

## Correlation between the spinal levels identified by palpation of the iliac crests and the posterior superior iliac spine and radiology in patients undergoing lower limb orthopaedic surgeries

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### Article Info

**Received:** 9<sup>th</sup> January, 2019

**Accepted:** 22<sup>nd</sup> April, 2019

**Published Online:** 22<sup>nd</sup> August, 2019

**Keywords:** Interspinous space, Palpation, Radiology, Intercristal line, Posterior superior iliac spine.

### Abstract

**Introduction:** The assessment of spinal levels by palpation using the superior aspect of iliac crest as a guide is a routine practice. Through this study we want to assess the accuracy of the determination of lumbar spinal spaces by palpation of iliac crest and posterior superior iliac spine using an X-ray image intensifier.

**Materials and Methods:** 132 Patients scheduled for lower limb orthopaedic surgery were included. The spinal level corresponding to the intercrystal line (ICL) and posterior superior iliac spine (PSIS) line was identified by palpation and marked with a radio-opaque marker in the sitting position. A radiology image was then taken in supine position to locate the position of the markers.

**Results:** The levels identified by palpation were in agreement with radiological levels in 51.5% of cases. In 39% cases the level identified was one space higher and in 9.5% cases it was two spaces higher. PSIS line identified the L5-S1 inter-spinous space in 34 (25.75%) patients, S1 and S2 spinous processes in 52 (39%) patients and 17 (12.8%) patients respectively.

**Conclusion:** In 49% of the cases there was an inaccurate identification of the spinal level by palpation of iliac crest in cephalad direction, more so in elderly patients and patients with higher BMIs. So in these cases a clinician should be doubtful of the palpated landmark to be corresponding to a higher level. PSIS line ranges from L4-L5 interspace to S2 spinous process and therefore cannot be a reliable guide for identification of a spinal level.

### Introduction

Identification of lumbar space by palpation of superior aspect of iliac crest as a guide is a standard practice. The line connecting the highest points of both iliac crests is known as the Tuffier's line or intercrystal line (ICL); it generally passes through the fourth lumbar vertebra or the inter-vertebral space between fourth and fifth vertebrae. Using this as a reference, spinal anesthesia is given at an inter-vertebral space between third and fourth lumbar vertebrae or fourth and fifth lumbar vertebrae; in order to avoid an injury to the spinal cord which usually ends at the second lumbar vertebra.<sup>1,2</sup>

Lower limb orthopaedic surgeries are usually performed under neuraxial blockade; spinal, epidural or a combined block. The blockade is performed with the patient either in sitting or in lateral position. The proper positioning of patients going for lower limb surgeries is sometimes difficult due to the associated pain.

The major concern with improper positioning is incorrect identification of the intervertebral space, as a result of which anesthesia may be given at a level higher to conus medullaris. Transient and permanent neurological damage

may occur as a result of direct trauma from the spinal or epidural needle to a low lying spinal cord or in case of an inadvertent high needle insertion.<sup>2,3</sup>

An accuracy varying from 30% to 70% has been demonstrated in previous studies among varied populations including elderly and pregnant patients. The reason for the wide variation in accuracy of lumbar space identification may be because of the variation in the built, height and BMI of the people of different ethnicity.<sup>4-12</sup>

The line joining the two-posterior superior iliac spines (PSIS line) is stated to cross the second sacral vertebra and has been used as a reference for giving subarachnoid block for Taylor approach and S2 trans-foraminal block.

### Objectives

We conducted this study to assess the accuracy of spinal level identification by palpation of the iliac crest, which we confirmed by fluoroscopy; in patients undergoing lower limb orthopaedic surgeries. We also assessed the effect of age, sex and body mass Index (BMI) on the accuracy of identification of the spinal level by Tuffier's line and spinal

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<http://doi.org/10.18231/ijca.2019.060>

levels corresponding to the line joining the two-posterior superior iliac spines.

