Risk of Cephalic Vein Injury During the Creation of an Anterior Portal in Shoulder Arthroscopy

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Background: There is a risk of cephalic vein injury during shoulder arthroscopy. However, limited data regarding its anatomic course are available.

Purpose: To analyze the positional relationship and factors affecting the distance between the coracoid tip and cephalic veins.

Study design: Case series; Level of evidence, 4.

Methods: A total of 80 contrast-enhanced computed tomography images from 80 patients (mean age, 49.6 ± 20.3 years; 61 men) were retrospectively analyzed. The distance between the center of the coracoid tip and the vertical line through the cephalic vein was measured in the axial (D1) and sagittal (D2) planes. The distance between 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein was measured in the sagittal plane (D3). Each distance was compared according to patient sex and laterality. Associations between each distance and the patient's age, height, weight, and body mass index were investigated.

Results: The mean D1 was 18.4 ± 7.3 mm in 59 patients. The mean D2 was 23.4 ± 11.6 mm, and it was within 10 mm in 10 patients (12.5%). The mean D3 was 33.7 ± 12.2 mm. There was no significant difference in D1, D2, and D3 according to patient sex or laterality. A positive correlation was observed only between D3 and patient height (r = 0.320; P = .034).

Conclusion: The cephalic vein was found to travel a mean of 23.4 mm distal and 33.7 mm distal to 1 cm lateral to the coracoid tip. Care should be taken to avoid cephalic vein injury when creating an anterior inferior portal or 5-o'clock portal around these areas.

Keywords: anterior shoulder portal; cephalic vein; cephalic vein injury; contrast-enhanced computed tomography; coracoid tip; shoulder arthroscopy

Arthroscopy is widely used for shoulder disorders because of the minimal invasiveness of the procedure and the expected earlier postoperative recovery associated with it than that seen with open procedures.[6] However, a disadvantage of arthroscopic surgery is that neurovascular structures cannot be directly visualized and could be injured during a procedure. In particular, the most important neurovascular structures are present anterior to the glenohumeral joint. The cephalic vein is the structure most susceptible to injury during the creation of anterior portals in shoulder arthroscopy.[3,9,13,15]

The cephalic vein is a superficial vein that originates in the radial aspect of the forearm. The vein passes through the deltopectoral groove and travels inferior and medial to the coracoid process. Ultimately, it joins the axillary vein. The cephalic vein can be injured either during portal creation or from the repetitive insertion of devices during the procedure. Although the frequency or the clinical outcomes of cephalic vein laceration have not been reported, perforation of the cephalic vein could result in increased blood loss, deterioration of the arthroscopic field of view, development of postoperative hematomas, and adhesion formation. Therefore, cephalic vein injury should be avoided.

The coracoid tip has often been used to determine the location of the anterior portals in shoulder arthroscopy,

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as it is easily palpable through the skin.[9,19] Anterior portals are usually created just inferior or slightly lateral to the coracoid tip to avoid injuring the multiple neurovascular structures present along the medial aspect.[1,12,19] Wolf[19] established an anterior inferior portal at the inferior edge of the coracoid tip. Anz and Labrum[1] utilized a 5-o'clock portal (on the right shoulder) positioned 2 cm inferior to the coracoid tip. Matthews et al[12] reported that the skin incision point of an anterior central portal was just lateral to the coracoid tip. Considering that the mean width of the coracoid tip is approximately 2 cm,[17] the area just lateral to the coracoid tip represents approximately 1 cm lateral to the center of the coracoid tip. When considering the risk of cephalic vein injury during the creation of anterior portals, it is important to be aware of the distance from the coracoid tip to the cephalic vein.

The distance between the cephalic vein and the coracoid tip has been described using cadaveric dissections[1,9,15]; nonetheless, no studies have examined the relationship in vivo. Moreover, it is unknown whether physical characteristics—such as patient height, weight, body mass index (BMI), or age—affect the distance between the cephalic vein and the coracoid tip. Understanding this positional relationship could help avoid cephalic vein injury when creating anterior portals.

This study aimed to clarify the location of the cephalic vein relative to the coracoid tip and evaluate the correlation between the position of the cephalic vein and patient size and age. We hypothesized that the distance from the coracoid tip to the cephalic vein would be short in shorter patients.

