



# Intercristal line determined by palpation in parturients in the sitting and the lateral decubitus positions: a prospective observational study

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Received: 15 November 2021 / Accepted: 26 January 2022  
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## Abstract

**Purpose** We aimed to investigate intersected vertebral level changes in the palpated intercrystal line (PI-line) when shifting from a sitting to a lateral decubitus position in parturients.

**Methods** We consecutively enrolled parturients with a gestational age of  $\geq 36$  weeks. The attending anesthesiologists palpated the superior aspects of the posterior iliac crests bilaterally in a sitting position and then in a lateral decubitus position. The blinded investigators performed the ultrasound and recorded the intersected segment level of the PI-line. The distance between any two consecutive vertebral interspaces was divided into 3 segments, and comparisons were made with 15 segments of five vertebral interspaces above the sacrum. The primary outcome was the concordance rate of intersected segment level of the PI-line between the two positions. We also examined the intersected segment level of the PI-line of the two positions and the magnitude of these changes.

**Results** Thirty-nine parturients were analyzed. The concordance rate of intersected segment levels of the PI-line between the two positions was 21% (8/39). In 56% (22/39) of the parturients, the intersected segment level of the PI-line in the sitting position was more cephalad and 23% (9/39) were more caudal. Fifteen percent (6/39) of parturients had three or more segment differences between the two positions.

**Conclusions** The intersected segment level of the PI-line, measured with trisected segments in each vertebral interspace, was different between the sitting and the lateral decubitus positions in approximately 80% of the parturients. Notably, 15% (6/39) of the parturients had at least one vertebral interspace deviation.

**Keywords** Tuffier's line · Jacoby's line · Neuraxial anesthesia · Cesarean section · Lateral decubitus position

## Introduction

The intercrystal line connecting the superior aspect of the posterior iliac crests, known as Tuffier's line or Jacoby's line, is an anatomical landmark for estimating vertebral levels during neuraxial anesthesia. The intercrystal line is known to most frequently cross the L4 spinous process or the L4–L5 interspace [1, 2]. Although ultrasound has been increasingly used to facilitate neuraxial anesthesia [3–5], palpation of anatomical landmarks is still common in clinical obstetric situations [6].

Several investigators have demonstrated the vertebral levels at which the intercrystal line determined by palpation (palpated intercrystal line: PI-line) intersected in a sitting position [7, 8] and in a lateral decubitus position [9]. However, the relationship between the PI-line and vertebral level due to positional change has not yet been addressed. In cases where the procedure is difficult or the fetal status is non-reassuring, a positional change of the parturient is required during neuraxial anesthesia. The PI-line may change with positional changes. Thus, misidentification of the vertebral level due to PI-line fluctuations can lead to needle trauma to the spinal cord. Therefore, examining how the PI-line changes when shifting from a sitting to a lateral decubitus position in parturients is important.

We hypothesized that the intersected vertebral level of the PI-line would be different between the sitting and the lateral decubitus positions in parturients. This study aimed to investigate the concordance rate between the intersected

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vertebral level of the PI-line in sitting and lateral decubitus positions. We also examined the vertebral level of the PI-line in the two positions and the magnitude of these changes.

## Materials and methods

This was a single-center prospective observational study approved by the Nagoya City University Graduate School of Medical Sciences and Nagoya City University Hospital Institutional Review Board and registered in the UMIN-Clinical Trial Registry (UMIN000039490). All parturients provided written informed consent before the study entry.

### Patients

We consecutively enrolled parturients with a gestational age of  $\geq 36$  weeks who were hospitalized for elective cesarean delivery or induction of labor epidural analgesia at our tertiary perinatal center from May 1 to August 17, 2020. We excluded women with known scoliosis, previous spinal surgery, who were unable to cooperate with positioning, or were undergoing emergency situations. In cases where the fetal status was non-reassuring, we discontinued the study and excluded the parturient from the analysis.

