ORIGINAL ARTICLE

Accuracy of Right sternocleidomastoid's surface landmark for Internal jugular vein catheterization in Thai critically ill patients

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Background: Central venous catheterization of the internal jugular vein (IJV) is crucial for critically ill patients. While ultrasound guidance is the recommended method, the surface landmark technique using the sternocleidomastoid (SCM) muscle is still utilized in some settings.

Objective: The present study aimed to assess the accuracy of this technique in Thai critically ill patients and explore related factors.

Materials and Methods: This diagnostic accuracy study enrolled 85 Thai critically ill patients from the medical intensive care units. The primary outcome was the accuracy of the right SCM surface landmark for IJV catheterization in a supine position with the head turned to 45 degrees, measured by the distance between the landmark and the center point of the IJV on 2D ultrasound. Secondary outcomes included the relationship between the IJV and the common carotid artery (CCA) based on the classification model by Lin et al., as well as factors influencing accuracy.

Results: The surface landmark technique achieved an accuracy of 63.53% (54/85). Type b (IJV lateral upward to CCA) was the most frequent, observed in 65.88% (56/85) of cases, while types d and e (small IJV above and lateral to the CCA) were not present in the present study. Height was the only factor significantly associated with accuracy, with shorter individuals exhibiting higher precision rates ($p=0.03$).

Conclusion: The surface landmark technique for IJV catheterization has limited accuracy in Thai critically ill patients; however, accuracy would increase to 98.82% if moved laterally by 5 mm to the landmark surface. The association between height and accuracy warrants further investigation.

Keywords: Central venous catheterization; Anatomical landmark; Surface landmark; Internal jugular vein

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Insertion of a jugular central venous catheter is an important procedure in the care of critically ill patients[(1)] because it has many necessary indications, such as intravenous administration of high-concentration drugs, parenteral nutrition, hemodynamic parameters monitoring or unable to access peripheral blood vessels[(1)]. There are several methods of inserting a large vein catheter in the neck. But the method that is currently recommended is the use of ultrasound guidance during insertion[(2)] because it can cause undesirable complications such as pneumothorax, hemothorax, and insertion of the wrong catheter into the common carotid artery[(3)], which conditions increase the morbidity and mortality rate. In areas where there was no ultrasound device on-site, the use of surface landmarks of the sternocleidomastoid muscle is also preferred (Sternocleidomastoid's surface landmark) by taking the top of the intersection of the muscles in the neck. It is assumed that below this point is the location of the large internal jugular vein[(4)], but there have been reports of discrepancies in the location of the vein and arteries, such as studying the location of the Internal jugular vein and the location of common carotid artery from computerized radiographs in normal supine positions in Thai patients. It was found that the position of the major vein was in the wrong position in 5.8%[(5)]. When the head was turned, the position of the vein was estimated to have shifted from the original by 0.54±0.50 centimeters [95% CI 0.44 to 0.64][(6)]. Therefore, the accuracy of the surface observation of the sternocleidomastoid muscle when turning the head in American patients was studied. Surface landmarks did

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not match the location of the jugular vein in 34% of cases [95% CI 0.25 to 0.44][7], and the use of surface landmarks of the sternocleidomastoid muscle in inserting a large venous catheter into the neck is a skill that depends on increased experience from studies in anesthesiologists. It was found that higher training years use more accurate observation of the surface of the sternocleidomastoid muscle to insert a large jugular venous catheter[8,9].

In Thailand, it was just a study of the relationship between the jugular veins. And arteries in the neck in patients with chronic kidney failure at Loei Hospital by using an ultrasound wave reflection image to examine the neck area. However, the location was not specified as a surface landmark of the sternocleidomastoid muscle. It was found that the veins were in normal position 87%[10].

As a result, no study in Thailand demonstrates the accuracy of the surface observation points of the sternocleidomastoid muscle for catheter insertion. Blind technique with the surface landmark is still famous usage because they do not have adequate ultrasound machines. The present study can be developed to find a method for catheter insertion without using an echo imager which is suitable for the context of most hospitals in Thailand in the future.

