Original Article

Computed tomography in measuring electrode insertion angle and depth for cricopharyngeal muscle electromyography

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Background: Electromyography of the cricopharyngeal muscle (CP-EMG) is one of many assessment tools for dysphagia. The key to performing EMG and BTX injections is to precisely locate the cricopharyngeal muscle with an electrode. One of the main difficulties of electrode insertion is the fact that the CP muscle is located deep within the neck. Since a neck computed tomography (CT) can clearly display the CP muscle, thyroid, and blood vessels in the neck, we speculate that a safe concentric needle electrode insertion path to the cricopharyngeal muscle can be simulated with the assistance of the patient's neck CT which clearly marks the angle and depth of concentric needle electrode insertion. The purpose of this study was to explore simulated electrode insertion angles and insertion depths for cricopharyngeal electromyography based on retrospective CT data and present a method of percutaneous localization of the cricopharyngeal muscle based on CT images of the neck.

Methods: One hundred and forty-three neck CT scans performed between January 2019 and November 2020 were included in this study. With the assistance of the angle and straight-line tools found in the Advantage Workstation 4.4 (GE, HealthCare), simulated insertion angles and depths from the anterior border of the sternocleidomastoid muscle to the cricopharyngeal muscle were obtained.

Results: The 143 CT images originated from participants that included 63 males (44.1%) with an average age of 46.2±13.9 years old. The insertion angle, insertion depth, and neck thickness measured on the CT images were 53.2±10.7°, 24.2±4.1 mm, and 130.1±17.7 mm, respectively. The insertion angle and depth

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were significantly greater in males than in females (P<0.05), and the insertion angle increased with the age of participants (P<0.05). A generalized linear model (GLM) showed that insertion angle was positively correlated with neck thickness (β=0.14; 95% CI: 0.03 to 0.25) and gender (β=5.08; 95% CI: 1.31 to 8.85), and negatively correlated with age (β=−5.88; 95% CI: −9.54 to −1.62). Insertion depth was only positively correlated with the neck thickness (β=0.11; 95% CI: 0.07 to 0.15).

Conclusions: This study indicates that age, gender, and neck thickness are influencing factors for insertion angle, while neck thickness is the influencing factor for insertion depth. The simulated concentric needle electrode insertion method based on CT can assist clinical operation to ensure safety and effectiveness of cricopharyngeal electromyography.

Keywords: Cricopharyngeal muscle; electromyography; computed tomography (CT)

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Introduction

The cricopharyngeal (CP) muscle is a striated muscle sphincter located at the juncture between the pharynx and the esophagus. It originates from the lower half of the lateral aspect of cricoid cartilage (1,2) and is innervated by the recurrent and superior laryngeal nerves, as well as the pharyngeal branch of the vagus nerve (3). The CP muscle is a primary component of the upper esophageal sphincter (UES) (4). It is tonically active at rest to prevent air from entering the esophagus and the reflux of esophageal content into the pharynx during breathing. When swallowing, vomiting, and belching, the CP muscle relaxes intermittently to allow liquid or gas to pass through (5). The timely closure and opening of the CP muscle is necessary for normal swallowing function. In some neurological diseases, myogenic diseases, or other idiopathic dysfunctions, CP muscle relaxation is reduced, not present, or the relaxation duration is shortened (6). This can cause food to not enter the esophagus smoothly when swallowing, which can result in piriform fossa retention, aspiration, and other swallowing disorders. Therefore, cricopharyngeal muscle function is important to consider during the assessment of dysphagia.

Electromyography of the cricopharyngeal muscle (CP-EMG) is one of many assessment tools for dysphagia (7). It quantitatively evaluates the function of the CP muscle through electromyographic response patterns. These patterns can be used to distinguish between myogenic disorders and neurogenic disorders and can help determine the specific etiology of neurogenic disorders (such as peripheral, central, or mixed) (8). CP-EMG is also used to guide botulinum toxin (BTX) injections for the treatment of CP achalasia (9) and it can provide direct information for the evaluation, prognosis estimation, and therapy design of swallowing disorders (10). The key to performing EMG and BTX injections is to precisely locate the cricopharyngeal muscle with an electrode. It is a difficult clinical process with several aspects that need to be considered. One of the main difficulties of electrode insertion is the fact that the CP muscle is located deep within the neck. Clinicians must avoid damage to important adjacent anatomical tissues such as blood vessels, the thyroid, and the recurrent laryngeal nerve.

