The Accuracy of 7th Cervical Spinous Process Identification Using Ultrasound Transverse Scan and Parasagittal Scan Compared to Palpation Technique

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Objective: To obtain the adequate surgical anesthesia from thoracic paravertebral block (TPVB), identifying the correct thoracic spine level is mandatory. Ultrasound has become a recent standard to perform regional anesthesia including TPVB. This study aimed to investigate two techniques of using ultrasound to identify C7 spinous process compared with the palpation method.

Material and Method: Twenty volunteers were invited to participate in the investigation. Each volunteer was evaluated using palpation method with flexion and extension maneuver, ultrasound transverse scan (US-TS) and parasagittal scan (US-PS) to identify C7 spinous process. All volunteers were scanned on both sides randomly, and finally checked with fluoroscope. The examinations were independently performed by different investigators. The invisible marker pen was used to locate C7 spinous process from each technique. The accuracy and frequency of identified level, both correction and errors, were recorded and compared.

Results: The accuracy of palpation method with flexion and extension maneuver for C7 spinous process identification was 72.5%. While identifications of C7 by using US-TS and US-PS were correct 52.5% and 30% respectively. Interestingly, most errors were one level higher than actual C7 spinous process.

Conclusion: Identifying C7 spinous process using ultrasound assisted, both US-TS and US-PS techniques had a lower accuracy compared with palpation method with flexion and extension maneuver. Thus, the technique of ultrasound assisted C7 spinous process identification need to be modified.

Keywords: C7 spinous process identification, Ultrasound assisted, Thoracic paravertebral block, Palpation method with flexion and extension maneuver

To identify the correct level of upper thoracic spine in order to provide optimal surgical anesthesia for thoracic paravertebral or epidural block is an essential maneuver during chest wall surgery, upper abdominal surgery or thoracotomy surgery. The correct placement of paravertebral blockade will assure the optimization of surgical anesthesia and analgesia with minimized side effects. Multiple level thoracic paravertebral blocks for breast surgery reduce chronic pain incidence and also improve the quality of life for breast cancer patients[1]. Palpation, the most prominent of the C7 spinous process method, is the common technique to identify upper thoracic vertebral level. However, the accuracy of this method to identify C7 spinous process was lower than 50%[2,3].

Ultrasound has become a recent standard to perform regional anesthesia including TPVB. Moreover, using ultrasonography has been studied to identify the cervical nerve roots by differentiating the transverse process of C6 and C7. Identifying C6 transverse process based on presence of a large anterior tubercle (Chassaignac tubercle) and a posterior tubercle, while C7 transverse process is absent of anterior tubercle of transverse process[4,5]. The studies showed 50% agreement between the landmark technique and

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ultrasound technique to identify C7-T1 interspace[5]. However, there was no study of the accuracy of using ultrasound to identify C7 spinous process before.

The authors have developed two techniques using ultrasonography to identify C7 spinous process; 1) Transverse scan (TS) by identifying the C7 transverse process with characterization of presence the vertebral artery and absence of anterior tubercle as a landmark[6] and then scanning back to find out the spinous process of C7; 2) Parasagittal scan (PS) by identifying the first and second ribs and then sliding the transducer medially until the lateral edge of C7 transverse process was depicted. Thereafter, the C7 spinous process that was located axial corresponding to the C7 transverse process was identified. The objective of this study was to evaluate the accuracy of these two techniques using ultrasound scan to identify C7 spinous process compared to palpation method with flexion-extension maneuver.

Material and Method
The study protocol was approved by the research ethical committee of Siriraj Institutional Review Board (Si 750/2016). The 20 volunteers were recruited to participate in the study and agreed to sign the informed consent form. All participants were placed on lateral position with neck flexion, slight hip and knee flexion. Each volunteer was evaluated using three techniques to identify C7 spinous process by three investigators (Palpation method: Pakpirom J, Transverse scan: Karmakar MK, Paramedian sagittal scan: Songthamwat B) independently and all volunteers were scanned both sides randomly. Thus, all examinations were forty in total.