## Materials and Methods

### Study Design

This was an observational single arm study conducted in a tertiary care health center in Eastern part of India from May to July 2018 (three months). The study was duly approved by institutional ethics committee (Regn. No. ECR/306/Inst/WB/2013) and was prospectively registered with clinical trial registry, India (Registration No-CTRI/2018/04/013448).

### Sample Size

Previous studies have shown that the accuracy of identification of correct lumbar space by palpation is seen in 30% of cases. Taking a confidence level of 95% and with an intention of absolute precision to be within 8% of the true value a sample size of 126 was calculated. 10% of the value i.e 13 was added to provide for attrition, making a total of 139.

### Participants

139 consecutive patients scheduled for lower limb surgeries in the orthopedic department of our institute were included in the study. The study subjects were of the age group 18 and above, of American society of Anaesthesiologists grade I, II and III. A written informed consent was obtained from all the study subjects prior to enrolling them in the study. Pregnant patients, patients with lumbar scoliosis, previous spinal surgery and non-consenting patients were excluded.

### Procedure

Patients were placed in sitting position on the operating table. ICL was marked after palpation of the iliac crest and the corresponding spinous process or the inter-spinous space was identified by the principal investigator, which was then marked with the radio-opaque marker (paediatric ECG lead) after giving the spinal or epidural anaesthesia. Simultaneously, a line joining the two-posterior superior iliac spines (PSIS line) was drawn and the corresponding level was marked with the radio-opaque marker. An antero-posterior radiology image was then taken with the c-arm after making the patient supine and the space where the radio-opaque markers were seen was identified. Similarly, the spinous levels where the second marker was located were recorded. Additional information about the subject's sex, body mass index, age and height were also recorded.

The primary aim of the study was to assess the accuracy of spinal level identification by palpation of the iliac crest, which we analogized by fluoroscopy. Secondary aim was to assess the effect of age, sex and BMI on the accuracy of identification of the spinal level by Tuffier's line and spinal levels corresponding to the line joining the two-posterior superior iliac spines.

The level identified by palpation was considered to be consistent or in agreement with the fluoroscopic level if both were same or the difference between the two levels was only half a segment. For example if the palpation identified L4-L5 and imaging showed L4 level, it was considered to be in agreement; similarly, if palpation

showed L5 spinous process and imaging showed L4-L5 space, it was also considered in agreement. If the difference between the two levels was of one or more segments then it was considered as in consistent or in disagreement.

### Statistical Analysis

The data were analyzed using SPSS 17 (IBM, New York). The demographic data of the study population were presented as means ( $\pm$  standard deviation).

Anthropometric and demographic data in group of patients with consistent and inconsistent results were compared using student t' test. Association between gender and level of agreement was analyzed using Chi square test.  $P < 0.05$  was considered as statistically significant. Data of patients with different PSIS line levels were expressed as percentage.

## Results

In the study period of three months duration, 139 adult patients were recruited for observation. Out of the enrolled 139, two were more than 80 years and an appropriate supine position could not be made, two did not give consent for procedure and three patients were excluded as the image quality was not clear, reducing the total number of subjects to 132.

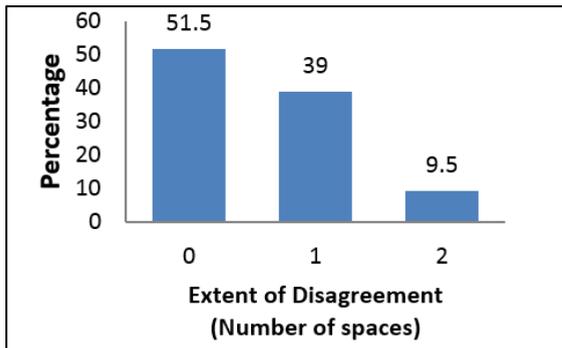
Of the 132 patients 84 (64%) were males and 48 (36%) were females, mean age of the study population was 55.71 ( $\pm 17.19$ ) years, mean height was 162.87( $\pm 6.08$ ) cm and mean BMI was 24.10 ( $\pm 3.13$ ) Kg/m<sup>2</sup> (Table 1).

