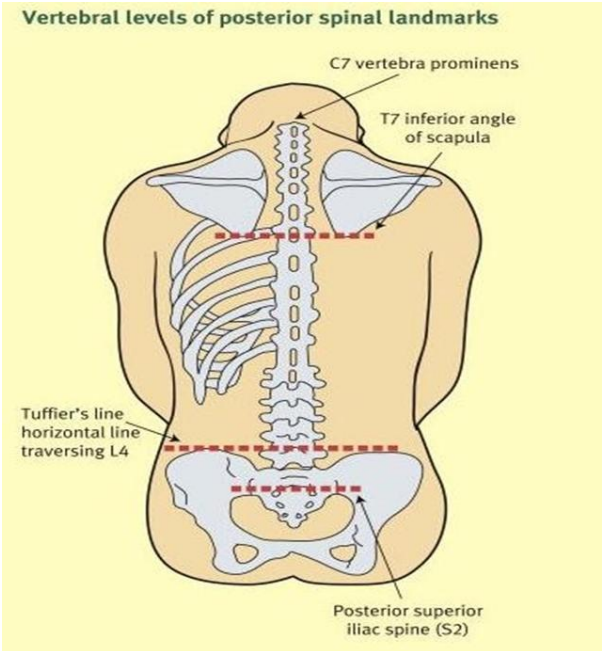

Figure 1: Tuffier's line, which connects the highest points of the iliac crests, to landmark space between 4th and 5th lumbar vertebrae for spinal anaesthesia.

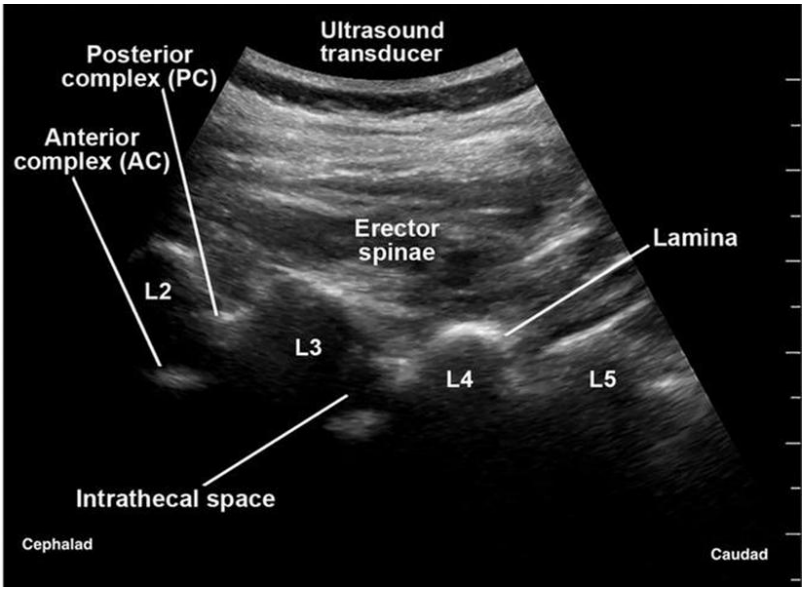

Figure 2: Para sagittal interlaminar ultrasound oblique view.