### Study design and outcome assessment

We obtained parturients' variables including age, gestational age, height, weight, body mass index (BMI), and nulliparous or multiparous from their electronic medical records. Parturients were positioned sitting on one side of a bed with the neck, back, and hips flexed to achieve the optimal posture for lumbar puncture. Attending anesthesiologists with more than 5 years of anesthesia experience palpated the superior aspects of the bilateral posterior iliac crests and marked them with an erasable marker. The markings were covered with the subject's gown by the attending anesthesiologist. Then, the investigator, who was blinded to these markings, performed spinal ultrasound to evaluate the lumbar interspaces. Ultrasound assessment was performed by two senior anesthesiologists with experience in over 50 ultrasound-assisted neuraxial procedures. A portable ultrasound system

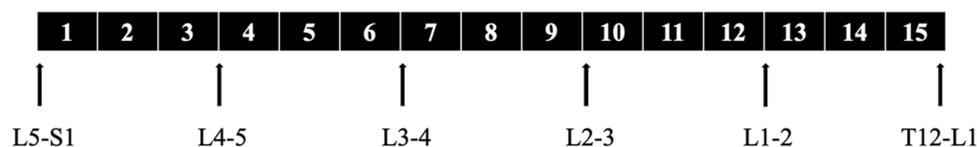
(SonoSite S-Nerve™, FUJI FILM, Tokyo, Japan), fitted with a 2–5 MHz curved linear probe, was used. The lumbar interspace between the sacrum and L5 was initially identified by the paramedian sagittal oblique approach [10]. The probe was then moved toward the cephalad while counting the lumbar interspaces. In each intervertebral space, we marked the optimal needle insertion points for lumbar punctures by the transverse median approach [7]. The distance between any two consecutive interspaces (the optimal needle insertion points) were divided into three equal segments. Starting from the L5–S1 interspace and counting toward cephalad to the T12–L1 interspace, 15 segments were marked and numbered sequentially from 1 (most caudal) to 15 (most cephalad) [7] (Fig. 1). After marking the segments, we removed the subject's gown and connected the iliac crests' markings with a measuring tape, which was defined as the PI-line. Then, we recorded which segment the PI-line intersected. These methods were the same as those used in a previous study [7]. After erasing all the markings, parturients were placed in the right lateral decubitus position with the neck, back, and hips flexed to achieve optimal posture for lumbar puncture. We performed markings and evaluation in the same way as it was done in the sitting position.

### Outcomes

The primary outcome was the concordance rate of the intersected segment level of the PI-line between the sitting and the lateral decubitus positions. We also examined the intersected segment level of the PI-line in the two positions and the magnitude of these changes.

### Statistical analysis

Descriptive statistics of parturients' variables were calculated using median and interquartile range for continuous variables and percentage for nominal variables. We have depicted a scatter diagram between the sitting and the lateral decubitus positions to illustrate these differences. The intersected segment level of the PI-line is depicted in a frequency histogram. The median [interquartile range] difference of the intersected segments between the sitting and the lateral



**Fig. 1** Pattern diagram of the fifteen segments. L5–S1; the L5–S1 vertebral interspace, L4–5; the L4–L5 vertebral interspace, L3–4; the L3–L4 vertebral interspace, L2–3; the L2–L3 vertebral interspace,

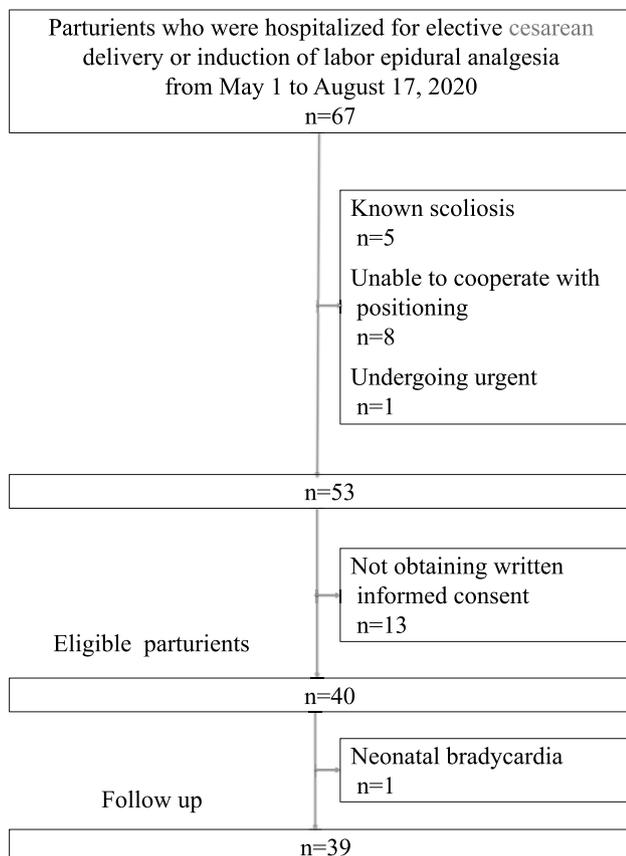
L1–2; the L1–L2 vertebral interspace, T12–L1; the T12–L1 vertebral interspace. These notations are only applicable when there are no spinal abnormalities

decubitus positions were calculated and compared using the Wilcoxon signed-rank test.