Materials and Methods

Study design

This is a diagnostic accuracy study of medical critically ill patients who admitted to the Internal Medicine ICU, Srinagarind Hospital, Khon Kaen, Thailand from July 2021 to December 2022 were eligible for the present study. The inclusion criteria consisted of: 1) Patients aged 18 or over, both males and females, 2) Admitted to medical ICU 1 or 2 in Srinagarind Hospital, Khon Kaen, Thailand. The patients who are: 1) Pregnant patients, 2) The skin in the area studied is wounded or has an infection, 3) History of blood clots in a large vein in the neck, 4) There was a previous catheter in the neck, 5) Patients with a tracheal tube inserted in their neck, 6) People with deformities in the neck that affect the location of blood vessels, such as lumps or lymph nodes in the neck, and 7) Patients who refused to participate in research were excluded from the present study. The primary objective of the present study is to find the accuracy of surface observation of the sternocleidomastoid muscle for right jugular vein catheter placement in Thai critically ill patients. The secondary outcomes are: 1) To study the factor associated with the accuracy of landmark surface, and 2) To study the relationship between the internal jugular vein and the common carotid artery. In the area under the surface landmark of the tip of the sternocleidomastoid muscle with supine position and head is turned 45 degrees to the left. Based on the relationship model of Lin et al. Classification[11]

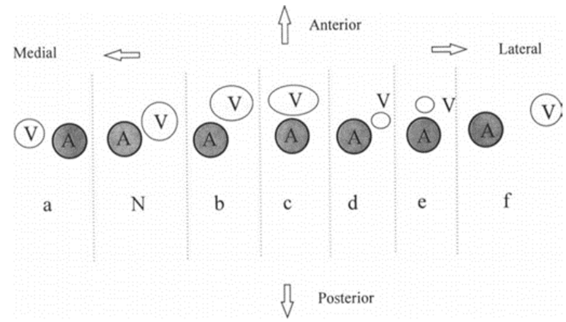


Figure 1. Various sizes and locations of IJV.

(A=carotid artery; V=internal jugular vein). N=IJV of adequate size and normal location. a=Reversal of CA and IJV; b=partially overriding IJV; c=completely overriding TJV; d=small IJV at the normal location; e=small, overriding IJV; f=distant IJV.

as shown in Figure 1.

Operational definitions

The right sternocleidomastoid's surface landmark is the triangular vertex in the skin area formed by the meeting of the heads of the sternocleidomastoid muscle. There is a point

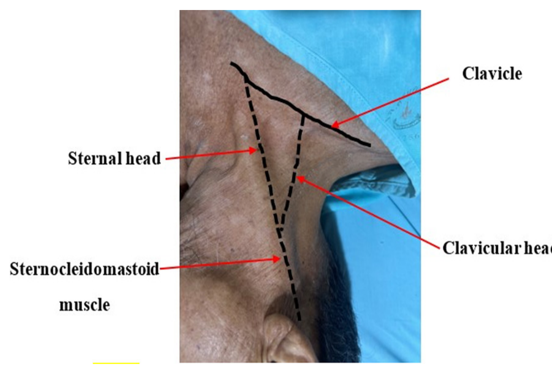


Figure 2. Surface landmarks of the sternocleidomastoid muscle.

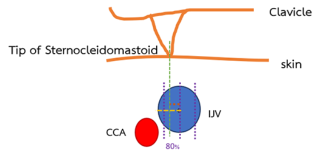
of attachment from the clavicular head and the sternal head with the base being the clavicle (4) as shown in Figure 2.

The small size IJV is less than 5 millimeters in diameter[11].

Accuracy is specificity that is measured from the triangular peak of the surface landmark of the sternocleidomastoid muscle drag through the jugular vein. The acceptable distance from the center to the line drawn through the vein is 80% of the radius[7] as shown in the Figure 3. Only the model of Lin et al. classification N, b, and c are normal positions of right IJV.

Ethnic Consideration and Procedure

The present study was approved by the Ethics



Calculation method

$$= \frac{\text{The distance from the center of IJV to the point where the apex of triangle passes through (dashed orange line)} \times 100}{\text{IJV radius (dashed yellow line)}}$$

Figure 3. Diagram of the measuring method.

Committee of the Center for Ethics in Human Research, Khon Kaen University (HE641273, 08/17/2021) by the Helsinki Declaration. The information obtained from the study, including the patient's history, was kept confidential and took into account the patient's rights. The results are represented as an overview, not individual data.

We collected data by reviewing medical records from the hospital information systems database (Health Object system) and inpatient log files. Patient demographic data, Height, and weight including BMI and Shock types were collected in a data record form that was approved by the Ethics Committee.

Study tools are as below

1) 2D sound wave reflection image generator (Ultrasound 2D), brand G&E, model VANUE® and linear vascular probe.

2) A retraction band across the bed for tying the patient's head so that it faces 45 degrees to the left.

3) Goniometer for locating the angle of 45 degrees.