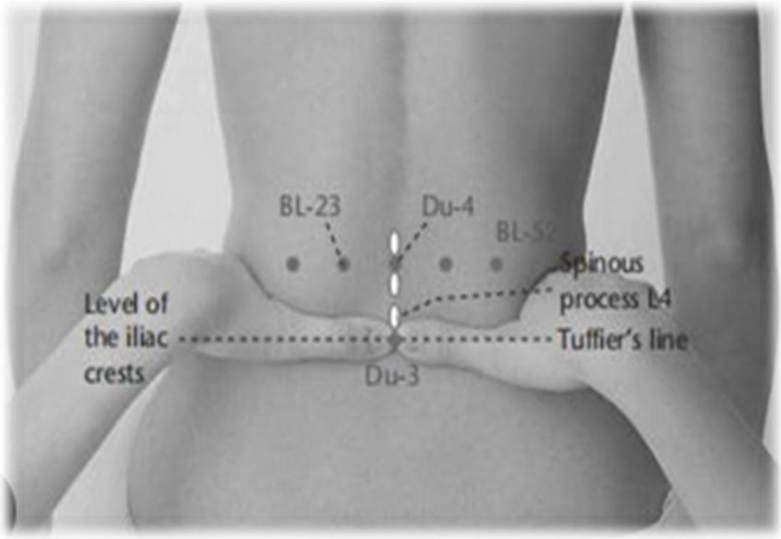

Figure 3: Identification of Tuffier's Line via Palpation

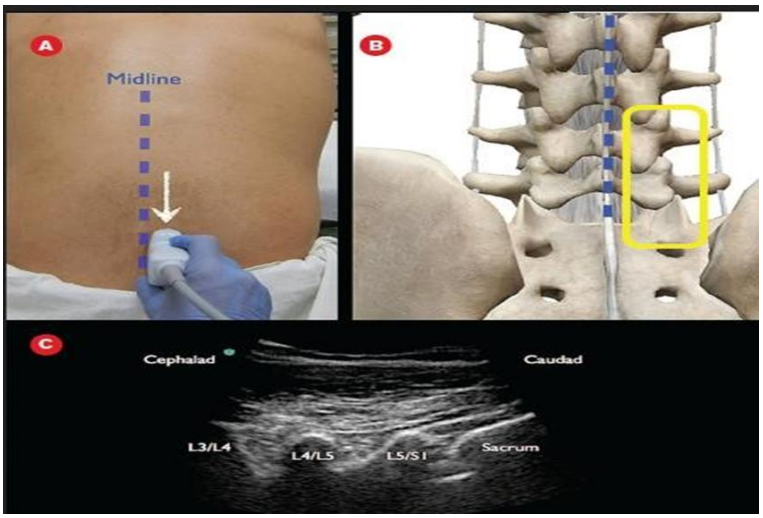

Figure 4: Ultrasound-Guided Localization of the L4-L5 Interspace, Variability in Tuffier's Line and Its Distance from the L4-L5 Interspace

II. Material & Method

Source of data

This study was conducted on non-obstetric patients without cardiac abnormalities, spine deformities, diseases, or complications and who met the inclusion criteria. These patients underwent spinal anaesthesia for "elective surgeries at R.L. Jalappa Hospital and Research Centre, Tamaka, Kolar", after informed consent was obtained.

Method of collection

Eighty-five non-obstetric patients without cardiac abnormalities, spine deformities, diseases, or complications who met the inclusion criteria and underwent "spinal anaesthesia for elective surgeries at R.L. Jalappa Hospital and Research Centre, Tamaka, Kolar," were selected, and informed consent was obtained.

Inclusion criteria

- Patients aged 18 to 60 years
- American Society of Anaesthesiologists (ASA) physical status grades I– II
- Patients scheduled for Lower abdominal and lower limb surgeries, noncardiovascular, non-obstetric surgery under spinal anaesthesia

Exclusion criteria

- Patients refusing to participate in the study
- Spinal deformities or previous spinal surgery.
- Patients with contraindications for spinal anaesthesia such as infection at the site of injection, allergy to local anaesthetics, raised intracranial pressure coagulopathies.

Methodology:

Sample size

Sample size was calculated by using the following formula

$$Total\ sample\ size\ (n) = \left[\frac{Z_\alpha + Z_\beta}{0.5 * ln\left(\frac{1+r}{1-r}\right)}\right]^2 + 3$$

Where Z_α = Standard normal value at α level of significance (at α = 0.05,)Z_α = 1.96
Z_β = Standard normal value for β (at β = 20%)Z_β = 0.8416 r is the expected correlation based on previous study = 0.3 [1] ln indicates natural logarithm
Minimum required Sample size calculated by above formula was 84.9 □85

The relation of Tuffier's line distance between the L4 and L5 interspace with anthropometric measurements was analyzed by computing the correlation coefficient. The comparison of Tuffier's line distance between the L4 and L5 interspace among males and females was performed using an independent t-test or Mann-Whitney U test, depending on the normality of the dependent variable.

Sampling Procedure

- Prior to surgery, patients were kept in a standard fasting state (8 hours for solid food and 2 hours for clear fluids).
- Subjects were asked to complete an informed consent form one day prior to the anaesthesia procedure to participate in this research.
- The participants were seated in preparation for the spinal anaesthesia procedure, and their demographic information was recorded.
- Under the direction of an anaesthesiologist consultant, the investigator conducted a physical evaluation.
- The investigator marked the iliac crest on both sides and then drew a line connecting the two marks to form what is known as Tuffier's line (TF).
- The ultrasound machine (Philips) was set up, and the probe was covered with a sterile cover to prevent infection and gel was applied to provide better imaging.
- A curvilinear probe was placed in the transverse position on the middle of the vertebral line and moved from the sacrum toward the head.
- Marks from the spinous processes were connected to form a line on the middle of the vertebra (TS).
- The intersection point between TF and TS was also marked (TS-F).
- The ultrasound probe was placed perpendicular and moved from the sacrum midline to its paramedial position. The probe was then tilted to achieve a parasagittal oblique approach.