The level of agreement was assessed between the level that was observed on palpation and the level which was observed on imaging (Table 2). In case of palpation it was found that the ICL corresponded to L3-L4 inter-spinous space in 18 (13.6%), L4 spinous process in 54 (41%), L4-L5 inter-spinous space in 59 (44.7%) and L5 in 1 (0.7%) individuals. The levels identified by palpation were in agreement with radiological levels in 51.5% of cases. In 39% cases the level identified was one space higher and in 9.5% cases it was two space higher (Fig.1). The palpated line did not identify a level lower than imaging at any occasion.

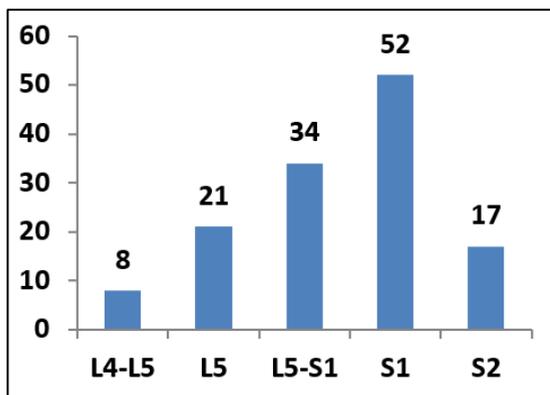
On comparing the demographic data in group of patients with consistent and inconsistent results, we found that the mean age of the group of patients with disagreement (62 $\pm$ 1.94 years) was significantly higher than the mean age of the group with agreement (49.81 $\pm$ 2.01 years) (Table 2). Among 132 participants, 58 patients were more than 60 years of age and were considered elderly. On further analysis, it was found that the level of disagreement was more in elderly group of patients but the difference between the consistent and inconsistent results was statistically non significant (Table 3). On the other hand in younger group of patients (age < 60 years) the level of agreement was significantly higher than the level of disagreement (Table 3). Although the level of disagreement was more in female population compared to males, but it was not statistically significant (Table 4). On comparing anthropometric profiles no difference was found in the height and weight in the groups with consistent and inconsistent results, but the

group of patients with inconsistent results had significantly higher BMI ( $24.7 \pm 0.42$ ) compared to the group of patients with consistent results ( $23.55 \pm 0.33$ ) (Table 2).

On palpation, the PSIS line identified the L5-S1 interspinous space in 34 (25.75%) patients, S1 spinous process in 52 (39%) patients and S2 spinous process in only 17 (12.8%) patients. The upper and lower levels were L4-L5 space and S2 spine respectively (Fig. 2).



**Fig. 1:** Disagreement of intervertebral space determination between the palpation and radiological methods in cephalad direction



**Fig. 2:** Spinous levels corresponding to the PSIS line

**Table 1:** Demographic profile of the study population

Total patients- 132	
Males- 84	
Females- 48	
Parameter	Mean ( $\pm$ SD)
Age (years)	55.71 ( $\pm$ 17.19)
Height (cm)	162.87 ( $\pm$ 6.08)
Body weight (kg)	63.76 ( $\pm$ 7.96)
BMI ( $\text{kg}/\text{m}^2$ )	24.10 ( $\pm$ 3.13)

**Table 2:** Comparison of anthropometric and demographic profiles in groups of patients with consistent vs inconsistent results. Student's t-test. (S- Significant, NS- Non-significant).

