Observational Study

Medicine®

OPEN

Ultrasound assessment of the anatomic landmarks for spinal anesthesia in elderly patients with hip fracture

A prospective observational study

Hyerim Kim, MD[a], Dongwook Won, MD[a], Jee-Eun Chang, MD[a], Jung-Man Lee, MD, PhD[a], Jung-Hee Ryu, MD, PhD[b,c], Seong-Won Min, MD, PhD[a,c], Kwanghoon Jun, MD[d], Hyung Sang Row, MD[d], Jin-Young Hwang, MD, PhD[a,c,*]

Abstract

Tuffier line is a common landmark for spinal anesthesia. The 10th rib line has been suggested as a new landmark to predict the intervertebral levels. We evaluated the accuracy of these 2 anatomic landmarks for identifying the L4-L5 intervertebral space using ultrasonography in elderly patients with hip fracture.

Seventy-nine elderly patients scheduled for hip fracture surgery under spinal anesthesia were included. In the lateral decubitus position with the fracture side up, the L4-L5 intervertebral space was identified alternately using Tuffier line, a line drawn between the highest points of both iliac crests, and the 10th rib line. The 10th rib line, an imaginary line that joints the 2 lowest points of the rib cage, passes through the L1-L2 intervertebral space or the body of L2. The L4-L5 intervertebral space was determined by the counting-down method from the 10th rib line. Then, the estimated intervertebral spaces were evaluated using ultrasonography.

The L4-L5 intervertebral space was correctly identified in 47 (59%) patients with Tuffier line and 45 (57%) patients with the 10th rib line ($P = .87$). The estimation ratio related to the intervertebral levels was not different between the 2 landmarks ($P = .40$). The wrong identifications of intervertebral level with Tuffier line and the 10th rib line was observed in the following order: L3-L4 intervertebral space: 27% vs 24%, L5-S1 intervertebral space: 9% vs 16%, and L2-L3 intervertebral space: 5% vs 3%, respectively.

Tuffier line and the 10th rib line may be unreliable to estimate the intervertebral space for spinal anesthesia in elderly patients with hip fracture.

Abbreviations: L1 = the 1st lumbar vertebra, L2 = the 2nd lumbar vertebra, L3 = the 3rd lumbar vertebra, L4 = the 4th lumbar vertebra, L5 = the 5th lumbar vertebra, S1 = the 1st sacral vertebra, T12 = the 12th thoracic vertebra.

Keywords: elderly, spinal anesthesia, the 10th rib line, Tuffier line

1. Introduction

Conus medullaris is extended to the lower 3rd portion of the L1 vertebral body, but there is a personal difference from T12 to upper 3rd of L3 vertebral body.[1] Thus, spinal anesthesia is usually performed at the L3-L4 or L4-L5 intervertebral spaces to avoid direct injury to the spinal cord.

Tuffier line, a horizontal line drawn across the highest points of both iliac crests, is a common landmark for spinal anesthesia. It is considered to intersect the body of L4 or the L4-L5 intervertebral space. However, several factors such as patient's age, sex, or body shape could change the location of Tuffier line.[2–5] Thus, the line could be drawn on the wrong points of vertebral level. Another landmark is based on the 10th rib under the assumption that the extended line passes through the L1-L2 intervertebral space or the body of L2.[6] The puncture level for spinal anesthesia can be determined by counting down the lumbar intervertebral spaces from this line. A previous study showed that the 10th rib line is more accurate to predict the intervertebral level with palpation than Tuffier line.[7]

Spinal anesthesia is usually performed in the lateral decubitus position. These landmarks are based on the assumption that the patient could pose for spinal anesthesia with their back hunched, both legs flexed on the abdomen symmetrically, and chin flexed on the chest. However, this conventional lateral decubitus posture is hard to make in patients with hip fracture due to painful patient positioning. Hip fracture is common in the aged population. The height of individual vertebral body decreases with aging, and thus the use of anatomical landmarks may be

Editor: Somchai Amornyotin.

The authors have no funding and conflicts of interest to disclose.

[a] Department of Anesthesiology and Pain Medicine, SMG-SNU Boramae Medical Center, Boramae-ro, Dongjak-gu, Seoul, [b] Department of Anesthesiology and Pain Medicine, Seoul National University Bundang Hospital, Gumiro, Seongnam-si, Gyeonggido, [c] College of Medicine, Seoul National University, Seoul, [d] Department of Anesthesiology and Pain Medicine, Seoul National University Hospital, Daehakro, Jongnogu, Seoul, Republic of Korea.