Palpation method: Patients were placed in lateral position with slight neck flexion. C7 spinous process was identified by using flexion-extension assisted technique[3]. Two prominent cervical spinous processes were palpated by single investigator (Pakpirom J) using index finger and middle finger. Then through the assisted movement of patient's neck, C7 is more flexible compared with T1 and more steady compared with C6. If the upper spinous process was moved or disappeared during the movement, the lower spine would be labeled as C7 and if both spinous processes were steady or remained during assisted movement, the upper spinous process would be recorded as C7. The tip of C7 spinous process was then marked with invisible and eracible marking pen using "x" sign on patient's skin. The invisible marker would only be seen under radiolucent light at the end

of study.

Ultrasound Transverse scan (US-TS): Patients were also placed in the same position as palpation method. Arietta 70 Aloca Hitachi ultrasound machine with high frequency transducer 18-5 MHz, 38 mm footprint was used in this study. One investigator (Karmakar MK) performed this technique in all volunteers independently. The ultrasound probe was placed at the cricoid cartilage then moved laterally to identify the transverse process of C6 and C7 by sliding probe cranially and caudally. C7 transverse process then was identified by 2 methods: 1) absense of anterior tubercle while C6 has a prominent anterior tubercle, 2) using a color Doppler to identify vertebral artery which passes anterior to the transverse process of C7[6]. Then moved the transducer to posterior following the C7 transverse process, articular process, lamina and spinous process (Fig. 1). Then the tip of C7 spinous process was marked on patient's skin with "O" sign using invisible marking pen.

Ultrasound Parasagittal scan (US-PS): this technique was performed by one investigator (Songthamwat B) independently. Patients were placed in the same position as 2 techniques described. Convex transducer (5-2 MHz) was used and placed parasagittal at cervicothoracic spine to obtain the first and second ribs. After that the probe was moved medially and cranially to identify C7 transverse process and placed on the middle of the probe (Fig. 2). The prominent spinous process corresponding to the middle of the probe would be marked as C7 spinous process using "Δ" sign with invisible marking pen on patient's skin.

Cervical fluoroscopy: Patients were placed in a lateral position with slightly shoulder traction in order to see all the cervical spine. A fluoroscope was taken on lateral view using radiopaque pointer placed on the suspected C7 spinous process (Fig. 3). After confirming the C7 spinous process it was marked as "-" using invisible marking pen.

All methods confirmed the correction of spinous level identification by fluoroscopy under radiolucent light. If the marking label was located on lower midhalf of intervertebral space above to, and upper midhalf of intervertebral space lower to spinous process, this would be assumed as the same spinous process. Then each technique identifying cervical level was recorded and defined the accuracy of identification.