METHODS

The study protocol received institutional review board approval; patient informed consent was not required. Contrast-enhanced computed tomography (CT) imaging (SOMATOM Definition Edge or Flash; Siemens; slice thickness, 1 mm) of the whole body was performed as part of our standard management for patients with high-energy injuries; the contrast agents were used to evaluate vascular injuries. In total, 193 CT images were obtained between May 2019 and December 2021. We included images that met the following inclusion criteria: (1) <30° of shoulder abduction; (2) contrast agent infused into the ipsilateral side of the arm; and (3) patients aged >15 years. The exclusion criteria were as follows: (1) nonenhanced cephalic vein; (2) any acute or chronic traumatic injury around the shoulder; and (3) severe osteoarthritis of the glenohumeral joint. Following these criteria, 14 images with a nonenhanced cephalic vein, 89 images with a shoulder abduction angle of >30°, and 10 images showing traumatic changes around the shoulder were excluded. The remaining 80 CT images were included for analysis in this study (Figure 1).

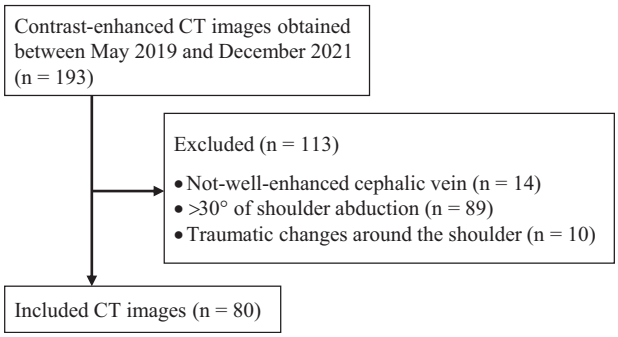

Figure 1. Flow diagram for study inclusion. CT, computed tomography.

For each included image, data on the height, weight, and BMI of the patient were collected from the medical records. Three-dimensional CT and multiplanar reconstruction images were obtained using SYNAPSE VINCENT (Fujifilm). The location of cephalic vein injury was determined by simulating vertical needle insertion into the patient undergoing CT imaging. The shortest distance between the center of the coracoid tip and the respective vertical lines to the sagittal and axial planes through the cephalic vein was measured in the axial (D1) and sagittal planes (D2). In addition, since portals were often created lateral to the coracoid tip in the clinical setting, the distance between a point 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein was measured in the sagittal plane (D3) (Figure 2). Considering that the mean width of the coracoid tip is approximately[17] 2 cm, D3 was located where the simulated portals were created just lateral to the coracoid tip.[12,19]

Two orthopaedic surgeons (J.I. and Y.I.) performed all measurements independently, and interobserver reliability was determined. One of the observers (J.I.) subsequently repeated them in 10 randomly selected images to determine intraobserver reliability.

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Ethical approval for this study was obtained from Komaki City Hospital (ref No. 201039).