[*] Correspondence: Jin-Young Hwang, Department of Anesthesiology and Pain Medicine, SMG-SNU Boramae Medical Center, Boramae-ro, Dongjak-gu, Seoul 07061, Republic of Korea, College of Medicine, Seoul National University, Seoul, Republic of Korea (e-mail: mistyblue15@naver.com).

Medicine (2019) 98:27(e16388)

Received: 9 November 2018 / Received in final form: 15 May 2019 / Accepted: 14 June 2019

http://dx.doi.org/10.1097/MD.0000000000016388

incorrect to detect the intervertebral space for spinal anesthesia particularly in elderly patients. In the present study, we evaluated the accuracy of Tuffier line and the 10th rib line to identify the lumbar intervertebral space for spinal anesthesia using ultrasonography in elderly patients with hip fracture.

2. Methods

This study was approved by the Institutional Review Board of our hospital (20170406/16-2017-46/051), and registered at ClinicalTrials.gov (NCT03182608). After obtaining written informed consents, patients over 65 years of age scheduled for hip fracture surgery under spinal anesthesia were recruited to the study. Patients were excluded if they had coagulopathy, known anatomical anomaly or pathology in the spine, or history of spine surgery or compression fracture.

Standard monitoring included noninvasive arterial pressure, electrocardiogram, and pulse oximetry. Patients posed the lateral decubitus position with the fracture side up, lower leg flexed, and upper fractured leg straight for spinal anesthesia. Assistants stood facing them, and helped posing and maintaining the lateral decubitus position. Folded cotton cloths were placed underneath the upper fractured leg to keep the leg straight. The L4-L5 intervertebral space was detected using Tuffier line and the 10th rib line in a random order by 2 experienced board-certified anesthesiologists. Tuffier line was defined as an intercristal line drawn between the tops of both iliac crests. It was considered to intersect the body of L4 or the L4-L5 intervertebral space. The 10th rib line was defined as an imaginary line connecting the 2 lowest points of the rib cage, which corresponds to the L1-L2 intervertebral space or the body of L2. The L4-L5 intervertebral space was determined by counting down the level from this line (Fig. 1). After determining the L4-L5 intervertebral space using each method alternately, horizontal skin marks were created with an erasable pen. Then, another experienced anesthesiologist for ultrasonographic examination assessed the intervertebral spaces, as described in a previous study.[8] A 2- to 5-MHz curved array probe (SonoSite MicroMaxx; SonoSite Inc, Bothell, WA) was placed over the lumbosacral spine, oriented longitudinally in a parasagittal plane lateral to the midline. After identifying the sacrum, the investigator moved the probe in a cephalad direction, counted the intervertebral spaces and assessed the actual intervertebral spaces of the 2 skin marks (Fig. 2). Then, spinal anesthesia was performed at the L4-L5 intervertebral space determined by ultrasonography.

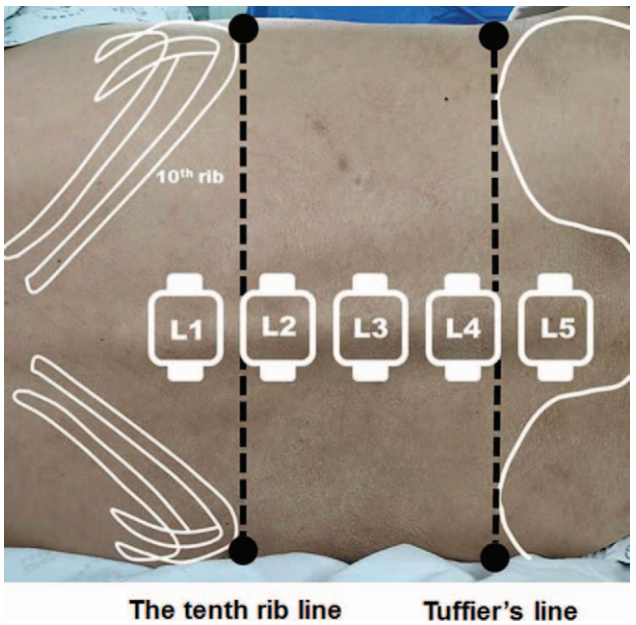

Figure 1. Anatomic landmarks for spinal anesthesia. The 10th rib line was defined as an imaginary line connecting the 2 lowest points of the rib cage, which corresponds to the L1-L2 intervertebral space or the body of L2. The L4-L5 intervertebral space was determined by counting down the level from this line. Tuffier line was defined as an intercristal line drawn between the tops of both iliac crests. It was considered to intersect the body of L4 or the L4-L5 intervertebral space.

