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Research Article

Reliability and Accuracy of Three Anatomical Landmarks for Spinal Level Estimations

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Abstract

Background: Three anatomical landmarks are used to identify a suitable vertebral level for spinal anesthesia: a) Tuffier's line (TL), b) tenth rib line (TRL) and c) posterior superior iliac spine (PSIS). We aim to determine reliability and accuracy of these landmarks compared to radiologic landmark.

Methods: Sixty patients undergoing lumbar microdiscectomy surgery under spinal anesthesia are included. The patients are placed in lateral position. Three anesthetists identified the L3-L4 interspinous space with each of the 3 landmarks and marked them with a marker only visible under ultraviolet light in 3 different forms (point, cross, star). The same vertebral interspace is verified by radiologic control, marked with a visible skin marker and compared to each of the 3 landmarks. The correct level is noted 0, the levels below or above 1 or 2 spaces are noted -1, -2, +1 or +2 respectively. χ^2-test and Fischer's exact test are used.

Results: The true level is noted in 48.33%, 53.33% and 65% of cases when using TL, TRL and PSIS respectively. The comparison of these 3 methods together shows no differences (p=0.17). The comparison by pairs shows no differences (TL vs TRL, p=0,58; TRL vs PSIS, p=0,19; TL vs PSIS, p=0,065), while comparing each of these 3 methods to radiologic landmark shows a statistically significant difference (p<0.001).

Conclusions: Our findings suggest that these palpatory techniques are not reliable compared to radiologic landmark and the differences between them were not statistically insignificant, albeit PSIS evidenced a trend (p = 0.065) toward superiority to TL.

Keywords: Anatomical landmarks; Spinal level; Tuffier's line; Tenth rib line; Posterior superior iliac spine.

Introduction

The accurate identification of spinal level is a prerequisite for the success and safety of spinal procedures (epidural block, spinal and epidural anesthesia, cerebrospinal fluid tapping, manipulative and physiologic therapeutics) [1]. Errors in identifying or numerating lumbopelvic spinal levels pose greater problems for anesthetists and other health care professionals. The detection of spinal levels by x-ray examination is more accurate than the palpation of surface anatomical landmarks, but it is difficult to order radiologic examinations on a routine basis during procedures, and thus, there is a need for an accurate, reliable and easy clinical method for identifying spinal level [2,3].

There are 3 methods of palpation used by anesthetists to identify a suitable vertebral level for epidural and spinal anesthesia: a) the Tuffier's line (TL) defined by drawing a horizontal line across the highest points of the iliac crests, is now the most widely used anatomical landmark and has been proven to correlate with the L4-L5 interspace or L4 spinous process [1,4]; b) the tenth rib line (TRL) which joins the 2 lowest points of the rib cage on the flanks, this line cross the intervertebral space corresponding to L1-L2 level or L2 spinous process [5]; and c) the Posterior Superior Iliac Spine (PSIS) is known to correlate with the S1-S2 interspace or S2 spinous process, often used by surgeons to estimate the spinal level [1]. The validity of these landmarks in the correct determination of lumbar interspaces was shown to be inaccurate, and the greatest risk is puncture of the conus medullaris which on average extends to the lower portion of L1 but may reach the upper portion of L3 [1,4-7].

The aim of this study is to determine reliability and accuracy of these 3 anatomical landmarks compared to radiologic landmark.

Materials and methods

Ethical approval for this study (Ethical Committee N° CEHDF 589) was provided by the Ethical Committee of Hotel-Dieu de France Hospital affiliated to the Medical Faculty of Saint-Joseph University of Beirut. Informed consent was obtained from each patient enrolled in the study. Sixty consecutive patients (pts) aged ≥18 years, with normal body build undergoing lumbar microdiscectomy under spinal anesthesia were included in this prospective study. Exclusion criteria included: age less than 18 years, obvious spinal deformity, severe spinal pain, history of lumbar surgery, inflexibility of hips, vertebral anomalies such as sacralisation, lumbarisation or spina bifida occulta, contraindications to spinal anesthesia, known allergy to local anesthetics, pregnancy and morbid obesity (BMI >40 kg/m^2). Age, sex, weight, height, body mass index (BMI), ASA physical status and score of palpatory difficulty were recorded.

All patients were not fed orally for at least 8 hours before the surgery and received hydroxyzine 1 mg/kg orally 45-60 minutes before anesthesia. They were given approximatively 8 mL/kg Ringer Lactate in 20 minutes. After getting into the operating room 3-leads electrocardiography, non-invasive blood-pressure and transcutaneous oxygen saturation were measured continuously and recorded.