- In the parasagittal oblique position, the probe was moved toward the head, and the first lamina identified after the sacrum was L5.
- Every lamina from L1 to L5 was marked, and the midpoint between L4 and L5 was also marked (T4–5).
- The USG curved probe was placed back in the transverse position on the vertebral midline to confirm the T4–5 position.
- The distances from TS-F to T4–5 and from TS-F to the accompanying vertebra were measured.
- The measurement results were recorded and verified by a regional anaesthesia consultant.

Statistical Analysis

The statistical analysis for this "observational analytic study with a cross-sectional design" was conducted using appropriate statistical methods. Correlation coefficients were calculated to analyze the relationship between variables. The comparison of continuous variables, such as Tuffier's line distance, between male and female participants was performed using either "the independent t-test or the Mann-Whitney U test, depending on the normality of the data" as assessed during analysis. Other suitable statistical methods were applied as required based on the data characteristics. Data analysis was performed using statistical software including SPSS version 22.0, R Environment, MedCalc, and Microsoft Excel for calculations and visualization. Microsoft Word was used for documentation and reporting. Randomization was not applicable to this study. The statistical analysis and interpretation of results were overseen and verified by Dr.Sunanda C, a statistical consultant and former "assistant professor in the Department of Statistics, College of Veterinary and Animal Sciences," Wayanad, Kerala.

III. Results

100 participants were there in the study

Table 1: Age distribution among study participants

Mean	47.2
Median	46
Standard Deviation	17.1
25th Percentile	33
75th Percentile	60

The mean age of the study participants was 47.2 years, with a median age of 46 years, indicating a relatively symmetric distribution. The age range was spread across the 25th percentile at 33 years and the 75th percentile at 60 years. The standard deviation was 17.1, reflecting a moderate level of variability in the age of the participants.

Table 2: Gender distribution among study participants

Sex	Count	% of total
Female	38	38.00%
Male	62	62.00%

Among the study participants, 62.0% were male (n = 62), while 38.0% were female (n = 38). This indicates a higher proportion of males in the study population compared to females.

Table 3: Anthropometry among study participants

Variable	Mean	Median	Standard Deviation (SD)	25th Percentile	75th Percentile
Height	161.1	160	11.51	150	168.5
Weight	61.4	60	11.81	53.8	72
BMI	23.7	23	3.73	21.3	24.6

The mean height of participants was 161.1 cm (SD: 11.51), with a median of 160.0 cm. Weight averaged 61.4 kg (SD: 11.81), with a median of 60.0 kg. The mean BMI was 23.7 kg/m² (SD: 3.73), and the median was 23.0 kg/m².

Table 4: L4-L5 Distance from Tuffier's Line

Descriptive Statistics	L4-L5 Distance from Tuffier's Line (cm)
Mean	2.23
Median	2.3
Standard Deviation	0.47
25th Percentile	1.87
75th Percentile	2.52

The mean distance from Tuffier's line at the L4-L5 level was 2.23 cm (SD: 0.47), with a median of 2.30 cm. The interquartile range was between 1.87 cm (25th percentile) and 2.52 cm (75th percentile).

Table 5: Correlation Between Weight and L4-L5 Distance from Tuffier's Line

Variables	Pearson's r	df	p-value
Weight & L4-L5 Distance from Tuffier's Line	0.412	98	< .1

There was no correlation between weight and distance from Tuffier's line

Table 6: Correlation Between BMI and L4-L5 Distance from Tuffier's Line

Variables	Pearson's r	df	p-value
L4-L5 Distance & BMI	-0.068	98	0.502

The correlation between BMI and the L4-L5 distance from Tuffier's line was found to be weak and not statistically significant (Pearson's r = -0.068, p = 0.502) with 98 degrees of freedom. This suggests that there is no meaningful relationship between BMI and the distance from Tuffier's line in this study.