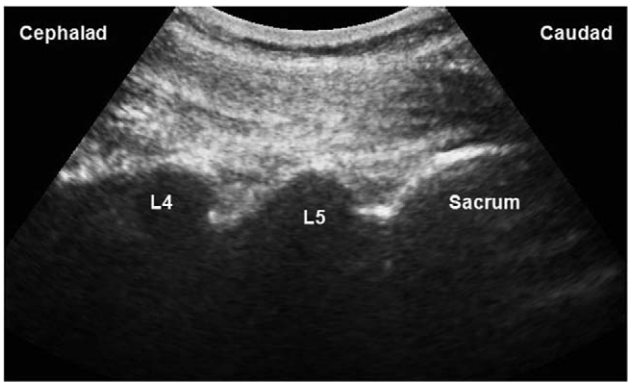

Figure 2. Longitudinal parasagittal image of the lumbosacral spine.

A pilot study was performed to determine the sample size in 30 elderly patients with hip fracture undergoing spinal anesthesia, and the accuracy to detect the L4-L5 intervertebral space was 59% using the 10th rib line. The accuracy, based on a previous study in general patient population, was 74% in the 10th rib-guided approach.[7] A power analysis was performed based on the difference between the 59% and 74% in the accuracy rate, and 76 patients were required at a significance level of 95% and with a power of 80%. Considering the possible dropouts, 84 patients were enrolled.

The SPSS for Windows software (ver. 20; IBM Corp, Armonk, NY) was used to conduct statistical analyses. Data normality was tested using the Shapiro-Wilk test. Data are expressed as number of patients (%) or mean ± standard deviation. Accuracy and the difference of estimation ratio related to the intervertebral spaces by 2 anatomic landmarks were compared by McNemar test. The association between the accuracy of each anatomic landmark and patient characteristics (sex, age, weight, height, and fracture site) was analyzed using Student *t* test or the Chi-squared test. A *P*-value $<.05$ was considered statistically significant.

3. Results

A total of 112 patients were recruited from June 2017 to March 2018, and 28 did not fulfill the inclusion criteria. Consequently, 84 patients were included in the study. Five patients were excluded due to poor image quality. Thus, 79 patients were included the analysis. Patient characteristics and fracture site are shown in Table 1.

The accuracy of the anatomic landmarks to determine the L4-L5 intervertebral space is presented in Table 2. No significant difference was observed between the accuracy of 2 anatomic landmarks ($P=.87$). The L4-L5 intervertebral space was

Table 1

Patient characteristics and fracture site.

Patients (n)	79
Age, yrs	77.6±7.9
Sex (M/F)	26/53
Height, cm	158.9±7.7
Weight, kg	58.3±6.9
Fracture site (left/right)	36/43

Values are mean ± standard deviation or number of patients.

Table 2

The accuracy of the anatomic landmarks.

	10th rib line			*P*-value
	Correct	Incorrect	Total	
Tuffier line				
Correct	27 (34)	20 (25)	47 (59)	.87
Incorrect	18 (23)	14 (18)	32 (41)	
Total	45 (57)	34 (43)		

Values are number of patients (%).

Table 3

Intervertebral spaces determined by anatomic landmarks.

	Tuffier line	10th rib line	*P*-value
L2-L3	4 (5)	2 (3)	.40
L3-L4	21 (27)	19 (24)	
L4-L5	47 (59)	45 (57)	
L5-S1	7 (9)	13 (16)	

Values are number of patients (%).

correctly estimated in 47 (59%) patients using Tuffier line and 45 (57%) patients using the 10th rib line. Both anatomic landmarks identified the L4-L5 intervertebral space in 27 (34%) patients, and estimated the other intervertebral spaces in 14 (18%) patients.

The actual intervertebral spaces determined by anatomic landmarks are shown in Table 3. The estimation ratio related to the intervertebral levels was not different between the 2 landmarks ($P=.40$). The wrong identifications of intervertebral level with Tuffier line and the 10th rib line were observed in the following order: L3-L4 intervertebral space: 27% vs 24%, L5-S1 intervertebral space: 9% vs 16%, and L2-L3 intervertebral space: 5% vs 3%, respectively.