Implementation of CP-EMG is typically performed through direct percutaneous positioning. Traditionally, a concentric needle electrode is inserted percutaneously into the outside of the cricoid cartilage and then advanced back along the contour of the cricoid cartilage (9,11-13). In some studies, the concentric needle electrode insertion site was positioned at the level of the inferior border of the cricoid cartilage (10), while in others, it was positioned at the level of the superior border of the cricoid cartilage (8,14). Akkin *et al.* (8) inserted the concentric needle electrode percutaneously at the level of the superior border of the cricoid cartilage, anterior to the anterior border of the sternocleidomastoid muscle at a 60-degree angle to the frontal plane in the posteromedial direction. Successful insertion into the CP muscle on 10 cadavers and 37 patients was demonstrated using this method. Compared with the traditional electrode insertion method, Akkin *et al.*'s method avoids situations where the cricoid cartilage plate is too wide for insertion of the concentric needle electrode.

However, the cricopharyngeal muscle is located behind the cricoid cartilage and is far from the skin of the cervical surface. Since EMG localization is not a visual operation, many scholars have reported using auxiliary localization methods such as endoscopic positioning (15-17), ultrasound positioning (18), balloon radiography combined with CT positioning (19), or a combination of balloon catheter, ultrasound, and EMG guidance (20,21). Among these, endoscopic positioning is mainly used to guide botulinum toxin therapy, which needs to be performed after balloon dilation under anesthesia or sedation (17,22). This is difficult to implement in patients with poor physical condition. Furthermore, due to the influence of tracheal gas, it is difficult to visualize the cricopharyngeal muscle via ultrasound positioning. Balloon radiography combined with CT localization requires CT scanning before and after concentric needle electrode insertion and only the surface of the CP muscle can be marked by the balloon. The safety of the insertion procedure is not clear, and the use of balloons is also difficult to implement in patients with medical conditions. Xie *et al.* (21) used a combination of ultrasound balloon catheters and EMG to locate the CP muscle. In this approach, a water injection balloon is first used to locate the lower edge of the CP muscle. A concentric needle electrode is then inserted from the pre-marked side under the guidance of ultrasound positioning. With the balloon being used as a reference to locate the CP muscle, a change in the EMG signal implies the successful insertion of the concentric needle electrode into the CP muscle. This combined positioning method can accurately locate the cricopharyngeal muscle. However, since this method involves the collaborative operation of two or three departments, it is difficult to coordinate in a clinical setting which can lead to poor patient tolerance, limiting is ability to be adopted and popularized in clinical practice.

Many studies use CT images or magnetic resonance images (MRI) to measure the safe range of depths for concentric needle electrode insertion (23,24). Since a neck CT can clearly display the CP muscle, thyroid, and blood vessels in the neck, we speculate that a safe concentric needle electrode insertion path to the cricopharyngeal muscle can be simulated with the assistance of the patient's neck CT which clearly marks the angle and depth of concentric needle electrode insertion. This can greatly improve the safety and efficacy of direct cricopharyngeal muscle percutaneous positioning. It may also improve patients' tolerance. Additionally, the operation can be conveniently performed, which can help promote its clinical use.

In their study, Chen *et al.* demonstrated that the insertion depth of abdominal acupoints in children was related to several factors including gender, age, body weight, and waist girth (23). Thus, we hypothesized that gender, age, body weight, and neck circumference would affect the insertion angle and the insertion depth of CP-EMG electrodes. In this study, obtaining body weight and neck circumference was difficult due to the fact that these data were not included in the electronic medical record system; therefore, neck thickness was selected as the substitute parameter for neck circumference. We thus explored static simulated concentric needle electrode insertion paths to the cricopharyngeal muscle, including measurements of the angle and depth of concentric needle electrode insertion based on CT images as well as the factors that influence the insertion angle and depth.

Methods

Participants

A retrospective study was performed on neck CT images taken between January 2019 and November 2020 in the Yueyang Hospital of Integrated Traditional Chinese and Western Medicine and the Shuguang Hospital. The inclusion criteria were as follows: (I) CT images of patients between 20 and 80 years of age; (II) clear CT images with the neck fully exposed. The exclusion criteria were the following: (I) a patient history of neck surgeries such as thyroidectomy or laryngectomy; (II) visible lesions, such as an enlarged thyroid or cyst, that affect the anatomical position of the neck tissue on the level of the CP muscle; (III) head posture not in the anatomical median position, or (IV) natural physiological curvature of the cervical spine not maintained during the CT scan. A total of 143 CT images were included from 80 female and 63 male participants. The study was approved by the Ethics Committee of Yueyang Hospital and was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Individual consent for this retrospective analysis was not required.