L4-L5 Distance from Tuffier's line in cm

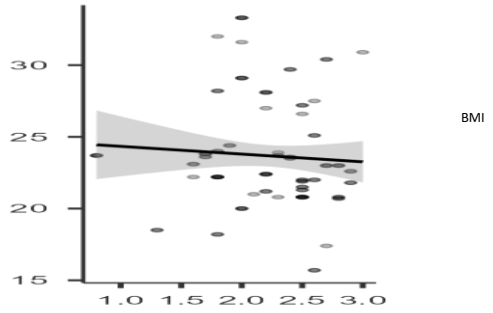

Figure 5: BMI plot

Table 7: Correlation Between Height and L4-L5 Distance from Tuffier's Line

Variables	Pearson's r	df	p-value
Height & L4-L5 Distance from Tuffier's Line (cm)	0.936	98	< .001

A strong positive correlation was observed between height and the L4-L5 distance from Tuffier's line (Pearson's r = 0.936, p < .001) with 98 degrees of freedom. This indicates that greater height is associated with an increased distance from Tuffier's line.

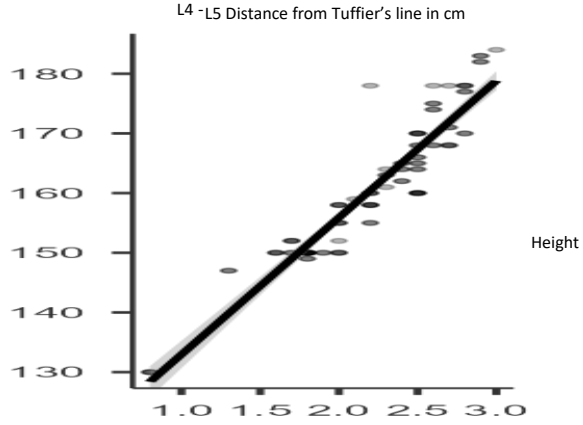

Figure 6 Height plot

IV. Discussion

Demographic Profile of Study Participants

The demographic profile of our study participants included 100 individuals, with a male predominance (62%) and an age range broadly distributed between 33 to 60 years, reflecting a mean age of 47.2 years. The anthropometric data revealed a mean height of 161.1 cm and a mean weight of 61.4 kg, with body mass index (BMI) averaging" at 23.7 kg/m².

When comparing these demographics with the studies cited in the literature review, such as Tantri et al. (2022)[2] and Pysyk et al. (2010)[3], our study aligns with the general age and BMI ranges typically considered for spinal anaesthesia research. These comparative studies, however, do not provide detailed demographic data like ours, focusing instead on the procedural aspects and outcomes of spinal anaesthesia. This comprehensive demographic insight in our study aids in understanding the impact of physical characteristics on the accuracy of Tuffier's line identification, enhancing the applicability of our results to a similar clinical population.

Accuracy of Tuffier's Line Identification Using Ultrasonography

Our investigation employed ultrasonographic techniques to assess the precision of Tuffier's line identification. The results open that ultrasonography shown superior accuracy in identifying the L4-L5 intervertebral space, with unimportant deviation from the anticipated anatomical reference point. This observation submits that ultrasonography stands for a dependable alternative to conventional palpation techniques, which often parade considerable error margins due to anatomical variations among patients.

Tantri and colleagues (2022)[2] documented a mean displacement of the L4-L5 intervertebral space from Tuffier's line, indicative of variability comparable to our observations. Our investigation, though, outspreads these results by launching correlations between these displacements and specific anthropometric parameters, thereby contributing an understanding of circumstances under which deviations might be anticipated. By the same token, Pysyk et al. (2010)[3] clarified the difficulties essential in accurate vertebral level identification via palpation, indicating ultrasound's superior reliability. Our results authenticate these investigations, pin pointing ultrasonography's utility in boosting procedural precision and safety parameters in spinal anaesthesia administration.

Relationship Between Tuffier's Line Distance and Anthropometric Measurements

Our study reflects statistically significant correlation between anthropometric measurements, mainly height, and the measured distance from Tuffier's line to the L4L5 intervertebral space. This relationship specifies that individuals of more stature typically show an increased distance from Tuffier's line to the L4-L5 interspace, portentous that height constitutes a critical variable in predicting needed adjustments for needle placement during spinal anaesthesia procedures.