Parameter	Mean ( $\pm$ SD)		Statistical significance
	Agreement (n=68)	Disagreement (n=64)	
Age (years)	49.81 ( $\pm$ 2.01)	62 ( $\pm$ 1.94)	S, 0.0001
Height (cm)	162.9 ( $\pm$ 0.64)	161.1 ( $\pm$ 0.75)	NS, 0.072
Body weight (kg)	63.68 ( $\pm$ 0.86)	63.86 ( $\pm$ 1.10)	NS, 0.89
BMI ( $\text{kg}/\text{m}^2$ )	23.55 ( $\pm$ 0.33)	24.7 ( $\pm$ 0.42)	S, 0.03

### Discussion

The correct identification of the vertebral space before giving spinal anaesthesia is very crucial. As per traditional teaching; the inter-cristal line crosses the body of L4 vertebra or the L4-L5 inter-vertebral space. This is used as a reference while giving spinal anaesthesia. However, multiple studies have identified this landmark as unreliable and its usefulness has been questioned time and again.<sup>4-11</sup> The most dreaded complication is injecting a local anesthetic at a higher level which is more cephalad than the conus medullaris which can extend up to the L3 vertebral segment.<sup>12</sup> An inadvertent injection at a higher level can cause an injury to the spinal cord.<sup>2,3</sup>

Broadbent et al<sup>4</sup> demonstrated that anaesthesiologists could identify a particular lumbar inter-space correctly by palpation in only 29% of cases; they were one, two, three, or four spaces higher than the correct space (assessed by magnetic resonance imaging) in 51%, 15%, 2%, and 1% of cases, respectively. Margarido et al<sup>5</sup> after studying 45 pregnant women at term concluded that the inter-cristal line determined by palpation did not correspond to the Tuffier's line determined radiologically, they emphasized that it may intersect the spine at up to three interspaces higher especially in women with higher body mass indices.

There are some studies that have shown higher agreement levels. Duneic et al<sup>8</sup> found an agreement rate of 64% between clinical examination and ultrasonographic assessment of inter-vertebral space identification for lumbar puncture among 122 patients undergoing lower limb surgery. Another study conducted by Tanaka et al<sup>9</sup> in 835 pregnant patients in Japan demonstrated that the spinal level of puncture identified by anaesthesiologists by palpation were in agreement with the levels verified by X rays in 67% cases, which was measured as a 'fair' agreement. They have claimed the reason of their higher agreement levels compared to other studies is the comparatively lower body mass indices of the Japanese pregnant women.

**Table 3:** Comparison of agreement vs disagreement levels in elderly and younger patients. Chi square test (S- significant, NS- Non significant).

Age in years	Number of patients (n)	Agreement (n=68)	Disagreement (n=64)	Statistical significance
≥ 60	58	22	36	NS
< 60	74	46	28	S

**Table 4:** Comparison of agreement vs disagreement levels in both genders. Chi square test. (NS- Non significant)

Gender	Number of patients (n)	Agreement (n=68)	Disagreement (n=64)	Statistical significance
Female	48	20	28	NS
Male	84	48	36	NS

A study conducted by Parate et al<sup>10</sup> has demonstrated that the vertebral level located by palpation method was in agreement with ultrasound location in 37.14% (39 out of 105) of the patients. However, in a subgroup analysis of their study they have found that the rate of errors was found to be significantly higher among the trainees (74.51%) than the consultants (51.86%). In our study, we have found a level of agreement between the palpation and radiological assessment in 51.5% of cases which is comparable with the level of agreement which Parate et al encountered with the experienced anaesthesiologists. In the present study, the identification of the inter-vertebral space by palpation was done by the principal investigator having fourteen years of experience. Whitley et al<sup>7</sup> experienced the correct identification of the vertebral level by palpation in 55% of cases. They had analyzed the palpated level using ultrasound and found it to be one space higher than estimated, in 39% of cases.

We have palpated the vertebral levels with the patient sitting slightly bent forward (i.e flexion at hip and neck), a position which is routinely used in clinical practice to give spinal anaesthesia. The radiology was done in supine position with a straight back. To eliminate the bias of the displacement of the marker we have considered the levels to be consistent if the difference between the palpated and the radiological level was only half a segment; for example, if the palpated level is L4-L5 segment and the radiological level is L4 vertebral body- we have taken it as consistent.