CT image acquisition

With the patient in a supine position, CT imaging was performed on a SOMATOM Definition 64-row, 128-slice CT machine (Siemens Healthineers). The scan results were transmitted to an Advantage Workstation 4.4 (ADW 4.4; GE HealthCare) in the form of DICOM standard data.

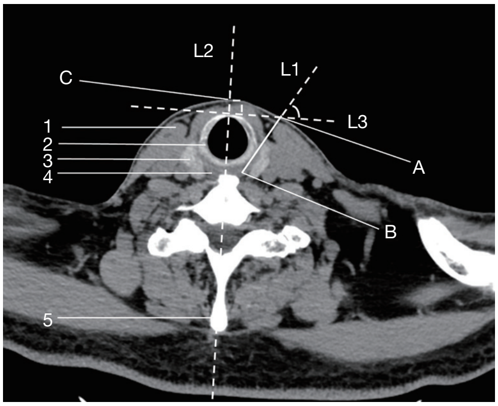

Figure 1 Measurement of the insertion angle, the insertion depth, and the distance. 1: the sternocleidomastoid muscle. 2: the cricoid cartilage. 3: the thyroid gland. 4: the cricopharyngeal muscle. 5: the cervical spine. A: the anterior border of the sternocleidomastoid muscle. B: the most superficial position of the CP muscle; L1: extension of line through A and B. L2: the line through the midpoint of the anterior border of the cricoid cartilage and the midpoint of the cervical spinous process to mark the mid-sagittal plane. L3: the straight line through the anterior border of the sternocleidomastoid muscle (point A) and perpendicular to L2.

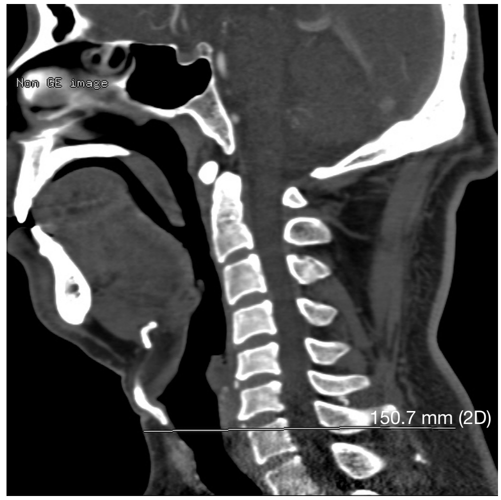

Figure 2 At the level of the upper edge of the cricoid cartilage, the straight-line tool was used to measure the horizontal distance between the front and back skin of the neck.

Measurement method and data collection

Age and gender data were collected through the electronic medical record system. The angle of electrode deflection and the electrode insertion depth were calculated using ADW4.4.

Concentric needle electrode entry point

The CT window width was set to 600 HU and the window level to 60 HU. The level of concentric needle electrode insertion was located in CT images at the level where the cricoid cartilage just formed a complete ring. This level is the superior border of the cricoid cartilage. Here, the sternocleidomastoid muscle, thyroid, cricoid cartilage, CP muscle, common carotid artery, and internal jugular vein can be seen. The CP muscle is the gray image behind the contour of the cricoid cartilage seen in *Figure 1*. The anterior edge of the sternocleidomastoid muscle and the junction with the skin on this cross section is the concentric needle electrode entry point A (*Figure 1*).

Depth of simulated concentric needle electrode insertion

With the straight-line tool, a line segment was drawn from the anterior border of the sternocleidomastoid muscle (point A) to the most superficial position of the CP muscle (point B), with the line kept close to the cricoid cartilage but not passing through it. The length of the line segment (AB) was the insertion depth. An extension of AB is shown in *Figure 1* as line 1.

Angle of simulated concentric needle electrode insertion

In the transverse plane at the level of concentric needle electrode insertion, a straight line (line 2) was drawn through the midpoint of the anterior border of the cricoid cartilage and the midpoint of the cervical spinous process to represent the mid-sagittal plane. At the anterior edge of the sternocleidomastoid muscle (point A), a straight line (line 3) was drawn perpendicular to line 2. Line 3 was in the coronal plane where the anterior edge of the sternocleidomastoid muscle is located. The angle between line 1 and line 3 was the insertion angle, as shown in *Figure 1*.

Neck thickness

The horizontal length between the front and back skin of the neck at the level of the upper edge of the cricoid cartilage was measured using the straight-line tool. This is shown in the mid-sagittal plane in *Figure 2*.