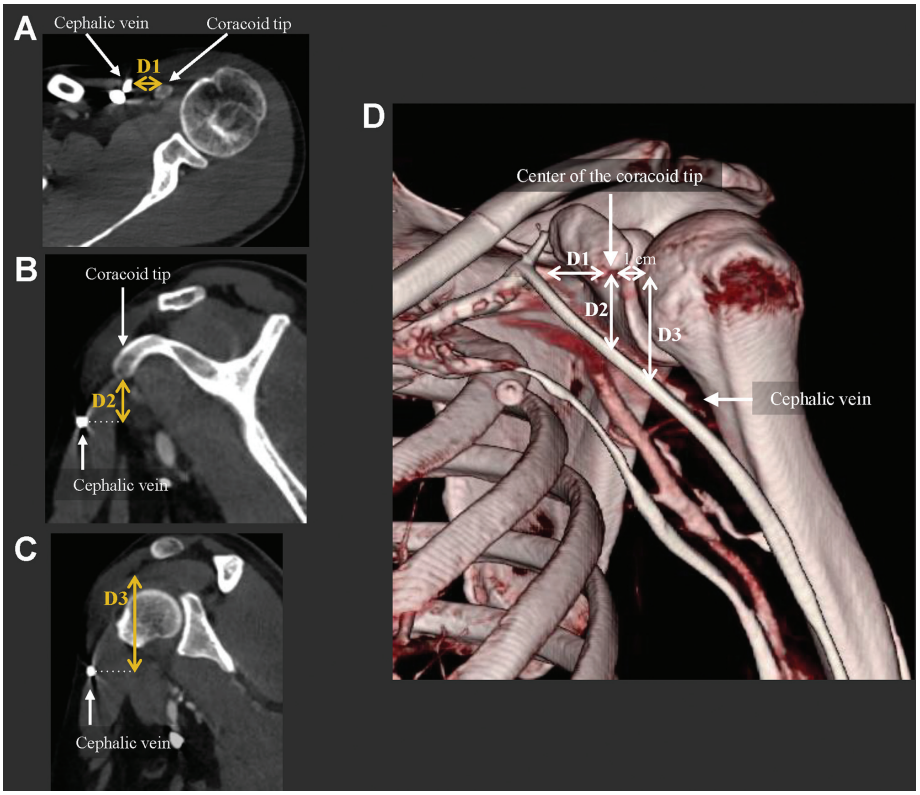

Figure 2. Measurements used in this study. (A) D1, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the axial plane. (B) D2, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane. (C) D3, the distance between 1 cm lateral of the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane. (D) A 3-dimensional computed tomography image demonstrating D1, D2, and D3.

Statistical Analysis

The inter- and intraobserver reliability of the distance measurements was calculated using the intraclass correlation coefficient (ICC). Each distance measurement was compared according to patient sex and laterality using the independent-samples *t* test. In addition, the associations between D1, D2, or D3 and the patient's age, height, weight, and BMI were investigated using the Pearson correlation coefficient (*r*). Statistical analyses were performed using the SPSS Version 21.0 software (IBM). Statistical significance was set at $P < .05$.

The statistical power was calculated using G*Power Version 3.1.9 (Heinrich Heine University) to determine the required sample size for identifying the correlation between the distance measurements and patient characteristics. At least 29 cases were needed to achieve a power of 0.80 with an effect size of 0.43. This was determined according to the results of the primary cases; the threshold for significance was set at $P < .05$.

RESULTS

The ICCs for inter- and intraobserver reliability of the distance measurements were 0.974 (95% CI, 0.947-0.988) and 0.975 (95% CI, 0.948-0.988), respectively, indicating excellent agreement for both.

The 80 CT images were from 61 male and 19 female patients. The mean patient age was 49.6 ± 20.3 years (range, 17-90 years). The shoulder position on the images was neutral or internally rotated in all patients. The mean D1, measured on 59 images, was 18.4 ± 7.3 mm. In the remaining 21 cases, D1 could not be calculated because the cephalic vein was connected to the axillary vein underneath the tip of the coracoid process. The mean D2 was 23.4 ± 11.6 mm, and it was within 10 mm in 10 cases. The mean D3 was 33.7 ± 12.2 mm, and it was within 10 mm only in 1 case (Table 1 and Figure 3). There were no significant differences in D1, D2, and D3 according to the patient's sex or laterality (Table 2).

The data on height, weight, and BMI were available for 44 patients for D2 and D3 and 29 patients for D1. Their mean values were 163.5 ± 9 cm, 59.2 ± 12.1 kg, and 21.7 ± 2.7, respectively. The correlation analysis revealed a positive correlation only between D3 and the patient's height ($r = 0.320$; $P = .034$) (Table 3).

DISCUSSION

The most important finding of this study was that the cephalic vein was at the highest risk for injury when