The patients were placed in the lateral position (on the non-painful side) with flexed knees and hips. The lumbar spine was examined by the same first anesthetist and scored for difficulty in feeling lumbar spinal and iliac crest anatomy (grade 1 = easy to grade 4 = very difficult) [8]. This anesthetist identified the estimated level with the TL landmark using a marker (point model). The second and third same anesthetists, blinded to the interspace documented by other anesthetists, identified the estimated level with the TRL and PSIS landmarks using the same marker (cross and star models respectively). The L3-L4 interspace was selected for this study. We note that all the markers are only visible under ultraviolet light and all anesthetists are attending physicians with a minimum 5 years of experience. As the three anesthetists involved in the study were the same, so the risk of interexaminer error was avoided.

The neurosurgeon and the radiology technician, blinded to the interspace estimated by each of the 3 anesthetists, performed the x-ray, identified the L3-L4 interspinous space and marked it with a visible skin marker.

The primary outcome was the level of agreement between the lumbar interspinous space identified by x-ray and thus estimated by palpation using each of the 3 anatomical landmarks (TL, TRL and PSIS).

The vertebral level punctured was verified by radiologic control and compared to each of the 3 anatomical landmarks. The correct level was noted 0, the levels below or above 1 or 2 spaces were noted -1, -2, +1 or +2 respectively.

Sample size estimation was calculated around the assumptions that radiography determination of the correct level was 80% accurate and that clinical palpation was 50% accurate with type I and type II errors 5% and 10% respectively. The sample estimation required 51 patients. Statistical evaluation for the variability of the anatomical landmarks was performed by the Wilcoxon signed rank test and statistical analysis used Chi-Squared and Fischer's exact test as required. All statistical procedures were performed using SPSS statistical software, version 17.0 for windows® (Chicago, IL, USA). Results throughout the text and tables were presented as mean value ± SD or proportions (%) unless otherwise indicated, and statistical significance was designed as $p < 0.05$.

Results

Patients' characteristics are given in table 1. The estimated spinal levels marked by each of the 3 anatomical landmarks (TL, TRL and PSIS) and compared to the radiologic landmark are shown in table 2. For the 60 patients studied, the correct level was noted in 48.4%, 53.4% and 65% of cases when using the anatomical landmarks TL, TRL and PSIS respectively. Considering all 3 methods, a correct level was determined only in 55.5% of the cases. Level misses were converted into continuous data to calculate the mean error and standard deviation for each method as shown in table II. Based on the discrepancies between measurements using the 3 landmarks, our study showed that the PSIS method had the highest percentage accuracy (65%), but the tenth rib method had the smallest mean error (0.17) with the highest variability (SD 0.74). Table 3 showed the 3 methods compared together, and then with the radiologic landmark: There were no significant differences among the 3 methods, while the differences were statistically significant for all 3 compared to radiology ($p < 0.001$).

Table 1: Demographic data.

Number of patients	60
Age (years)	49.62 ± 14.42
Gender (M/F)	37 / 23
Weight (kg)	77.57 ± 13.82
Height (cm)	175.2 ± 3.7
BMI (kg/m^2)	26.6 ± 5.24
ASA (I / II / III / IV)	41 / 17 / 2 / 0

Data presented as mean (range or SD) or absolute numbers.

Table 2: Estimated spinal levels compared to radiologic landmark.

Estimated spinal level	TL (%)	TRL (%)	PSIS (%)	Total (%)
Correct Level	29 (48.4%)	32 (53.4%)	39 (65%)	100 (55.5%)
Incorrect Level	31 (51.6%)	28 (46.6%)	21 (35%)	80 (45.5%)
-1	29 (48.4%)	16 (26.6%)	20 (33.4%)	65 (36.1%)
+1	1 (1.6%)	10 (16.6%)	1 (1.6%)	12 (6.7%)
-2	1 (1.6%)	2 (3.4%)	0	3 (1.7%)
Mean Error	-0.5	-0.17	-0.32	
Standard Deviation	0.57	0.74	0.5	

TL: Tuffier's line, TRL: tenth rib line; PSIS: posterior superior iliac spine; Correct level: 0; one level below: +1; two levels below: +2, one level above: -1; two levels above: -2.

Table 3: Comparison of the 3 anatomical landmarks and testing against radiology.