The study methods are as below

1) Request permission from the patient or legal representative in cases where the patient is unconscious and able to make decisions on their own.

2) Position the patient in a supine position at 180 degrees.

3) Position the patient's head 45 degrees to the left using a goniometer. Then immobilize the patient's head with a retraction band across the bed.

4) Locate surface landmarks of the sternocleidomastoid muscle, by marking the top of the landmark triangle with pen ink.

5) Place the angiography probe at the center of the probe perpendicular to the triangular vertex.

6) Specify the IJV and CCA by pressing and relaxing (Compression test), which is confirmed by the Pulse-wave form.

7) Measures the depth between the skin and the upper edge of the jugular vein.

8) Measures the diameter of the vein for radius and 80% acceptable line as in picture 3.

9) Create a line from the center of the image with M mode and then the distance from the center of the vein to the drawn line.

10) Capture ultrasonic image for recording form.

Sample size calculations

The infinite population proportion was used for estimating the sample size. Based on a previous study, the accuracy rate was 87%.(10) The estimated sample size was calculated with Proportion (p) of 0.87, Error (d) of 0.05, Alpha (α) of 0.05, and Z (0.975) of 1.96. At least 82.79 patients were required to reach statistical significance for the primary outcome. A total of 85 patients were included in the present study.

Statistical analysis

We used the SPSS program ver.26 (Khon Kaen University, Khon Kaen, Thailand) for statistical analysis. Based on descriptive statistics, categorical data was presented as numbers and percentages, and descriptive numerical data was presented as median ± interquartile range (IQR) for non-normally distributed parameters. The Chi-square test and Mann-Whitney U-test were used for dichotomous variations. Statistical significance was obtained using a p-value less than 0.05.

Results

A total of 85 patients were included in the present study between August 2021 and December 2023. The patients' characteristics are shown in Table 1. A total of 85 patients were male 51 (60%). The median age was 62 (IQR 57, 78) years. The median height and weight were 163 (IQR 155, 165) and 58 (IQR 49, 70) respectively. A tiny percentage of 5.88 was shock stage in the present study due to excluded patients who had central catheters before recruitment. The accuracy of surface observation of the sternocleidomastoid muscle for right jugular vein catheter placement in the present study is 63.53% (54 of 85 patients). The height in the accuracy group (mean 160 (IQR 155, 165)) cm was shorter than the inaccuracy group (mean 168 (IQR 159, 170)) with a statistically significant difference, p=0.03.

The relationship between the IJV and CCA in the area of the surface landmark of the sternocleidomastoid muscle is reported in Table 2. Almost all patients (80/85, 94.12%) have IJV lateral to CCA. Fifty of 85 patients (58.28%) had A-V relation type b, 14 of 85 patients (16.47%) had A-V relation type c, 7 of 85 patients (8.24%) had A-V relation type N, 5 of 85 patients (5.88%) had A-V relation type a, 3 of 85 patients (3.53%) had A-V relation type f, and no type d and e were detected in the present study. There was no small-size IJV in this report, the mean radius was 6.73±2.03 mm. No statistically significant difference in type and radius between the accuracy and inaccuracy groups.

Analysis of distance from the tip of SCM to the center of IJV varied on the type of A-V classification was shown

Table 1. Patient characteristics

Factor	Total (n=85)	Accuracy group (n=54)	Inaccuracy group (n=31)	p-value
Basic characteristic				
Sex: male, n (%)	51 (60)	29 (53.70)	22 (70.97)	0.12
Age (year), median (IQR)	67 (57 to 78)	67 (57 to 75.75)	67 (59.50 to 82)	0.60
Height (cm), median (IQR)	163 (155 to 170)	160 (155 to 165)	168 (159 to 170)	0.03
Body weight (kg), median (IQR)	58 (49 to 70)	56.50 (48.10 to 70)	58 (50 to 65.50)	0.92
BMI (kg/m^2), median (IQR)	21.45 (19.50 to 24.97)	21.64 (19.51 to 25.77)	21.33 (19.28 to 23.56)	0.44
BMI ≥23 (kg/m^2), n (%)	30 (35.29)	19 (35.19)	11 (35.48)	0.98
BMI ≤18 (kg/m^2), n (%)	13 (15.29)	8 (14.81)	5 (16.13)	0.87
Hemodynamic status				
Shock state, n (%)	5 (5.88)	2 (3.70)	3 (9.68)	0.26
Hypovolemic shock, n (%)	1 (1.18)	0	1 (3.23)	0.18
Septic shock, n (%)	3 (3.53)	1 (1.85	2 (6.45)	0.27
Cardiogenic shock, n (%)	1 (1.18)	1 (1.85)	0	0.45