Statistical analysis
Data was analysed using SPSS for Windows, 18.0 Chicago: SPSS Inc. The Kolmogorov-Smirnov was
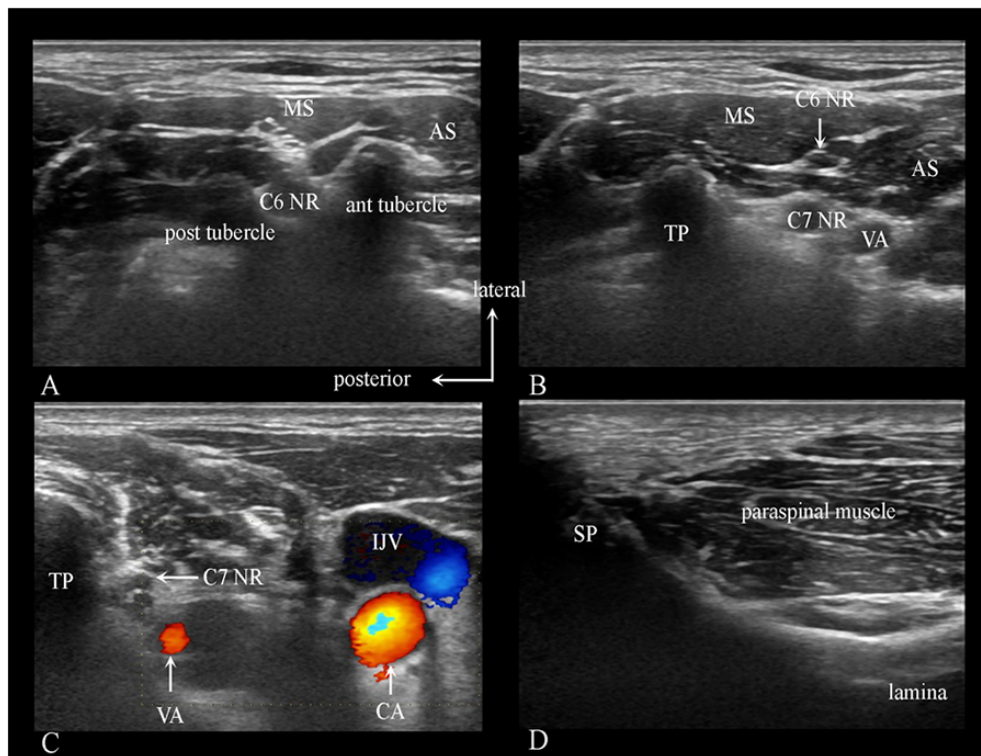
MS = middle scalene muscle; AS = anterior scalene muscle; SP = spinous process; NR = nerve root; TP = transverse process; VA = vertebral artery; CA = carotid artery; IJV = internal jugular vein

Fig. 1   Illustration the step of US-TS to identify C7 transverse process and spinous process. Linear high frequency transducer (18-5 MHz) was placed transverse axial at lateral neck. A) Demonstration C6 transverse process composing of anterior and posterior tubercles where C6 nerve root, hypoechoic oval structure, emerges from intervertebral foramen at this level; B) Transducer was slightly moved caudally from A to identify the C7 transverse process which has only posterior tubercle. C7 nerve root and vertebral artery were also delineated anterior to the C7 transverse process; C) Color Doppler showing the vertebral artery located next to the C7 nerve root at this level; D) Transducer was slid posteriorly following the C7 lamina until visualizing the spinous process of C7.

used to test the normality distribution of continuous variables. The McNemar test was used to find out the difference between the techniques used to identify C7 cervical spinous process. Sample size calculation was to estimate the accuracy of using ultrasound based on previous study showing the 80% correct cervical spine identification using transverse scan[6]. With 20% acceptable error ($\alpha = 0.05$, $\beta = 0.2$), 16 subjects were required and including 20% possible dropouts, finally 20 subjects were recruited for the study.

Results

The volunteer demographic data is shown in Table 1. The accuracy of the palpation method using cervical movement assisted C7 spinous process identification was in 29 of 40 performances (72.5%, 95% CI = 58.7 to 86.3). While using ultrasound transverse scan (US-TS), parasagittal scan (US-PS) were correctly identified in 21 (52.5%, 95% CI = 37.0 to 68.0) and 12 (30%, 95% CI = 15.8 to 44.2) respectively. The accuracy of palpation method using cervical movement assisted C7 identification was higher than US-TS and US-PS. Nevertheless, there was no statistically significant difference between palpation method and US-TS method but significant difference between palpation method and US-PS method as shown in Table 2. The distribution of each technique identification was shown in Fig. 1.