In a sample size calculation, 36 subjects were needed if the concordance rate was 30% and the confidence interval was  $\pm 15\%$  based on our preliminary experiment. To account for a 10% loss due to potential withdrawals and technical failures, we increased the target sample size to 40 subjects. *P* values of  $<0.05$  were considered to indicate statistical significance. All statistical analyses were carried out using the R software program (version 3.5.0, R Foundation for Statistical Computing, Vienna, Austria).

## Results

Among 67 parturients enrolled, 14 were excluded and 13 did not have written informed consent obtained. One was discontinued because of neonatal bradycardia. In total, 39 parturients completed and were finally analyzed in the study (Fig. 2). The parturients' characteristics are shown in Table 1.



**Fig. 2** Study flow diagram. The values indicate the number of all enrollments during the study period

**Table 1** Descriptive statistics of parturients' characteristics

Variable	<i>n</i> = 39
Age (years)	33 [29–38.5]
Gestational age (weeks)	38 [37–39]
Height (cm)	159 [156–162]
Weight (kg)	60 [55–64.5]
BMI (kg/m <sup>2</sup> )	23.3 [22.6–25.5]
Nulliparous (%)	25 (64)

Data are described as median [interquartile range] or number (%)

*BMI* body mass index

The concordance rate of the intersected segment of the PI-line between the sitting and the lateral decubitus positions was 21% (8/39). Figure 3 shows the scatter diagram of the intersected segment between the sitting and the lateral decubitus positions. Fifty-six percent (22/39) of the parturients had the intersected segment level of the PI-line that was more cephalad in the sitting position than in the lateral decubitus position, with ten (26%) having one segment, seven (18%) having two segments, and five (13%) having three or more segments discrepancy. Twenty-three percent (9/39) of parturients had the intersected segment level of the PI-line that was more caudal in the sitting position, with seven (18%) having one segment, one (3%) having two segments, and one (3%) having three or more segments discrepancy. In total, 15% (6/39) of the parturients had a difference of three or more segments between the two positions.

Figure 4 shows frequency histograms of intersected segment level of the PI-line in the sitting and the lateral decubitus positions. The median (interquartile range) segment level of the PI-line was more cephalad in the sitting position compared to the lateral decubitus positions [6 (4.5–8) vs. 5 (4–6), *P* = 0.008]. The detailed parturients' variables and results are listed in Supplemental Table S1.

