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### RESEARCH ARTICLE

#### ULTRASOUND MEASUREMENT OF THE VERTEBRAL LEVEL OF TUFFIER'S LINE IN ELDERLY WOMEN ( A COMPARITIVE CROSS SECTIONAL STUDY )

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#### Abstract

**Background:** Sometimes, generalizing the vertebral level which is determined by palpation in patients across all the age groups may be inaccurate. This study has aimed to compare the vertebral level intersected by the Tuffier's line in elderly women versus adult women utilizing an ultrasound in the left lateral decubitus flexed position, to provide a more precise understanding of the potential age-related differences.

**Methods:** We enrolled 50 female patients over the age of 65 (elderly group) and 50 female patients between ages 20-50 (control group) who had been scheduled to undergo surgeries under spinal Anaesthesia. Using ultrasound, we marked the L2-L5 lumbar spinous processes and intervertebral spaces. The most cephalad part was labeled as 1 and the most caudal part was labeled 11. We then identified to which line of these vertebral levels Tuffier's line crossed using an ultrasound.

**Results:** In the elderly group, the median vertebral level of Tuffier's line was found to be located at L2-L3 (median value = 3), whereas in the control group, it was situated at the lower part of L4 (median value = 8). Moreover, a significant correlation was found between the vertebral level of Tuffier's line and age, weight and BMI in the elderly group ( $P < 0.001$ ), indicating a significant association between these factors.

**Conclusions:** The ultrasound measurement in the left lateral decubitus flexed position revealed that the Tuffier's line was situated more cranially (towards the head) in elderly women compared to the control group. This indicates that the needle may be inserted at a higher level than anticipated, indicating the importance of careful level determination during spinal Anaesthesia in elderly women to avoid complications.

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**Introduction:-**

The growing life expectancy leads to a higher number of elderly patients undergoing surgeries. For orthopedic or urological surgical procedures, spinal Anaesthesia is widely used. It is essential to identify the appropriate landmarks for needle insertion in order to conduct safe spinal anaesthesia. Tuffier's line is a horizontal line that connects the highest points of the iliac crests, is an important landmark to determine the puncture level. In adults, it is usually considered as a hypothetical line which passes through the L4 spinous process or the L4-5 intervertebral space.

Manual palpation of the vertebral body is the most widely used method of determining the vertebral level of Tuffier's line. Though it is a convenient method, it may also be inaccurate. Van Gessel et al. [1] have reported that the vertebral level of Tuffier's line which is determined by palpation is higher than the actual vertebral level measured by spinal imaging. The concordance rate between clinical examination and assessment of intervertebral space identification for lumbar puncture is only reported as 64% [2].

Ageing leads to various kinds of physical changes as a person grows older. These include changes in the height of vertebral bodies, spinal degeneration, bone density loss and reduction of skeletal muscles. These changes are clearly seen in postmenopausal women [3]. Due to ageing process of the skeletal system, level through which Tuffier's line passes may be measured higher or lower than the usual level, which is the cause of inaccuracy. Hence, it would be incorrect to generalize the vertebral level determined by palpation to patients of all the ages [4].

Left lateral decubitus position is the most commonly used position for administration of spinal Anaesthesia. Though it is possible to obtain an accurate measurement of the vertebral level with X-ray for spinal Anaesthesia, it is difficult to apply this method in every case due to the amount of radiation exposure. It is also not easy to identify the precise vertebral level because the spine overlaps with patient's iliac bones or femurs in the lateral decubitus flexed position. The use of ultrasound for regional Anaesthesia has been increasing tremendously [5,6]. The advantage of ultrasound is that it is free of radiation exposure and it is also suitable for examination of the vertebral level from a patient's back in the left lateral decubitus flexed position. Thus, the use of ultrasound plays an important role in preventing complications that may arise from inaccurate prediction of the vertebral level.

The main purpose of this study was to compare the vertebral level crossed by Tuffier's line in elderly women with that in adult women using ultrasound in the left lateral decubitus flexed position. We have also evaluated the correlation between the vertebral level measured by ultrasound and other variables including patient characteristics.