The identification of the spinal level by palpation in erect position and then locating the level in supine position by imaging can lead to the displacement of the marker and will have a confounding effect, which can be the reason of high levels of disagreement in some of the studies using MRI, X-ray and fluoroscopy for imaging. This bias is claimed to be eliminated with the use of ultrasound, which is done in the same erect and flexed position. Therefore, we can observe a higher level of agreement in studies where ultra-sonographic imaging is used to confirm the vertebral levels.<sup>7</sup> Cooperstein and Truong have emphasized that if we reinterpret the accuracy achieved in the studies where imaging is done in supine position, after adjusting the bias of the displacement of markers, the accuracy would be higher than has been previously reported<sup>11</sup>.

In the present study it was observed that the age of the patients was higher in the group of patients with inconsistent result. Increased age can be a factor for a higher level identification by palpation of ICL. The reason can be attributed to the presence of degenerative and other age-related changes leading to height loss of the vertebral column as well as age-related alteration of the distribution of body fat.<sup>14,15</sup>

High BMI or obesity is one of the factors which tend to diminish the accuracy in palpating ICL and raised the spinal level.<sup>4,13</sup> In this study it was revealed that the weight and height had no impact on the accuracy of location of vertebral level by palpation. However, the group of patients with inconsistent results had a higher mean value of BMI. Although, the difference in the BMI levels of the group of patients with inconsistent and consistent results was not so pronounced clinically, but it was statistically significant. Presence of subcutaneous fat tissue between the fingertips of the palpating hand and iliac crest can be the reason of high localization of ICL and hence a more cephalad spinal level identification. It is a known fact that for an equivalent body mass index, women have significantly greater amounts of total body fat than men; therefore, they may have proportionately higher levels identification on palpation. In our study, we found that the level of disagreement was more in female population but it was statistically insignificant.

Though the spinal levels corresponding to PSIS show a wide range, it is documented that the PSIS corresponds to the S2 spinous process in 81% of the cases.<sup>16,17</sup> We observed that the PSIS line corresponded to the S1 in 52 (39%) cases, L5-S1 in 34 (25.75%) of cases, and L5 in 22 (16%) cases. The upper and lower levels identified were L4-L5 space and S2 spinous process. These findings are different from the findings of Chakraverty et al, PSIS line corresponded to S2 in 51% cases and S1 in 41% cases in their study.<sup>13</sup> One limitation in the methodology of the present study is that we assumed that while changing the position of the patient from flexed sitting to supine some amount of dislocation of the marker could be possible, but an exact measurement of the dislocation was not recorded. To avoid the error, we considered the difference of half a segment in the position as agreement.

## Conclusion

The present study has shown that there is a frequent inaccurate identification of the correct spinal level by palpation of iliac crest in the cephalad direction, which is more in patients with higher BMIs and in elderly patients. In such cases, the clinician should be aware of the possible identification of a higher landmark corresponding to L3 vertebra or L3-L4 inter-vertebral space and an attempt should be made to locate the L4-L5 inter-vertebral space by using the 12<sup>th</sup> rib as a landmark as well, in order to avoid the incorrect identification. In addition, the PSIS line frequently identifies the S1 spinous process or L5-S1 space, but ranges from L4-L5 interspace to S2 spinous process; it is therefore an unreliable guide for identification of the correct spinal level.

## Acknowledgement

We thank Dr. Nishat Hussain Ahmed and Dr. Tabish Hussain for their contribution in analysis and interpretation of the data and revising the article critically for important intellectual content.

**Conflicts of Interest:** There are no conflicts of interest.

**Funding and Financial support:** Nil.

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**How to cite this article:** Naz A, Sanyal R, Chakraborty N, Alima, S Raha A. Correlation between the spinal levels identified by palpation of the iliac crests and the posterior superior iliac spine and radiology in patients undergoing lower limb orthopaedic surgeries. *Indian J Clin Anaesth* 2019;6(3):312-6.