	TRL	PSIS	RADIOLOGY
	Chi-Squared (p-value)	Chi-Squared (p-value)	Chi-Squared (p-value)
TL	0.3	3.39	41.8
	-0.58	-0.065	(<0.001)
TRL		1.69	36.5
		-0.19	(<0.001)
PSIS			25.45
			(<0.001)

TL: Tuffier's line; TRL: tenth rib line; PSIS: posterior superior iliac spine.

Discussion

Neuraxial anesthesia is not without risk. Transient and permanent neurological deficits may occur as a result of direct trauma from a spinal or epidural needle to a low-lying spinal cord, or as a result of an inadvertent high needle placement [9,10]. In a normal distribution, the mean position of the conus medullaris has been traditionally considered to be at the level of L1-L2 [11]. Several series described the spinal cord extending to the body of L3 in 1-3% of cases, and to L2 or lower in almost 50% of cases, with increased variability in women [11]. The results of this study do not show that differences in the determination of intervertebral spaces raise the risk related to spinal anesthesia. None of our patients with different anatomical and radiologic findings have complications.

Tuffier's line has been the most popular landmark for rapid and easy identification of the lumbar intervertebral level during spinal block. Bony segmental levels at which TL crosses the vertebral column are distributed in a normal fashion [12-14]. However, palpating the upper iliac crests and drawing a line to join them seems to be an unreliable guide in determining the intervertebral space, with a tendency to be one or two spaces higher than assumed [15]. Normally, TL is assumed to be close to the forth lumbar spine, but it may cross higher or lower [12].

Other approaches appear to be less practicable. Thavasothy [16] recommends a method of identifying the vertebra that is attached to the twelfth rib and counting down from this vertebra, but this is also likely to prove difficult, particularly in the obese [2]. However, the TRL can be performed as easily as TL at the bedside and seems to be easily identifiable on the flanks. Because the clinical use of TL requires palpation through a variable amount of subcutaneous fat, high placement is especially likely in the obese [17] or in term parturient with edema [4,17]. Palpation of the lowest points of the rib cage will have the same tendency but, in the opposite, caudal direction [5].

Kim and colleagues [1] showed that PSIS palpation had statistically higher interexaminer reliability than iliac crest level so clinicians should be cautious when applying this method as a measurement tool because estimated spinal level by palpation can be influenced inadvertently by examiner skill and anatomical variations. Counting down from the spinous process of C7 could be an alternative technique, but may be tedious and difficult, especially in obese patients, and may introduce an additional source of error [2,16]. The vertebral level of TL in this study closely matches those of other previous reports [12-14] suggesting that this study was performed accurately.

In our study, the vertebral level identified by radiography, agreed with the anesthesiologists recorded by the 3 palpatory landmarks (TL, TRL and PSIS) in 48.33%, 53.33% and 65% of the cases respectively. If there was disagreement, the radiologic level was usually higher than the level described by palpation. Our findings agree with other studies [2,6] which have found that clinicians select interspaces that are one or two spaces higher than they intended selected space.

As suspected by many clinicians, precise lumbar interspace identification by palpation is prone to error. Broadbent and colleagues [2] confirmed this, showing that anaesthetists were 29% accurate, as determined by MRI. Furness and colleagues [18] showed that clinical identification by anaesthetists using palpation was 30% accurate, as determined by lumbar spine ultrasound. In contrast, in a latter study, correct placement of markers using ultrasonography at the L3-4 interspace was 76% [11]. The difference between these 2 studies is that ultrasonography was performed by a consultant radiologist. Both studies showed that clinical identification by anesthetists was often inaccurate by 2, 3 or 4 interspaces. Using ultrasound markers were always within one interspace of the intended position. In our study, clinical identification of the vertebral level was performed by the same anesthetist for each of the anatomical landmarks avoiding any influence of each examination on the others.

Limitations of this study include the fact:

1) The majority of the patients in our study had lumbar spine symptoms, so discomfort or difficulty with flexion might be expected. In the clinical situations, many patients receiving spinal anesthesia are either pregnant or elderly, so flexion may be difficult.

2) The level of the intercrestal line may frequently vary depending on the degree of lumbar flexion and the presence of sacralization. This variation is limited to only one level [19].

Conclusion

This prospective study suggests that the three anatomical landmarks used still prone to substantial inaccuracies in terms of defining exact spinal level. PSIS landmark seems to be more accurate than TRL and TL. The tendency is to underestimate the levels and sting spaces higher than expected. Hence, when these anatomical landmarks are taken as surface markers to identify specific spinal levels, practitioners should be conscious of the limitations of these methods. Since anatomical landmarks are not very accurate, the use of ultrasound or radioscopy to locate the true intervertebral space is strongly advised in selected situations.

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