**Materials and Methods:-**

**Study design:**

Hospital based Comparative Cross sectional study

**Source of Data:**

The present study was conducted in Department of Anaesthesiology at Basaveshwar Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi.

**Sample size:**

Total - 100 patients  
50 Female Patients above 65 yrs of age (Elderly group)  
50 Female patients in age group 20-50 yrs (Control group)

**Inclusion Criteria**

1. Females
2. Patients scheduled for elective surgery under spinal Anaesthesia
3. Patients above 65 yrs of age
4. Patients with age between 20-50 years

**Exclusion Criteria:**

1. Patients who had received spinal surgery
2. Patients with spondylolisthesis
3. Patients with compression fractures
4. Patients with Scoliosis
5. Patients with Transitional vertebrae
6. Patients with any known spinal deformities.

**Methods of statistical Analysis:**

Statistical data analysis was analyzed by using IBM SPSS statistics(ver. 20.0, IBM Corp, Armonk, NY, USA) . Student's t-test , The Mann-Whitney U test and Spearman's correlation were used to obtain the data .

The P value < 0.05 concluded the study as statistically significant

**Methodology:-**

50 female patients above the age of 65 (elderly group) and 50 patients between the age group 20-50 ( control group ) who were to undergo spinal Anaesthesia for the surgery were enrolled in this study. All the patients underwent lumbar spine X-rays who were scheduled for spinal Anaesthesia.

The patient was put in a lateral decubitus position, onto her left side and with flexion of her neck, back, buttocks, and knees. The patient was maintained in this posture with the help of an assistant. Using a 2–5 MHz curved array probe (M-Turbo™; SonoSite Canada Inc., Markham, ON, Canada), a probe was placed 3 cm away from the midline of the vertebra in the longitudinal plane. Next, the probe was slightly tilted toward the spinal midline and placed in the paramedian longitudinal plane. The probe was moved gradually cephalad from the patient's sacrum, the L2–L5 lumbar spinous processes were scanned and marking of the intervertebral spaces between each of them was done. The intervertebral space was considered as one segment, and each spinous process was equally divided into two parts, labeling the upper half as "upper" and the lower half as "lower." The intervertebral spaces were labeled as L1–2, L2–3, L3–4, and L4–5, respectively. Beginning from the L5 lower part to the L2 upper part, consecutive numbers were assigned: the most caudal part was labeled as 11, and the most cephalad part was labeled as 1. This method used arbitrary labeling (Fig. 1). After palpating the superior aspects of the iliac crests, a straight line was drawn connecting the points. We then determined which vertebral level was crossed by Tuffier's line. The patients' weight , age , height and body mass index (BMI; kg/m<sup>2</sup>) were taken into consideration.

**Fig - 1:- Arbitrary labeling of vertebral levels**

Vertebral body	Vertebral level	Segment
□	L2 upper	1
	L2 lower	2
	L2-3	3
□	L3 upper	4
	L3 lower	5
	L3-4	6
□	L4 upper	7
	L4 lower	8
	L4-5	9
□	L5 upper	10
	L5 lower	11

**Results:-**

This particular study had an enrollment of 100 patients out of which 50 patients were included in the elderly group and 50 patients in the control group. The total data was analyzed and found significant differences in

the heights and age between the two groups ( $P < 0.001$ , Table 1). There were no differences seen in weight and BMI.