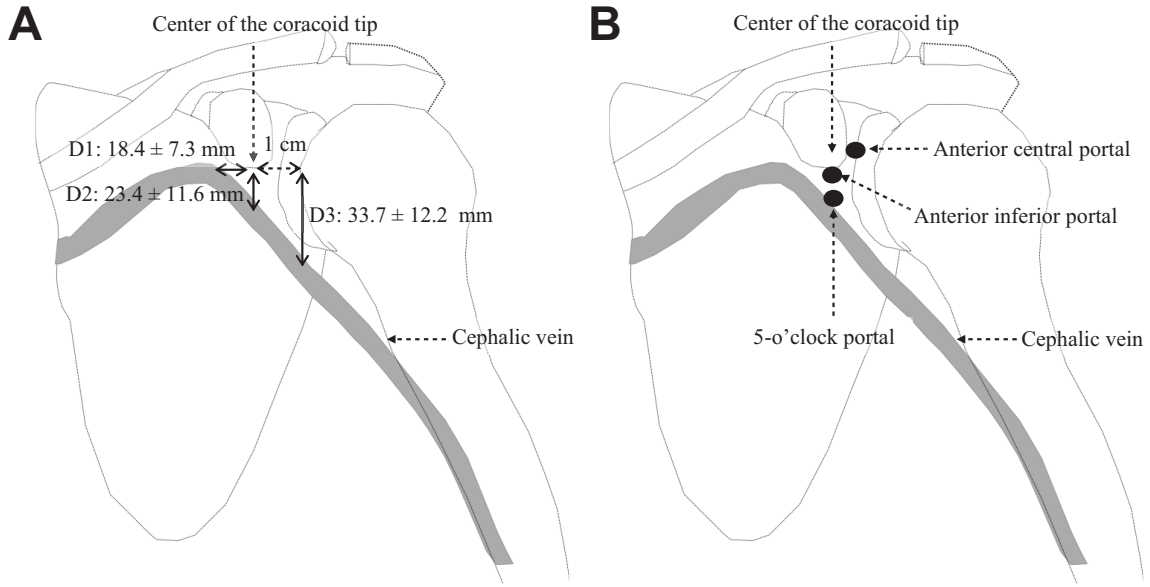

Figure 3. Positional relationship between the coracoid tip and cephalic vein and (A) the mean distance measurements and (B) anterior portals. D1, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the axial plane; D2, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane; D3, the distance between 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane.

TABLE 1
Distance From the Coracoid Tip to the Cephalic Vein[a]

Parameter	Distance, mm	Distance ≤10 mm
D1 (n = 59)	18.4 ± 7.3	7 (11.9)
D2	23.4 ± 11.6	10 (12.5)
D3	33.7 ± 12.2	1 (1.3)

[a]Data are presented as mean ± SD or n (%). D1, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the axial plane; D2, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane; D3, the distance between 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane.

TABLE 2
Comparison of Distances From the Coracoid Tip to the Cephalic Vein According to Sex and Laterality[a]

	D1, mm	D2, mm	D3, mm
Sex			
Male	18.7 ± 7.8	23.6 ± 11.9	34.6 ± 11.5
Female	17.4 ± 5.3	22.7 ± 11.1	30.8 ± 14.3
P	.573	.786	.242
Laterality			
Right	18.3 ± 7	23.8 ± 10.8	34.6 ± 10.7
Left	18.5 ± 7.6	23.1 ± 12.2	33.2 ± 13.1
P	.909	.819	.630

[a]Data are reported as mean ± SD. D1, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the axial plane; D2, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane; D3, the distance between 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane.

a portal was created 2 to 3 cm distal to the coracoid tip because the mean distances from the coracoid tip and 1 cm lateral to the coracoid tip to the cephalic vein in the sagittal plane were 23.4 and 33.7 mm, respectively. Moreover, in 12.5% of patients, the cephalic vein ran within 10 mm of the coracoid tip. Therefore, the cephalic vein could be injured even though an anterior inferior portal is created just distal to the coracoid tip. When creating a portal at this site, a sharp incision should be made only on the skin to avoid cephalic vein injury.

When a portal was created 1 cm lateral to the coracoid tip, the cephalic vein rarely passed within 10 mm of the coracoid tip. In addition, no cephalic vein passed lateral to the coracoid tip in the axial plane through the coracoid tip. Thus, an anterior central portal appears to have a low risk of cephalic vein injury as the portal is created just lateral to the coracoid tip.[12] Considering the mean glenoid height[4,7,11] of 32 to 38 mm and the mean distance of 33.7 mm between 1 cm lateral to the coracoid tip and the cephalic vein observed in this study, the risk of cephalic vein injury appeared to be low when anterior portals were created 1 cm lateral to the coracoid tip. However, surgeons must remember that the cephalic vein tends to be close to

TABLE 3
Correlation Analysis Between Explanatory Variables and Distances From the Coracoid Tip to the Cephalic Vein[a]

	D1 (n = 29)		D2 (n = 44)		D3 (n = 44)	
Variable	*r*	*P*	*r*	*P*	*r*	*P*
Age, y	–0.183	.164	–0.166	.142	–0.172	.127
Height, cm	0.242	.206	0.172	.264	0.320	**.034**
Body weight, kg	0.004	.984	0.025	.874	0.006	.971
BMI, kg/m^2	–0.186	.334	–0.088	.572	–0.204	.184

[a]The bold *P* value indicates statistical significance ($P < .05$). D1, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the axial plane; D2, the distance between the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane; D3, the distance between 1 cm lateral to the center of the coracoid tip and the vertical line through the cephalic vein in the sagittal plane. BMI, body mass index.

the coracoid tip in shorter patients, regardless of anterior portals being created 1 cm lateral to the coracoid tip.