Two researchers measured the simulated concentric needle electrode insertion angle, depth, and neck thickness of the 143 participants. Inter-rater reliability was obtained

Table 1 Demographic feature and insertion measures based on CT image among participants in Shanghai, China

Variables	Total participants (n=143)	Participants with left image (n=96)	Participants with right image (n=47)	P
Age (years)[†], mean (SD)	46.2 (13.9)	48.3 (14.4)	41.7 (11.9)	0.004
Age (years)[†], (median, range)	43.0 (23.0–76.0)	50.0 (23.0–76.0)	37.0 (24.0–67.0)	0.007
Age groups (years), n (%)				0.056
Less than 45	75 (52.5)	44 (45.8)	31 (65.9)	
45–59	36 (25.2)	26 (27.1)	10 (21.3)	
Equal and over 60	32 (22.3)	26 (27.1)	6 (12.8)	
Gender, n (%)				0.184
Male	63 (44.1)	46 (47.9)	17 (36.2)	
Female	80 (55.9)	50 (52.1)	34 (63.8)	
Insertion angle (°), mean (SD)	53.2 (10.7)	52.6 (11.2)	54.3 (94.0)	0.371
Insertion angle (°), (median, range)	54.0 (28.0–80.0)	53.0 (28.0–80.0)	55.0 (31.0–79.0)	0.510
Insertion depth (mm), mean (SD)	24.2 (4.1)	24.3 (4.1)	23.8 (4.3)	0.485
Insertion depth (mm), (median, range)	24.2 (13.6–33.6)	24.4 (13.6–32.5)	24.0 (15.1–33.6)	0.493
Neck thickness (mm), mean (SD)	130.1 (17.7)	129.9 (18.8)	130.6 (15.6)	0.841
Neck thickness (mm), (median, range)	128.5 (96.0–174.0)	128.6 (96.0–174.0)	128.4 (102.0–166.0)	0.825

[†], the differences between groups on demographic feature was statistically significant (P<0.05). SD, standard deviation; CT, computed tomography.

by comparing the measurement results of the 2 researchers. After 2 weeks, 1 of the researchers randomly selected 30% of the participants to retest in order to obtain the test-retest reliability. The intraclass correlation coefficient (ICC) between the evaluators and the retest was greater than 0.9.

Statistical analysis

Statistical analysis was conducted using SPSS 25.0 (IBM Statistics Corp.). Data are described as the means and standard deviation (SD) or median and interquartile range (IQR) for quantitative variables. Qualitative variables are expressed as frequency counts and proportions. A student *t*-test or Mann-Whitney U test was applied to examine differences between quantitative variables and a chi-squared test was used to test differences between qualitative variables. A generalized linear model (GLM) was applied to calculate the β and 95% confidence interval (95% CI) to identify potential influencing factors on insertion angle and depth. Pearson correlation, stratified by age and gender, was used to analyze the correlation of neck thickness with the insertion angle and depth. In this study, a value of P<0.05 (2-tailed) was considered statistically significant.

Results

Participant demographic information is shown in *Table 1*. The ages of the 143 participants ranged from 23 to 76 years with an average age of 46.2±13.9 years. The average insertion angle was 53.2±10.7°. Insertion depth and neck thickness were 24.2±4.1 and 130.1±17.7 mm, respectively. Of the 143 CT images, 96 were analyzed with the simulated concentric needle electrode insertion on the left side of the neck (67.13%), and 47 were analyzed with the simulated concentric needle electrode insertion on the right (32.87%). No significant difference between the left and right insertion groups was observed for gender or neck thickness. More importantly, there was also no significant difference in angle or depth of simulated concentric needle electrode insertion.

Age and gender differences in insertion angle and depth

Table 2 shows the mean and SD, median and IQR of the

Table 2 Age and gender disparity of measures based on CT image among participants in Shanghai, China

Variables	Gender			Age (years)			
	Male	Female	P	<45	45–59	≥60	P
Insertion angle (°), mean (SD)	57.6 (9.4)	49.7 (10.4)	<0.001	50.8 (11.1)	54.4 (10.3)	57.4 (8.6)	0.009
Insertion angle (°), median (IQR)	59.0 (51.5–64.0)	50.0 (43.0–57.0)	<0.001	51.0 (43.5–59.0)	55.5 (46.5–60.0)	57.5 (51.0–62.5)	0.013
Insertion depth (mm), mean (SD)	26.1 (3.2)	22.6 (4.1)	<0.001	23.6 (4.4)	25.2 (3.7)	24.3 (3.6)	0.141
Insertion depth (mm), median (IQR)	26.6 (23.8-28.1)	23.1 (19.5–25.2)	<0.001	24.1 (19.9–26.8)	24.9 (23.2–28.2)	23.5 (21.3–27.3)	0.218
Neck thickness (mm), mean (SD)	141.4 (15.2)	121.3 (14.3)	<0.001	125.4 (15.7)	136.8 (18.9)	133.6 (18.1)	0.003
Neck thickness (mm), median (IQR)	141.5 (129.2–151.1)	119.3 (111.8–129.8)	<0.001	124.5 (113.8–135.7)	139.7 (121.9–149.0)	130.6 (125.1–146.1)	0.005