Discussion

This study demonstrated a low accuracy of using US-TS and US-PS to identify the C7 spinous process compared with flexion-extension assisted palpation technique. The accuracy of US-TS using the
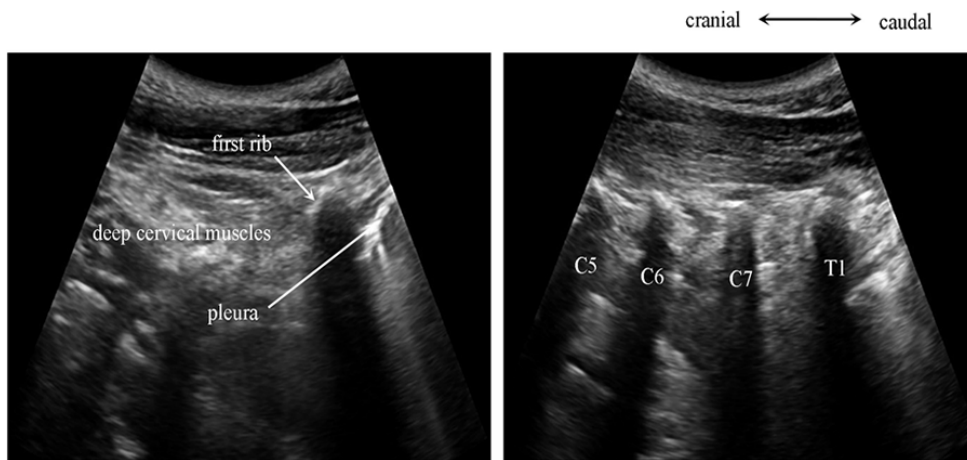
cranial ← → caudal

Fig. 2 Demonstration the step of US-PS to identify C7 transverse process, curve low frequency transducer (5-2 MHz) was placed paramedian sagittal scan, 2 cm lateral to midline, at the base of posterior neck. A) Ultrasound image shows scanning to identify the 1st rib visualized as hyperehoic line with acoustic shadow. Deeper to the rib, parietal pleura were illustrated as hyperehoicline, B) Transducer was sliding medially and transverse process of C5, C6 and C7 suddenly appeared cranial to the T1 transverse process.

Fig. 3 Fluoroscopy lateral view of cervical spine showing metallic indicator to localize the tip of C7 spinous process.

Table 1. Demographic information of healthy volunteers (n = 20)

Variables	Mean ± SD
Age (years)	33.3±10.4
Weight (kg)	61.8±12.9
Height (cm)	167.5±8.2
BMI (kg/m²)	21.9±3.8

C7 transverse process and vertebral artery as a landmark to identify the C7 level then identifies C7 spinous process showed 52.5% correct identification. The accuracy of US-PS using the first and second rib as a landmark and scan medially to visualize the transverse process of T1 and C7 then the spinous process that corresponding with the C7 transverse process showed

only 30% correct identification.

The most prominent of C7 spinous process has been used as a landmark to describe the cervicothoracic junction and upper thoracic intervertebral space to perform central neuraxial anesthesia or thoracic paravertebral block (TPVB). However, previous studies[2,3,7] demonstrated that using this method to identify the C7 spinous process was not reliable and had a low accuracy rate. Shin et al[3] demonstrated that using flexion and extension assisted palpation method improved the accuracy of C7 spinous process identification. The reason is C7 spinous process usually stationary during cervical flexion and extension compared to C6 spinous process. This study used palpation with flexion and extension maneuver to identify the C7 spinous process, and the current study also shows 72.5% accuracy of C7 spinous process identification, which this number was similar to previous study described by Shin et al[3].

Table 2. The accuracy and frequency of level of identification from palpation, ultrasound transverse scan (US-TS) and ultrasound parasagittal scan (US-PS) methods

	Palpation method (n = 40)	US-TS (n = 40)*	US-PS (n = 40)#
Accuracy of C7 identification; [95% CI]	29 (72.5) [58.7 to 86.3]	21 (52.5) [37.0 to 68.0]	12 (30) [15.8 to 44.2]
Level of identification; n (%)			
C5	0	1 (2.5)	3 (7.5)
C6	8 (20)	18 (45)	25 (62.5)
C7	29 (72.5)	21 (52.5)	12 (30)
T1	3 (7.5)	0	0

Data presented as number (%).
* Compared US-TS with palpation method, *p*-value = 0.057; # Compared US-PS with palpation method, *p*-value <0.001