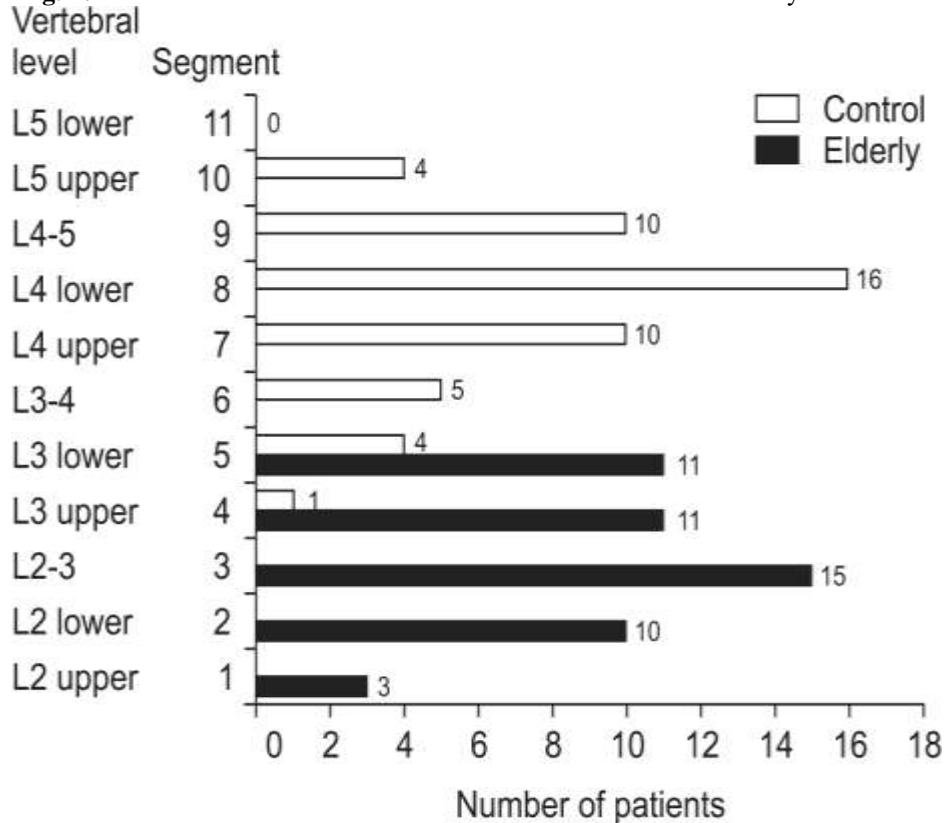
**Table 1:-**

Patient Characteristics	Elderly ( n = 50 )	Control ( n = 50 )	P value
Age	73.3 ± 5.5	38.8 ± 8.4	< 0.001
Height ( cm )	153.4 ± 5.1	159.4 ± 4.2	< 0.001
Weight ( kg )	58.0 ± 8.7	60.4 ± 9.7	< 0.200
BMI ( kg/m <sup>2</sup> )	24.6 ± 3.2	23.8 ± 3.6	< 0.228

Values are mean ± SD. There are significant differences between the two groups in age and height. Elderly : the elderly group, Control : the control group, BMI : Body mass index.