Although significant secondary clinical morbidity from cephalic vein injury rarely occurs,[8,18] there have been some reports on cephalic vein injury in a clinical setting.[3,10] Cameron[3] reported that a venous pseudoaneurysm occurred after shoulder arthroscopy because of a cephalic vein injury, which required additional surgery. In addition, Matache et al[10] reported that the postoperative patency of the cephalic vein affected postoperative limb edema. An injury to a vascular structure would likely require the opening of the shoulder for exploration and treatment. Moreover, the cephalic vein should be preserved, as it can be required for heart catheterization or long-term venous access in chemotherapy.[2,16]

In this study, the standard deviations for D1, D2, and D3 were relatively large, which indicated that the distances had individual differences. Although a positive correlation was found between D3 and patient height, it would be better to assess the position of the cephalic vein individually to strictly avoid cephalic vein injuries, such as those on the side of the shunt in patients on dialysis. Since contrast-enhanced CT is not often used in patients undergoing shoulder arthroscopy, ultrasound may be used to confirm the exact location of the cephalic vein.

Some cadaveric studies have investigated cephalic vein injuries during shoulder arthroscopy.[1,8,13,15] Meyer et al[13] reported the mean distances from the anterior inferior portal, anterior central portal, and 5-o'clock portal to the cephalic vein as 14, 17, and 17 mm, respectively. They also stated that in some cases, trocars inserted from the anterior inferior and anterior central portals injured the cephalic vein.[13] Marsland and Ahmed[9] inserted 2 wires from 1 or 2 fingers widths below the coracoid tip and reported that the risk of cephalic vein injury was 30% in both cases. Lo et al[8] demonstrated that the mean distances from an anterior inferior portal and a 5-o'clock portal to the cephalic vein were 18.8 and 9.8 mm, respectively. Anz and Labrum[1] reported that the distance from the cephalic vein to a 5-o'clock portal was approximately 7 mm. In contrast, the distance was approximately 2 mm when a portal was established 1 cm medial to the portal. Pearsall et al[15] reported that the mean distance from the cephalic vein and 2 pins inserted from the 3-o'clock and 5-o'clock positions were 4 and 2 mm, respectively. Pearsall et al[15] did not recommend using a 5-o'clock portal because of the associated high risk of cephalic vein injury.

In this study, the mean distance from the coracoid tip to the cephalic vein was 23.4 mm; thus, if a portal was created 2 cm below the coracoid tip, it would be within 3.4 mm of the cephalic vein. This result seems consistent with those of previous studies. However, previous cadaveric studies were performed with a small sample size (5-12 shoulders), and the shoulders were dissected from the neck and the humerus,[1,9,13-15] which would affect the distance from the vein to the coracoid tip. The advantage of the present study is that the distances were measured on whole-body CT images, and a larger sample size was included.

Limitations

This study had some limitations. First, the shoulder position could not be controlled among the patients because this study was based on a retrospective review. The shoulder position was either neutral or internally rotated, differing between the patients. As the cephalic vein runs from the distal to the medial aspect of the coracoid process, it can move laterally when the shoulder is rotated externally. This would result in the shortening of D1, D2, and D3. According to a previous cadaveric study, the distance from the cephalic vein to a 5-o'clock portal varied between 0° and 30° of shoulder abduction.[1] However, the value of the difference was only 1.1 mm (4.1 vs 5.2 mm). Therefore, the difference in the abduction angle seen in this study appeared to have a small effect on the distance. Second, CT was performed with the patient in the supine position, although shoulder arthroscopy is usually performed with the patient in a beach chair or a lateral decubitus position. Gelber et al[5] reported that the distance from the cephalic vein to an anterior inferior portal increased by approximately 1.5 mm when the position was changed from beach chair to lateral decubitus. Therefore, the difference in patient positioning could have slightly affected the distance measured in this study. Third, patient height, weight, and BMI could not be collected from all patients since patient records from emergency center visits were

not able to be used and some patients did not come after only one visit. Fourth, although D2 and D3 were measured vertically toward the coronal plane, in the clinical setting, anterior portals are obliquely created in the coronal plane. Therefore, when referring to the results of this study during the establishment of anterior portals, the depth of the cephalic vein from the skin should be considered, which would differ between patients and for each part of the cephalic vein. Fifth, the mean values of D1, D2, and D3 reported in this study should be interpreted with caution because of the relatively large standard deviations, indicating individual differences in distance. Despite these limitations, the results of this study could aid surgeons in avoiding cephalic vein injury when creating an anterior portal during shoulder arthroscopy.

CONCLUSION

On average, the cephalic vein traveled 23.4 mm distal to the coracoid tip and 33.7 mm distal to 1 cm lateral to the coracoid tip. Therefore, care should be taken to avoid cephalic vein injury when creating an anterior inferior portal or 5-o'clock portal around these areas.

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