Using ultrasonography to identify the cervicothoracic intervertebral space (IVS) can be performed by "counting up approach" from lumbosacral junction done by Arzola et al[5]. They performed paramedian scan, 2 cm lateral to midline, using low frequency (5-2 MHz) transducer, starting from the sacral where the ultrasound image showed hyperechoic line of sacral bone. After that curve transducer was moved cranially to delineate "saw-tooth" sign where the hyperechoic line, US beam hit lamina of spine, was interrupted with hypoecholic line, US beam penetrating through the interlamina space to spinal canal[8,9]. After that the curve transducer was moved cranially to identify the cervicothoracic intervertebral space (IVS) level. However, this study did not investigate the accuracy of using US to identify the cervicothoracic level. They described 50% agreement between using landmark method and ultrasound method. Moreover, using this US scanning method, starting from lumbosarcral junction and counting up approach to identify cervicothoracic IVS level, would have a high tendency of counting error and misinterpretation during long distance scan from sacrum to cervicothoracic junction. Rasoulian et al[10] used US-PS, starting from the T12 IVS where corresponding to the last rib, and using the counting up approach to upper thoracic IVS. The thoracolumbar spine morphologic abnormality such as lumbarization, sacralization, lumbar ribs, narrow lumbar IVS and apposition of adjacent lumbar spinous processes from degenerative disc disease could influence missed interpretation during counting up approach technique to identify upper thoracic IVS and cervicothoracic junction[11,12].

The current study proposes to use US-TS, linear high frequency transducer, to identify the C7 transverse process, recognized by C7 transverse process with absence anterior tubercle[13] and it is the only cervical vertebrae with missing anterior tubercle[14]. After C7 transverse process identification, the transducer was moved posteriorly following the alignment of articular process, lamina and spinous process to identify the C7 spinous process (Fig. 1). The result of this technique demonstrated 52.5% correct C7 spinous process confirmed by fluoroscopy. The accuracy of this technique was lower than using palpation with flexion and extension maneuver reported by this study and previous study[3]. The low accuracy and missed identification could occur during moving transducer from the transverse process of C7 to the spinous process. There was a chance to identify higher level of spinous process because the C7 spinous process produces caudal angulation to the horizontal body axis, while transducer was moved perpendicular to the body axis. In addition, C7 transverse process identification using ultrasonography was reported 85% accuracy confirmed by fluoroscopy[6]. Therefore, these factors may contribute to C7 spinous process missed level identification.

Moreover, the current study investigated the accuracy of US-PS to identify C7 spinous process. The authors speculated that US-PS might be less difficult than US-TS especially in short and thick necks. US-PS technique used curve low frequency transducer (5-2 MHz) placing paramedian, 2 cm lateral to midline, at the upper thoracic spine to identify the first and second rib. The characteristics of ultrasonography of ribs, compared to transverse process, have wider hyperecchotic line on top of the pleura and are located more superficially than transverse process[15] (Fig. 2). After that, transducer was moved medially so that the ultrasound beam insonates over transverse process, then C7 transverse process suddenly appeared cephalic to the T1 transverse process and located deeply

compared to T1 transverse process. The horizontal corresponding spinous process to the C7 transverse process was identified as C7 spinous process. The current study found that the accuracy of this method to identify C7 spinous process was 30%, lower than US-TS and flexion-extension assisted palpation method. Interestingly, this method identified C6 spinous process being C7 spinous process as high as 62.5%. According to the method of C7 spinous process identification, the spinous process corresponding to the midpoint of the curve transducer was labeled C7 spinous process. This may lead to one level higher than the actual level because the tip of lower cervical spinous process usually produces a caudal angulation.

The technique of utilizing ultrasonography to identify C7 spinous process or upper thoracic intervertebral level including both US-TS and US-PS need to be remodified in order to improve the accuracy and reliability for clinical use. The strength of this study, apart from previous studies[5,6,10] used "counting up" approach from lumbosacral junction to identify upper thoracic IVS level. This was the first study utilizing US to identify C7 SP level using C7 transverse process in both transverse and sagittal scan.