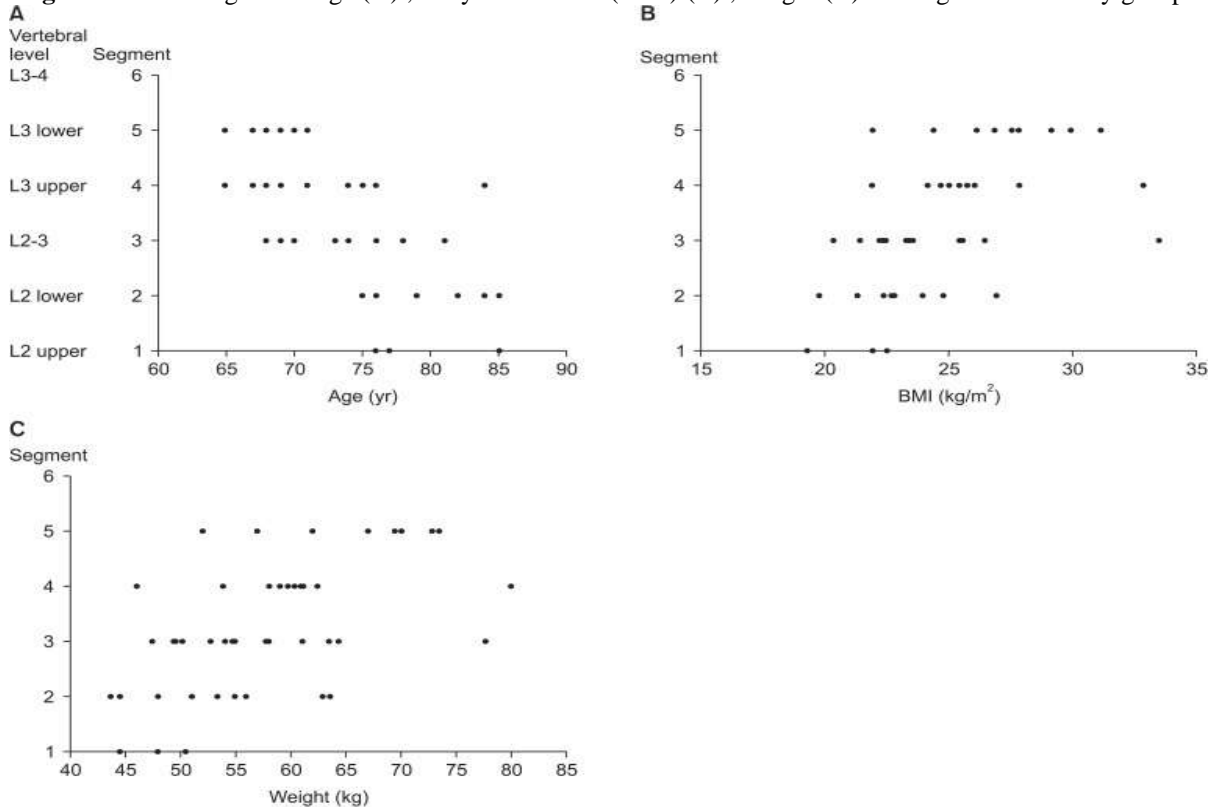
The median vertebral level of Tuffier's line was found to be L2-3 (median value = 3) in the elderly group, whereas in the control group, it was located at the lower part of L4 (median value = 8). This difference was statistically significant ( $P < 0.001$ ). Notably, 76% of elderly subjects (38/50) had Tuffier's line located at L2-3 or L3, while 72% of control subjects (36/50) had it located at L4 or L4-5. Importantly, all participants showed Tuffier's line to be located below L2 (Fig. 2).