Association between the accuracy of each anatomic landmark and the patient data is shown in Table 4. No significant association was found in the accuracy of each anatomic landmark with age, sex, height, weight, and fracture site.

4. Discussion

This study showed that Tuffier line and the 10th rib line may be unreliable to detect the L4-L5 intervertebral space for spinal anesthesia in elderly patients with hip fracture.

In the present study, the accuracy of Tuffier line was 59%, consistent with previous studies showing its accuracy of 60% to 64% in general population.[7,9] The accuracy of the 10th rib line was 57%, which was lower than the result in a previous study where showed the 74% accuracy of the 10th rib line.[7] In that study, they compared Tuffier line and the 10th rib line to predict the L4-L5 intervertebral space in young and healthy population, and showed that the 10th rib line is more accurate than Tuffier line (74% vs 60%, respectively). With the 10th rib line, the L4-L5 intervertebral space is determined by counting down the level from the 10th rib line that corresponds to the L1-L2 intervertebral space or the body of L2. The 10th rib line has been suggested as a new landmark of the lumbar vertebral level as well as a safe guard to prevent the high level puncture based on the X-ray data in young and nonobese volunteers.[6] Our study was performed in elderly patients over 65 years old with hip fracture. The estimation of intervertebral space by counting down the level from the 10th rib line may be incorrect in elderly patients because the height of vertebral body decreased due to aging process such as osteoporosis and degeneration.

According to the previous studies,[4,7,10] the wrong identified intervertebral level was mostly the higher level with Tuffier and the lower level with the 10th rib line. In our study, the wrong estimation ratio related to the intervertebral level was not different between the 2 landmarks; 1 upper level (L3–L4 intervertebral space, 27% vs 24%, Tuffier line vs the 10th rib line, respectively) and 1 lower level (L5–S1 intervertebral space, 9% vs 16%). Moreover, the 2 upper level (L2–L3 intervertebral space) was identified in 4 patients (5%) with Tuffier line and 2 patients (3%) with the 10th rib line. According to a previous study,[11] the distance in segments between the conus medullaris and Tuffier line was shorter with increased age. It results from age-related vertebral deformity and reduced height of the vertebral body. Thus, when these anatomic landmarks are used in this population, the needle may be directed close to the spinal cord in some cases, and special attention is required.

Bedside ultrasound-guided identification of intervertebral space for spinal anesthesia is a simple and effective method to prevent the injury to the spinal cord. It may also facilitate the successful spinal anesthesia in these patients although it was not evaluated in this study.[8,12] However, visualization of the intervertebral spaces can be difficult in some elderly patients because of narrow interspinous spaces caused by ossification of the interspinous ligaments. Prominent spinous process in thin stooping elderly patients may disturb adequate skin-probe

Table 4

Association of the patient data with the accuracy of anatomic landmarks.

	Tuffier line		*P*-value	10th rib line		*P*-value
	Correct	Incorrect		Correct	Incorrect	
Age, yrs	77.5±7.5	77.8±8.7	.86	77.0±8.1	78.5±7.8	.42
Sex (M/F)	18/29	8/24	.24	12/33	14/20	.23
Height, cm	159.3±7.0	158.4±8.8	.62	158.5±8.3	159.5±7.1	.59
Weight, kg	59.0±6.8	57.2±7.1	.27	59.0±7.5	57.3±6.1	.29
Fracture (left/right)	23/24	13/19	.50	22/23	14/20	.65

Values are mean ± standard deviation or number of patients.

contact and result in poor image quality.[13] Thus, the use of ultrasonography coupled with the anatomic landmarks may provide more effective and safer spinal anesthesia.

This study has some limitations. First, the skin marks were not sealed during the ultrasonographic examination, but the ultrasonographic examination was performed according to a standardized protocol. Second, this study included patients with normal body habitus because non-obese patients are more susceptible to hip fracture.[14,15] Thus, our results could not be generalized to obese patients.

5. Conclusion

Tuffier line and the 10th rib line are unreliable to detect the L4-L5 intervertebral space in elderly patients undergoing hip fracture surgery. Ultrasonographic assessment of intervertebral spaces should be considered for safe and effective spinal anesthesia in this population.