Conclusion

This study demonstrated a low accuracy of using ultrasonography assisted, both US-TS and US-PS techniques, to identify the C7 spinous process compared with palpation method with flexion-extension maneuver. Before the actual clinical use, the future trial with remodified techniques is necessary.

What is already known on this topic?

To obtain the adequate surgical anesthesia from regional techniques such as thoracic paravertebral block, identifying the correct thoracic spine level is mandatory. Fluoroscopy has been accepted as a gold standard of locating method. The palpation method has normally been used by anesthesiologists to identify the levels and the chance for errors is accepted to occur.

What this study adds?

This was the first study utilizing US to identify C7 spinous process level using C7 transverse process in both transverse and parasagittal scan. Even though the accuracy of using ultrasonography to identify C7 spinous process or upper thoracic intervertebral level was low both US-TS and US-PS techniques, this techniques might be remodified in order to improve the accuracy and reliability for clinical use.

Potential conflicts of interest

None.

References

1. Karmakar MK, Samy W, Li JW, Lee A, Chan WC, Chen PP, et al. Thoracic paravertebral block and its effects on chronic pain and health-related quality of life after modified radical mastectomy. Reg Anesth Pain Med 2014; 39: 289-98.
2. Holmaas G, Frederiksen D, Ulvik A, Vingsnes SO, Ostgaard G, Nordli H. Identification of thoracic intervertebral spaces by means of surface anatomy: a magnetic resonance imaging study. Acta Anaesthesiol Scand 2006; 50: 368-73.
3. Shin S, Yoon DM, Yoon KB. Identification of the correct cervical level by palpation of spinous processes. Anesth Analg 2011; 112: 1232-5.
4. Saranteas T, Paraskeuopoulos T, Anagnostopoulou S, Kanellopoulos I, Mastoris M, Kostopanagiotou G. Ultrasound anatomy of the cervical paravertebral space: a preliminary study. Surg RadiolAnat 2010; 32: 617-22.
5. Arzola C, Avramescu S, Tharmaratnam U, Chin KJ, Balki M. Identification of cervicothoracic intervertebral spaces by surface landmarks and ultrasound. Can J Anaesth 2011; 58: 1069-74.
6. Choi DH, Jung HG, Lee JH, Park JH, Choi YS. Effectiveness of doppler image of the vertebral artery as an anatomical landmark for identification of ultrasound-guided target level in cervical spine. Asian Spine J 2015; 9: 683-8.
7. Teoh DA, Santosham KL, Lydell CC, Smith DF, Beriault MT. Surface anatomy as a guide to vertebral level for thoracic epidural placement. Anesth Analg 2009; 108: 1705-7.
8. Karmakar MK, Li X, Kwok WH, Ho AM, NganKee WD. Sonoanatomy relevant for ultrasound-guided

central neuraxial blocks via the paramedian approach in the lumbar region. Br J Radiol 2012; 85: e262-e269.

9. Chin KJ, Karmakar MK, Peng P. Ultrasonography of the adult thoracic and lumbar spine for central neuraxial blockade. Anesthesiology 2011; 114: 1459-85.

10. Rasoulian A, Lohser J, Najafi M, Rafii-Tari H, Tran D, Kamani AA, et al. Utility of prepuncture ultrasound for localization of the thoracic epidural space. Can J Anaesth 2011; 58: 815-23.

11. Nakajima A, Usui A, Hosokai Y, Kawasumi Y, Abiko K, Funayama M, et al. The prevalence of morphological changes in the thoracolumbar spine on whole-spine computed tomographic images. Insights Imaging 2014; 5: 77-83.

12. Watson MJ, Evans S, Thorp JM. Could ultrasonography be used by an anaesthetist to identify a specified lumbar interspace before spinal anaesthesia? Br J Anaesth 2003; 90: 509-11.

13. vanEerd M, Patijn J, Sieben JM, Sommer M, Van Zundert J, van Kleef M, et al. Ultrasonography of the cervical spine: an in vitro anatomical validation model. Anesthesiology 2014; 120: 86-96.