Table 2. Various sizes and locations of IJV as Lin et al. classification

Factor	Total (n=85)	Accurate (n=54)	Inaccurate (n=31)	p-value
Type				
Type a, n (%)	5 (5.88)	4 (7.41)	1 (3.23)	0.43
Type N, n (%)	7 (8.24)	3 (5.56)	4 (12.90)	0.24
Type b, n (%)	56 (65.88)	36 (66.67)	20 (64.52)	0.84
Type c, n (%)	14 (16.47)	10 (18.52)	4 (12.90)	0.50
Type d & e, n (%)	0	0	0	0
Type f, n (%)	3 (3.53)	1 (1.85)	2 (6.45)	0.27
Type N + b + c	73 (85.88)	47 (87.04)	28 (90.32)	0.95
Radius, mm (mean ± SD)				
Type a	5.66±1.76	6±1.84	4.30±0	0.47
Type N	6.40±1.84	6.87±1.53	6.05±2.19	0.61
Type b	6.85±2.11	6.96±2.15	6.65±2.02	0.60
Type c	6.83±2.20	6.77±2.54	6.98±1.28	0.88
Type d & e	0	0	0	0
Type f	6.57±1.25	8±0	5.85±0.21	0.08
All types	6.73±2.03	6.87±2.12	6.48±1.87	0.41

in Table 3, Figure 4, and Figure 5. In the accuracy group, all types of A-V classifications (except type a) showed the tips of SCM were medial to the center of IJV in a range of 2.45±1.73. On the other hand, in the inaccuracy group, all types of A-V classifications (except type a) had the tips of SCM that were more distant from the 80% radius line of IJV about 3.83±3.82 mm.

Discussion

The present study investigated the accuracy of using the right sternocleidomastoid muscle's surface landmark for internal jugular vein (IJV) catheterization in Thai critically ill patients. While the method achieved an accuracy of 63.53%, this finding suggests limitations and raises crucial points for discussion. The results are similar to the research of Mr. Bailey PL et al.[7], which obtained an accuracy of 66%. And the results of the present study differ from a previous study in Thailand, by Wongput P. et al.[10] that found an accuracy of 87%. This may be explained by the study population not being in the ICU, which may cause the four numbers to differ.

Firstly, the 36.47% inaccuracy rate highlights the potential risks associated with solely relying on the surface landmark. This discrepancy between the landmark and the actual vein location can lead to complications during catheterization, such as arterial puncture, pneumothorax, and hemothorax. These complications can significantly increase patient morbidity and mortality. Additionally, if we move the surface landmark lateral to the tip of SCM for 5 mm, the accuracy might increase to 98.82% (84/85) as green arrow line in Figure 4 and 5.

Secondly, the association between height and accuracy

Table 3. Distance from the tip of SCM to the center and the outer 80% of IJV radius

Type	Δ from the tip of SCM, mm (mean ± SD)			
	Outer 20% of radius	Inner 80% of radius		Outer 20% of radius
	Medial	Medial	Lateral	Lateral
Accuracy group				
Type a	-	-	1.50±1.57	-
Type N	-	2.20±2.29	-	-
Type b	-	2.55±1.60	-	-
Type c	-	2.04±2.17	-	-
Type f	-	3.90±0	-	-
All type (except type a)	-	2.45±1.73	-	-
Inaccuracy group				
Type a	-	-	-	4.76±0
Type N	3.54±2.57	-	-	-
Type b	4.38±4.32	-	-	-
Type c	1.30±0.53	-	-	-
Type f	4.02±3.99	-	-	-
All type (except type a)	3.83±3.82	-	-	-

requires further exploration. While shorter individuals demonstrated a higher success rate in this study, a larger sample size is necessary to confirm this finding and elucidate the underlying mechanisms. It's important to avoid drawing definitive conclusions from limited data.

Thirdly, the analysis of the type of A-V classification did not yield significant results regarding accuracy. This suggests that the relative positions of the IJV and CCA might not be a major determinant of success in this specific study population. However, further research with a larger sample size and diverse patient characteristics could be beneficial to explore this aspect further.

Fourthly, the study emphasizes the importance of considering limitations when interpreting the findings. The single-center design and specific inclusion/exclusion criteria limit the generalizability of the results to the entire Thai population. Additionally, the study focused on healthy volunteers, and the results might not be directly applicable to critically ill patients who may have anatomical variations or physiological changes affecting the IJV location.