**Fig. 2:-** Distribution of the vertebral level of Tuffier's line measured by ultrasound.

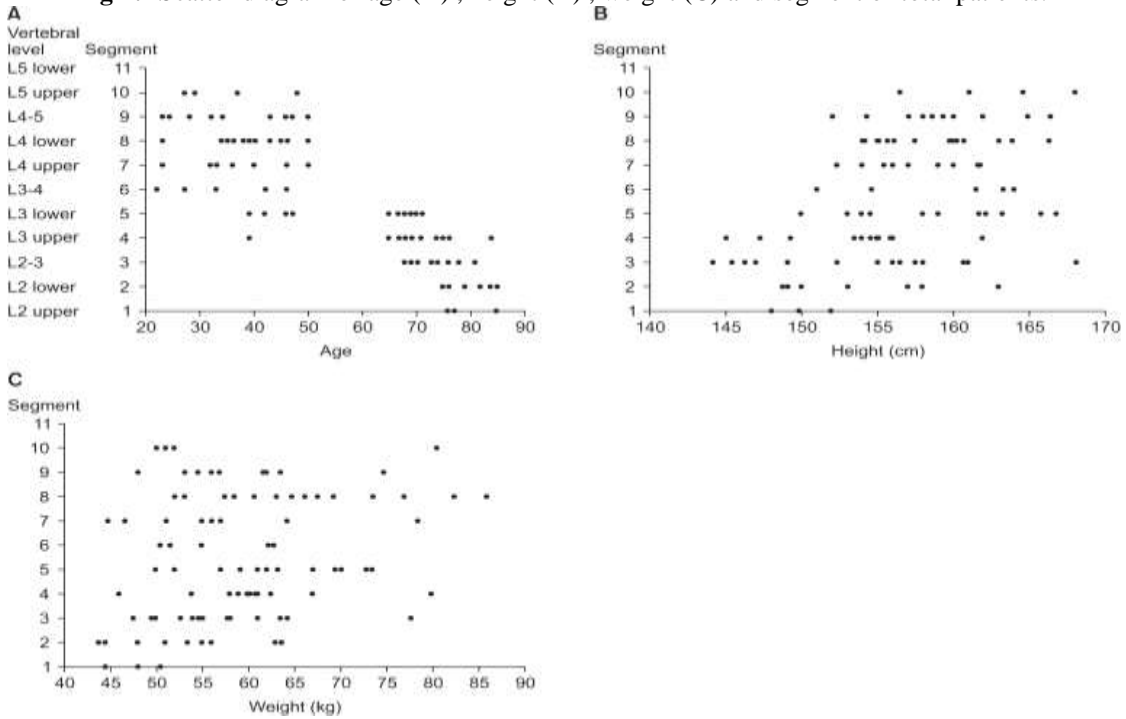


In the elderly group, a statistically significant correlation was observed between the vertebral level of Tuffier's line and age, BMI, and weight ( $P < 0.001$ , Fig. 3). Specifically, a positive correlation was found between Tuffier's line and BMI/weight, indicating that higher BMI and weight were associated with a lower vertebral level. Conversely, a negative correlation was found with age, indicating that older age was associated with a higher vertebral level. In contrast, no significant correlations were observed in the control group (Table 2). When the entire study population was analyzed, significant correlations emerged between the vertebral level of Tuffier's line and age, height, and weight (Table 2, Fig. 4).

**Fig. 3:-** Scatter diagram of age (A) , body mass index (BMI) (B) , weight (C) and segment in elderly group.



**Fig 4:-** Scatter diagram of age (A) , height (B) , weight (C) and segment of total patients.



**Table 2:-** Spearman's Correlation Analysis of the vertebral Level of the Tuffier's Line and Variables :

	Elderly ( n = 50 )		Control ( n = 50 )		Total ( n = 100 )	
	Correlation coefficient	P value	Correlation coefficient	P value	Correlation coefficient	P value
Age (yr)	- 0.714	< 0.001	- 0.091	0.531	- 0.839	< 0.001
BMI ( kg/m <sup>2</sup> )	0.599	< 0.001	0.029	0.842	0.041	0.687
Height (cm)	0.200	0.163	- 0.016	0.915	0.490	< 0.001
Weight (kg)	0.558	< 0.001	0.011	0.942	0.242	0.015

Elderly : The elderly group , Control : The control group , Total : The elderly and the control group ,BMI : Body Mass Index.

The correlations between the vertebral level of the Tuffier's line and age ,BMI and weight were shown to be significant in the elderly patients .

The correlations between the vertebral level of the Tuffier's line and age , height and weight were shown to be significant in the total patients .

### Discussion:-

We demonstrated that the vertebral level of Tuffier's line was more cephalad in the elderly group than that of the control group using ultrasound in the left lateral decubitus flexed position. To estimate the accurate vertebral level it is essential to determine the significant lumbar puncture level. Usually, the lumbar puncture point is determined based on Tuffier's line, which is an imaginary line that connects the superior aspects of the iliac crests. Anatomically, an adult's conus medullaris ends at the L1 or L2 vertebral level, and in order to prevent the risk of spinal cord injury, the needle should be inserted below the conus medullaris during spinal Anaesthesia. Based on Tuffier's line, if the vertebral level is incorrect and the needle is inserted above the end of the conus medullaris, it may result in indirect injury to the spinal cord.