14. Loizides A, Obernauer J, Peer S, Bale R, Galiano K, Gruber H. Ultrasound-guided injections in the middle and lower cervical spine. Med Ultrason 2012; 14: 235-8.

15. Karmakar MK, Li X, Li J, Hadzic A. Volumetric three-dimensional ultrasound imaging of the anatomy relevant for thoracic paravertebral block. Anesth Analg 2012; 115: 1246-50.

ความแม่นยำของการใช้เครื่องอัลตราซาวด์ในการระบุกระดูกคอข้อที่ 7 โดยการตรวจตามขวางและการตรวจตามแนวยาว ของกระดูกสันหลังระดับคอเปรียบเทียบกับการใช้เทคนิคการคลำกระดูกคอ

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วัตถุประสงค์: ในการระงับความรู้สึกเฉพาะส่วน เช่น การฉีดยาชาที่ด้านข้างกระดูกสันหลังส่วนอก เพื่อให้เพียงพอสำหรับการผ่าตัด การฉีดยา ในระดับที่ต้องการให้ถูกต้องเป็นสิ่งที่จำเป็น อัลตราซาวด์เข้ามามีบทบาทและเป็นมาตรฐานในการระงับความรู้สึกเฉพาะส่วนหลายอย่าง รวมทั้งการฉีดยา ที่ด้านข้างกระดูกสันหลังส่วนอก งานวิจัยนี้ทำขึ้นเพื่อ เปรียบเทียบความถูกต้องในการระบุตำแหน่งกระดูกสันหลังส่วนคอข้อที่ 7 ซึ่งมีความสำคัญ ในการฉีดยาชาที่ด้านข้างกระดูกสันหลังโดยวิธีการใช้เทคนิค อัลตราซาวด์ 2 เทคนิค และวิธีการคลำปุ่มกระดูกร่วมกับก้มเงยคอ

วัสดุและวิธีการ: ทำการศึกษาในอาสาสมัคร 20 คน ทั้งด้านซ้ายและขวา โดยการคลำปุ่มกระดูกร่วมกับการก้มเงยคอ การตรวจอัลตราซาวด์ ตามแนวตัดขวางของกระดูกคอที่ 7 และการตรวจตามแนวยาวของกระดูกสันหลัง นับจากกระดูกซี่โครงที่ 1 ตามลำดับ จากนั้นยืนยันความถูกต้อง โดยการเอกซเรย์ ตำแหน่งที่ได้จากการตรวจแต่ละวิธีจะถูกบันทึกไว้ และนำมาเปรียบเทียบความถูกต้อง

ผลการศึกษา: วิธีการตรวจโดยการคลำปุ่มกระดูกร่วมกับให้ผู้ป่วยก้มเงยคอถูกต้องร้อยละ 72.5 ในขณะที่การตรวจอัลตราซาวด์ตามแนวตัดขวาง ของกระดูกคอที่ 7 และการตรวจตามแนวยาวของกระดูกสันหลังนับจากกระดูกซี่โครงที่ 1 มีความถูกต้องร้อยละ 52.5 และร้อยละ 30 ตามลำดับ พบว่าการระบุตำแหน่งที่ผิดนั้นส่วนใหญ่เป็นกระดูกคอข้อที่ 6 ซึ่งสูงกว่าที่ต้องการหนึ่งข้อ

สรุป: วิธีการระบุกระดูกคอข้อที่ 7 ด้วยเครื่องอัลตราซาวด์โดยวิธีการตรวจตามขวางและการตรวจตามแนวยาวของกระดูกคอ พบมีความถูกต้องแม่นยำ น้อยกว่าวิธีการคลำปุ่มกระดูกร่วมกับการก้มและเงย และเทคนิคการใช้อัลตราซาวด์ในการตรวจยังต้องพัฒนาและปรับปรุงเพิ่มเติมถ้าจะนำไปใช้จริง