Furthermore, the present study highlights the need for further research to:

Replicate and validate the findings in a larger and more diverse patient population.

Investigate the association between height and accuracy with a larger sample size to confirm or refute the initial observation.

Explore the influence of other potential factors on accuracy, such as body mass index, neck anatomy variations, and underlying medical conditions.

Evaluate alternative methods for IJV catheterization that could potentially improve accuracy and safety.

By addressing a new landmark (5mm lateral to the tip of SCM), future research can contribute to establishing optimal practices for IJV catheterization in Thai patients and improve patient safety in critical care settings.

Conclusion

In light of these considerations, the present study contributes valuable insights into the limitations of using the surface landmark for right IJV catheterization in Thai critically ill patients. The significant inaccuracy rate and potential for complications underscore the importance of prioritizing ultrasound guidance as the preferred method for this procedure. Further external validation of the new landmark (5 mm lateral to the tip of SCM) might increase the accuracy.

What is already known on this topic?

The accuracy of the surface landmark of SCM for right IJV catheterization in USA patients was not very high about 66%. The Thai population has no data on critically ill patients who were at high risk of central venous catheterization.

What this study adds?

After analysis Thai critically ill patients had an accuracy of surface landmark same Americans. Additionally, if we move the surface landmark lateral to the tip of SCM for 5 mm, the accuracy might increase from 65.88% to 98.82% with further external validation in a large population.

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We could not have completed this project without

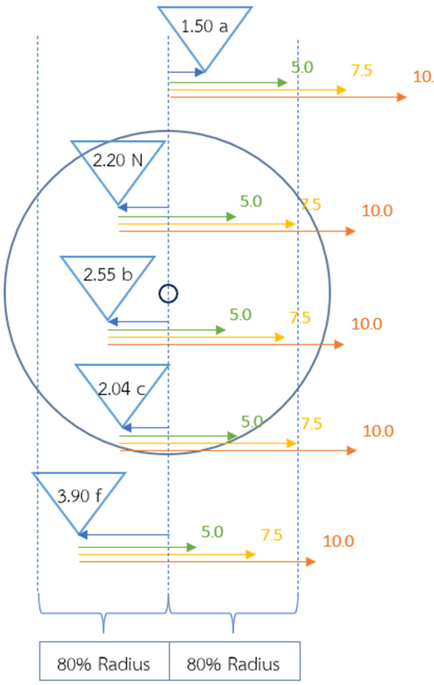

Figure 4. Distance from the tip of SCM to the center of IJV in an accuracy group.

Blue arrow = mean distance from the tip of SCM to outer 80% of IJV radius

Green arrow = suggestion point of new puncture from the tip of SCM to lateral about 5 mm.

Yellow arrow = suggestion point of new puncture from the tip of SCM to lateral about 7.5 mm.

Orange arrow = suggestion point of new puncture from the tip of SCM to lateral about 10 mm.

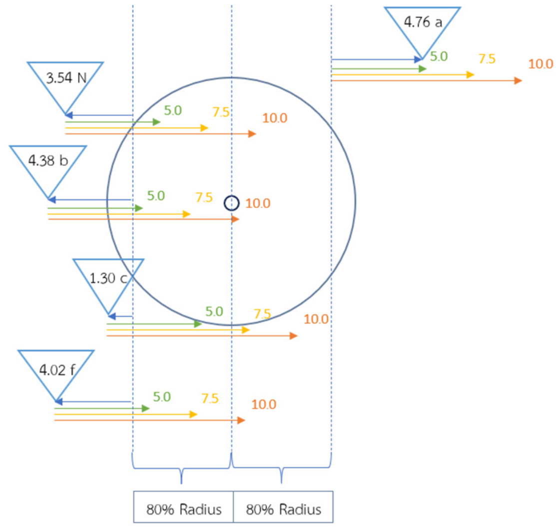

Figure 5. Distance from the tip of SCM to the outer 80% of the radius line of IJV in the inaccuracy group.

Blue arrow = mean distance from the tip of SCM to outer 80% of IJV radius

Green arrow = suggestion point of new puncture from the tip of SCM to lateral about 5 mm.

Yellow arrow = suggestion point of new puncture from the tip of SCM to lateral about 7.5 mm.

Orange arrow = suggestion point of new puncture from the tip of SCM to lateral about 10 mm.

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Conflicts of interest

The authors declare no conflict of interest.

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