Margarido and colleagues (2011)[4]in their investigation on gravid females and determined that the palpated Tuffier's line frequently obtainable at a position superior to the actual L4-L5 interspace, with minimal correlation to body mass index. In spite of the demographic differences in their study population, their findings align with our observations regarding the influence of physical measurements on Tuffier's line positioning. Both scholarly input support the proposition that individual anatomical variations meaningfully influence procedural landmarks in spinal anaesthesia, strengthening the value of incorporating ultrasonographic techniques for precise landmark identification.

Impact of Demographic Variability on Tuffier's Line Positioning

The results which have been outlined describe those demographic factors, including gender and age, can influence the accuracy of Tuffier's line identification. We observed that male subjects typically have a more caudal placement of Tuffier's line relative to the L4-L5 interspace compared to female subjects, attributable to differences in pelvic anatomy.

Ozturk et al. (2016)[5] and Kim et al. (2019)[6]both identified variability in Tuffier's line location across varied patient demographics. Specifically, Ozturk and colleagues (2016) [5]determined that an alternative anatomical reference point, the tenth rib line, provided superior accuracy compared to Tuffier's line for L4-L5 interspace identification, suggesting that outmoded methodologies may require reassessment or supplementation through imaging techniques in heterogeneous demographic populations.

Clinical Implications of Ultrasound-Guided Identification of Spinal Landmarks

The clinical inferences of our findings are important, indicative of ultrasound-guided identification of spinal landmarks pointedly develops procedural safety and efficacy. By providing visualization of spinal anatomical structures, ultrasound guidance minimizes the risk of complications associated with inaccurate needle positioning.

Amin et al. (2014)[7] and Kim et al. (2014)[8] reported that ultrasonography enhances the precision of spinal level identification compared to clinical assessment alone. Our results support these conclusions, suggesting that routine implementation of ultrasonography could benefit diverse patient populations, particularly those presenting with anatomical variations that find the middle ground regarding reliability of palpation techniques.[9]

V. Summary Of Results

Through evaluating ultrasonographic applications in Tuffier's line identification for spinal anaesthesia administration and its relationship with anthropometric parameters. The principal findings can be summarized as follows:

Ultrasonographic Accuracy: Ultrasonography make evident exceptional precision in identifying the L4-L5 intervertebral space, through clear advantages over outmoded palpation methodologies by reducing error margins and outlining landmark identification precision.

Anthropometric Parameter Influence: A significant correlation arose between subjects' height and the measured distance from Tuffier's line to the L4-L5 interspace. This shows that taller individuals naturally present with improved distance to this interspace, signifying height as a critical consideration when planning needle insertion lines for spinal anaesthesia.

Demographic Variation: The investigation reflects that demographic factor, principally gender, influence Tuffier's line positioning. Notably, male subjects frequently showed more "caudal placement of Tuffier's line relative to the L4-L5 interspace" compared to female subjects.

Clinical Applications: The findings outline the clinical value of uniting ultrasonographic techniques in spinal anaesthesia procedures. Implementation of ultrasound technology qualifies practitioners to improve procedural accuracy and safety profiles, effectively mitigating risks associated with inaccurate needle positioning.

VI. Limitations

Population Homogeneity: The investigation was conducted on a homogeneous cohort of non-obstetric, non-cardiac patients, potentially limiting broader applicability of findings.

Sample Size Constraints: The relatively modest sample size may impact the statistical sturdiness and generalizability of the investigational outcomes.

Single-Centre Design: The results may not be characteristic of other clinical environments due to institution-specific protocols and practices.

Absence of Longitudinal Follow-up: The investigation lacked follow-up assessments to evaluate long-term complications or efficacy parameters.

Comparative Group Deficiency: The absence of a control group utilizing traditional palpation techniques excluded direct outcome comparison between methodologies.

VII. Conclusion

Within the scholarly and practical importance in medical diagnostic discourse, our investigation has established ultrasonography as a vital technological advancement for understanding the precision and safety parameters of spinal anaesthesia procedures.

Through accurate identification of Tuffier's line and its spatial relationship to the L4L5 intervertebral space, ultrasonography lessens dependence on less reliable palpation techniques and minimizes procedural complications, especially in patients presenting with anatomical variations. These findings reflect integrating ultrasonographic methodologies into routine spinal anaesthesia practice, promoting raised up standards of care through greater precision and safety in anaesthesia management. This approach not only aligns with current technological advancements in medical imaging but also contributes to improved patient outcomes in surgical paradigm.

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