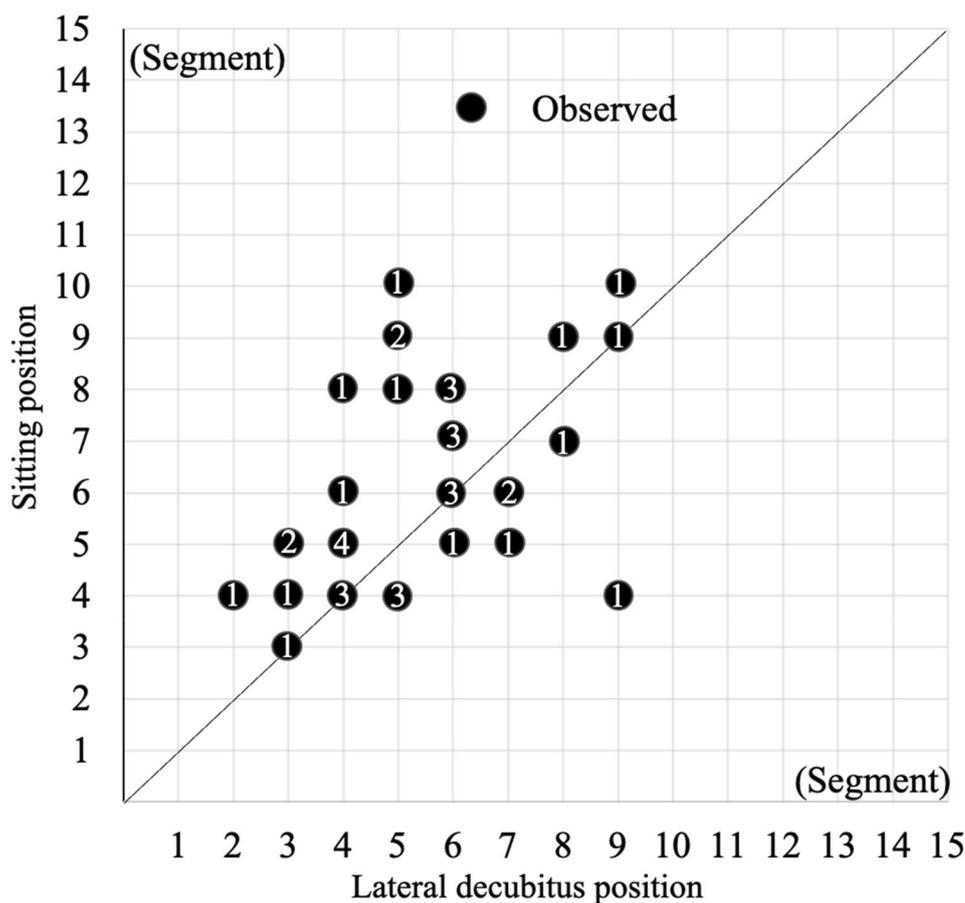
## Discussion

In this study, we performed a spinal ultrasound and investigated the intersected segment level of the PI-line, measured with trisected segments in each vertebral interspace, in both the sitting and the lateral decubitus positions in parturients with a gestational age of  $\geq 36$  weeks.

We found that the intersected segment levels of the PI-line were different between the sitting and the lateral decubitus positions in approximately 80% of the parturients. To the best of our knowledge, there are no studies on the relationship between the PI-line and vertebral level due to positional changes. Our results showing a high discordance rate between the two positions could be attributed to the classification into 15 segments [7]. Nevertheless, it is noteworthy

**Fig. 3** Scatter diagram of the intersected segment between the sitting and the lateral decubitus position. The numbers in the black circles represent the number of observations

### lateral decubitus position



that 15% (6/39) of the parturients had a difference of three or more segments, indicating at least one vertebral interspace deviation. Therefore, if the position of the parturient is changed during neuraxial anesthesia, the appropriate needle puncture point should be reconfirmed in consideration of a possible shift in the vertebral level of the PI-line.

We found that 56% of the parturients' intersected segment level of the PI-line were more cephalad in the sitting position than in the lateral decubitus position. In particular, 13% (5/39) of the parturients had three or more cephalad segments level discrepancy in the sitting position. One possible explanation for our result could be that the parturients flexed to different degrees in the sitting and the lateral decubitus position. A previous non-obstetric radiological study demonstrated that the influence of lumbar flexion on the intercrystal line level should be considered when the puncture site is determined with the palpation of the iliac crest [11]. Our finding is an issue of great concern for parturients' safety because neuraxial anesthesia should be performed below the level of the conus medullaris to minimize the risk of spinal cord trauma. Indeed, an incorrect PI-line can cause major morbidity during lumbar puncture [12, 13]. Thus, correct

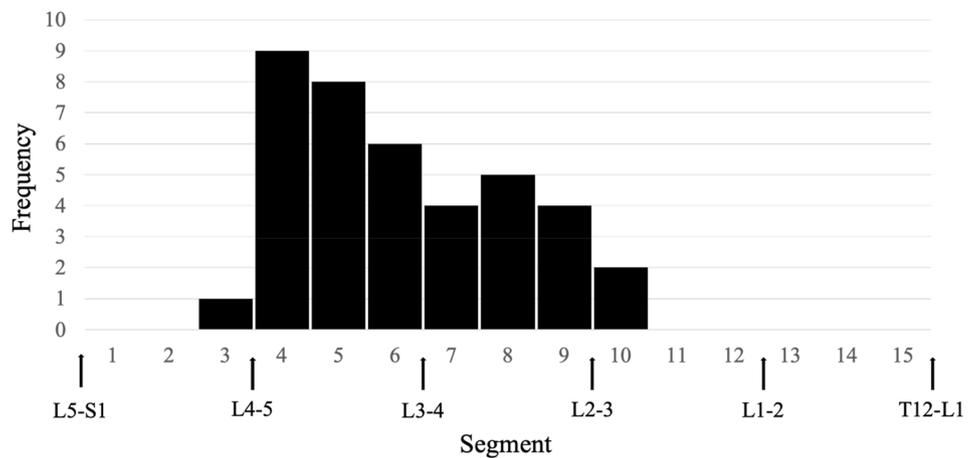
identification of vertebral levels would be essential to avoid needle trauma to the spinal cord during neuraxial anesthesia, especially in the sitting position where PI-line tends to be more cephalad.