Generally, Tuffier's line crosses the L4 or L4–5 vertebral level [7]. It has been reported that in supine position these points of intersection are mostly located at L4–5 (50.4%) or L4 (28.6%), and that they tend to be lower in a sitting position, usually at L4–5 (44%) or L5 (38.8%) [8]. Moreover, in the Indian population, in the jack-knife position the vertebral level determined by Tuffier's line was usually found at L4–5 (69.6%) and L5 (20%) .

In the current study, the participants' vertebral levels were measured in the lateral decubitus flexed position with both legs flexed and the spine flexed as much as possible, which was the most commonly used position when giving spinal Anaesthesia. Many studies have suggested that the vertebral level of Tuffier's line determined by manual palpation and which were shown in radiographic images do not coincide with each other [9]. Chakraverty et al. [10] reported that while Tuffier's line which was confirmed by palpation was at L3 or L3–4 vertebral levels, Tuffier's line determined by imaging was at L4 or L4–5 levels, thus demonstrating the possibility of inconsistency. The use of fluoroscopy for spinal procedures reduced errors in determining the vertebral level. Considering the preparation of equipment and the amount of radiation exposure, this method is not much suitable for actual clinical practice. Therefore, the use of ultrasound, which is not only easily available , but also reduces the risk of radiation exposure, is currently increasing [11]. In the current study, we used ultrasound to determine the vertebral levels of patients, which gave accurate results. Manual palpation in left lateral decubitus flexed position offers greater accuracy due to gravity's effect on soft tissues like skin, fat, and muscles, which allows for better identification of bony landmarks like the iliac crests, compared to the sitting or prone position. Manual palpation of the iliac crests may be inaccurate to a certain degree, and this is the limitation in our present study.

Rahmani et al. [12] used magnetic resonance imaging to determine the vertebral level of the conus medullaris and the distance between the end of the conus medullaris and Tuffier's line was calculated. In individuals above 50 years, the conus medullaris was found to be positioned more caudad and a shorter distance was noticed between end of conus medullaris and Tuffier's line in women compared to men. However, this gender-based difference was not observed in individuals under 50, suggesting that the difference is age-related and only becomes apparent in older adults . The bone mineral density (BMD) of the spines decreases at a constant rate in all age groups after they pass the age of 20 in men contrast, to that of women whose spine BMD decreases at a four times faster rate than that of males, which was reported as a result of changes in female hormones after menopause [13]. However,

it is still controversial whether hormone therapy after menopause is truly effective or not.[14]. This study was conducted in elderly women, who were expected to have more obvious spinal degeneration than elderly men.

With increase in age, Tuffier's line is located at a higher vertebral level. In the current study this correlation existed only in the elderly group. In the control group, there was no correlation between age and the vertebral level of Tuffier's line. The vertebral level of Tuffier's line was found to be more cephalad in the elderly group compared to the control group, which can be attributed to the natural ageing process in elderly women. This process leads to decreased bone density, muscle mass, and ligament flexibility, as well as a reduction in spinal flexibility, resulting in decreased vertebral body height and intervertebral space. These changes likely contributed to the shift in the vertebral level of Tuffier's line observed in elderly female patients. A notable difference in height was observed between the two groups, which can be attributed to the natural ageing process. However, when the data was analyzed separately for each group, the results showed no significant differences in either group.

This study reveals that Tuffier's line is positioned at a higher vertebral level located more cephalad in elderly individuals, indicating that lumbar punctures may be performed at a higher level than anticipated in the lateral position. Consequently, when determining the vertebral level through palpation in older patients, there is a risk of unintended spread of the blockade to higher levels, potentially leading to complications like spinal cord injury. Therefore, extra caution and careful consideration are essential to minimize the risk of adverse effects.

In conclusion, by utilising ultrasound in the left lateral decubitus flexed position, we demonstrated that Tuffier's line was more cephalad in elderly women compared to the control group. We also found a significant correlation between this vertebral level and age, BMI, and weight in the elderly group. Therefore, while performing spinal Anaesthesia on elderly women, it is essential to be aware that the needle may need to be inserted at a higher level than anticipated, and exercise caution when determining the appropriate level of needle insertion to ensure safe and effective procedures.

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