Acknowledgment

The authors thank Sohee Oh, PhD of the Department of Biostatistics in Seoul Metropolitan Government Seoul National University Boramae Medical Center (Seoul, Republic of Korea) for statistical advice.

Author contributions

Conceptualization: Hyerim Kim, Jee-Eun Chang, Jung-Man Lee, Jung-Hee Ryu, Seong-Won Min, Jin-Young Hwang.
Data curation: Jung-Hee Ryu.
Formal analysis: Hyerim Kim, Dongwook Won, Jee-Eun Chang, Jung-Man Lee, Seong-Won Min, Kwanghoon Jun, Jin-Young Hwang.
Investigation: Hyerim Kim, Dongwook Won, Jee-Eun Chang, Jung-Man Lee, Jung-Hee Ryu, Seong-Won Min, Jin-Young Hwang.
Methodology: Hyerim Kim, Dongwook Won, Jung-Hee Ryu, Kwanghoon Jun, Jin-Young Hwang.
Resources: Hyung Sang Row.
Software: Kwanghoon Jun, Hyung Sang Row.
Validation: Hyung Sang Row.
Writing – original draft: Hyerim Kim, Dongwook Won, Jee-Eun Chang, Jung-Man Lee, Jung-Hee Ryu, Seong-Won Min, Kwanghoon Jun, Jin-Young Hwang.
Writing – review & editing: Hyung Sang Row.

References

[1] Saifuddin A, Burnett SJ, White J. The variation of position of the conus medullaris in an adult population. A magnetic resonance imaging study. Spine (Phila Pa 1976) 1998;23:1452–6.
[2] Lin N, Li Y, Bebawy JF, et al. Abdominal circumference but not the degree of lumbar flexion affects the accuracy of lumbar interspace identification by Tuffier's line palpation method: an observational study. BMC Anesthesiol 2015;15:9.
[3] Snider KT, Kribs JW, Snider EJ, et al. Reliability of Tuffier's line as an anatomic landmark. Spine (Phila Pa 1976) 2008;33:E161–5.
[4] Lee AJ, Ranasinghe JS, Chehade JM, et al. Ultrasound assessment of the vertebral level of the intercristal line in pregnancy. Anesth Analg 2011;113:559–64.
[5] Margarido CB, Mikhael R, Arzola C, et al. The intercristal line determined by palpation is not a reliable anatomical landmark for neuraxial anesthesia. Can J Anaesth 2011;58:262–6.
[6] Jung CW, Bahk JH, Lee JH, et al. The tenth rib line as a new landmark of the lumbar vertebral level during spinal block. Anaesthesia 2004;59:359–63.
[7] Ozturk I, Kilic B, Demiroglu M, et al. Comparison between two anatomic landmarks using ultrasonography in spinal anesthesia: a randomized controlled trial. Curr Med Res Opin 2016;32:1693–5.
[8] Chin KJ, Perlas A, Singh M, et al. An ultrasound-assisted approach facilitates spinal anesthesia for total joint arthroplasty. Can J Anaesth 2009;56:643–50.
[9] Duniec L, Nowakowski P, Kosson D, et al. Anatomical landmarks based assessment of intravertebral space level for lumbar puncture is misleading in more than 30%. Anaesthesiol Intensive Ther 2013;45:1–6.
[10] Chun EH, Kim JE, Kim DY, et al. Ultrasound measurement of the vertebral level of Tuffier's line in elderly women. Korean J Anesthesiol 2016;69:474–9.
[11] Kim JT, Bahk JH, Sung J. Influence of age and sex on the position of the conus medullaris and Tuffier's line in adults. Anesthesiology 2003;99:1359–63.
[12] Chin KJ, Perlas A, Chan V, et al. Ultrasound imaging facilitates spinal anesthesia in adults with difficult surface anatomic landmarks. Anesthesiology 2011;115:94–101.
[13] Chin KJ, Karmakar MK, Peng P. Ultrasonography of the adult thoracic and lumbar spine for central neuraxial blockade. Anesthesiology 2011;114:1459–85.
[14] Tang X, Liu G, Kang J, et al. Obesity and risk of hip fracture in adults: a meta-analysis of prospective cohort studies. PLoS One 2013;8:e55077.
[15] De Laet C, Kanis JA, Oden A, et al. Body mass index as a predictor of fracture risk: a meta-analysis. Osteoporos Int 2005;16:1330–8.