Our findings that the intersected segment level of the PI-line could be inaccurate and shifted with parturients' position changes reinforce the concept that preprocedural spinal ultrasound is effective. Spinal ultrasound has become widely available in the clinical setting, and may be advantageous in determining the exact level of the puncture. A recent review has recommended preprocedural ultrasound as a standard of care in obstetrics, given its potential effectiveness in preventing complications without significant prolongation of the total time required [14].

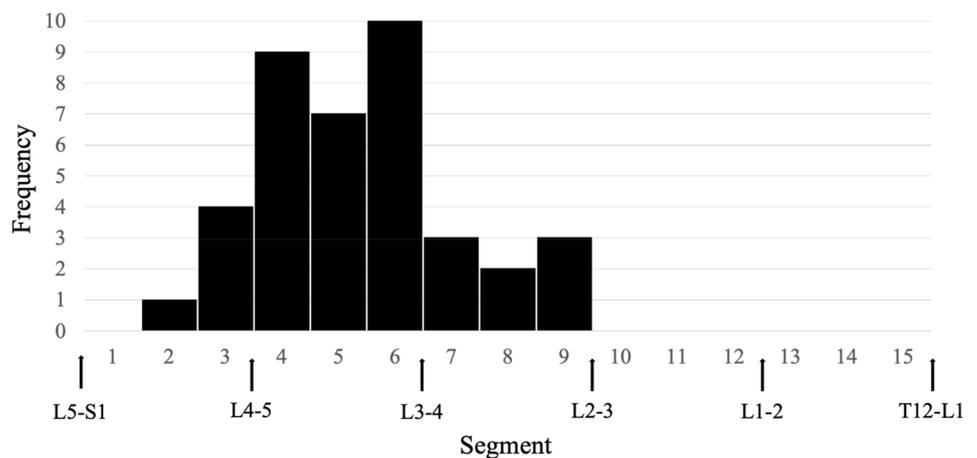
The strength of our study was that it was the first to research the relationship between the PI-line and vertebral level due to positional changes. Our findings would therefore be helpful when changing the parturients' position during neuraxial anesthesia. In addition, the preprocedural spinal ultrasound in our study was performed by the two senior anesthesiologists with experience in more than 50 cases of ultrasound-assisted neuraxial procedures. A previous

**Fig. 4** Frequency of spinal segments intersected by the palpated intercrystal line. **A** The sitting position and **B** the lateral decubitus position. L5–S1; the L5– vertebral interspace, L1–2; the L1–L2 vertebral interspace, T12–L1; the T12–L1 vertebral interspace. These notations are only applicable when there are no spinal abnormalities

### (A) Sitting position



### (B) Lateral decubitus position



study revealed that between 22 and 36 scans were needed to acquire reliable expertise to determine the correct level of the lumbar spinous process [15]. Our study should therefore have minimal concerns regarding procedure skills.

We acknowledge that our study has some more limitations. First, it was a single-center, observational study with a relatively small sample size. There was enough power to find a PI-line concordance rate of 20% in the two positions, but not enough for the other estimations. Second, although we consecutively enrolled parturients, a considerable number of them were excluded from the analysis, which may have led to selection bias. Third, the anesthesiologists who palpated the superior aspects of the bilateral posterior iliac crests had more than five years of anesthesia experience, which could lead to performance bias. Finally, the use of the sacrum as a reference point, which was the same method as that used in the previous studies [7, 10], might be arguable due to the anatomical variation at the

lumbosacral junction. Reportedly, 6% of the population has either sacralization of the lumbar vertebra or lumbarization of the sacrum [1]. This could have affected the accuracy of vertebral level determination. However, plain X-ray (the Guthmann method) performed before delivery confirmed that no abnormal findings, such as compression fracture or vertebral deformity, were observed in any of the parturients. Nevertheless, spinal abnormalities could not be completely excluded.

In summary, the intersected segment level of the PI-line, measured with trisected segments in each vertebral interspace, was different between the sitting and the lateral decubitus positions in approximately 80% of the parturients. Notably, 15% (6/39) of the parturients had at least one vertebral interspace deviation. This information should be taken into consideration while performing a neuraxial procedure, especially when changing positions.

**Acknowledgements** Not applicable.

## Declarations

**Conflict of interest** Yuji Kamimura, Azusa Nagai, Toshiyuki Nakaniishi, Tatsuya Tsuji, Motoshi Tanaka and Kazuya Sobue declare no conflict of interest.

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