SD, standard deviation; IQR, interquartile range; CT, computed tomography.

simulated concentric needle electrode insertion angle, insertion depth, and neck thickness measured by CT images in different genders and age groups. The neck thickness in males was significantly greater than that in females (P<0.05), and the neck thickness between different age groups was also statistically significant (P<0.05). The insertion angle in males was significantly greater than in females (P<0.05) and increased with the age of participants (P<0.05). The depth of concentric needle electrode insertion in men was significantly greater than in women (P<0.05).

Influencing factors for insertion angle and depth

The GLM indicated that the simulated insertion angle was positively correlated with neck thickness (β=0.14; 95% CI: 0.03 to 0.25) and gender (β=5.08; 95% CI: 1.31 to 8.85). A negative correlation was observed for age with beta values of −5.88 (95% CI: −9.54 to −1.62) for participants less than 45 years of age and (β=−3.90; 95% CI: −8.33 to 0.54) for participants between the ages of 46 and 59 years. In participants 60 years of age and older, a positive correlation was observed between simulated insertion depth and neck thickness (β=0.11; 95% CI: 0.07 to 0.15). These data are shown in *Table 3*.

Pearson correlation indicated that the simulated insertion depth was positively correlated with the neck thickness (r=0.56, P<0.01). The simulated insertion angle was also positively correlated with the neck thickness (r=0.41, P<0.01). These data are shown in *Figures 3,4*.

Discussion

In this study, the insertion angle was found to be 53.2±10.7°, and the single-factor analysis and GLM implemented in this study indicated that gender, age, and neck thickness were influencing factors of the electrode insertion angle. The average angle is similar with that reported by Akkin *et al.* (8), who inserted the electrode into the posterior medial cricoid cartilage at an angle of 60° from the frontal plane. In this study, the insertion point from Akkin *et al.*'s study was used for reference. On CT images, the insertion point was taken as the starting point to draw a line segment from the inside of the anterior border of the sternocleidomastoid muscle at the level of the superior border of the cricoid cartilage to the superficial position of the CP muscle. The line segments were drawn to avoid arteries, the cricoid cartilage, and other important tissues, then stopped at the CP muscle. In this study, we found that, on some CT images, the insertion point and a 60° insertion angle could be used to draw line segments into the CP muscle. Because of the size and location of the sternocleidomastoid muscle, neck blood vessels, thyroid gland, and other structures, we believe that even if the insertion point is determined, the insertion angle has a safe range rather than a fixed value of 60° as mentioned in Akkin *et al.*'s study. The safe range of insertion angles can be accurately measured using neck CT images, providing assistance for the operation of CP-EMG. Storck *et al.* (25) measured electrode insertion angles of the laryngeal muscles based on 3-dimensional magnetic resonance images and showed that there was no significant difference in insertion angles between male and female participants. In our study, the simulated insertion angle was significantly different between genders. In contrast to that used in Storck *et al.*'s study, the insertion angle in our study was measured from the skin surface anterior to the anterior border of

Table 3 The potential influencing factors for insertion depth and insertion angle based on GLM analysis

Variables	GLM model analysis for insertion angle		GLM model analysis for insertion depth	
	β	95% CI for β	β	95% CI for β
Neck thickness (mm)	0.14	0.03 to 0.25	0.11	0.07 to 0.15
Gender				
Male	5.08	1.31 to 8.85	1.32	−0.02 to 2.67
Female	0	–	0	–
Age groups (years)				
Less than 45	−5.58	−9.54 to −1.62	0.05	−1.36 to 1.47
45–59	−3.90	−8.33 to 0.54	0.34	−1.24 to 1.93
Equal and over 60	0	–	0	–

β in the GLM model is the regression coefficient which is typically estimated with maximum likelihood; the meaning of β is similar to that in linear regression. For example, the β value for neck width was 0.14 with a 95% CI of 0.03–0.05 in the GLM analysis for insertion angle, meaning that a 1-mm change in neck width will influence the insertion angle with a value of 0.14 under the condition that gender and age group are unchanged in the same time. The CI indicated whether the influence is statistically significant (0 is not in the interval range, and the P value is less than 0.05) or not (0 is in the interval range, P value is over 0.05). GLM, generalized linear model; CI, confidence interval.

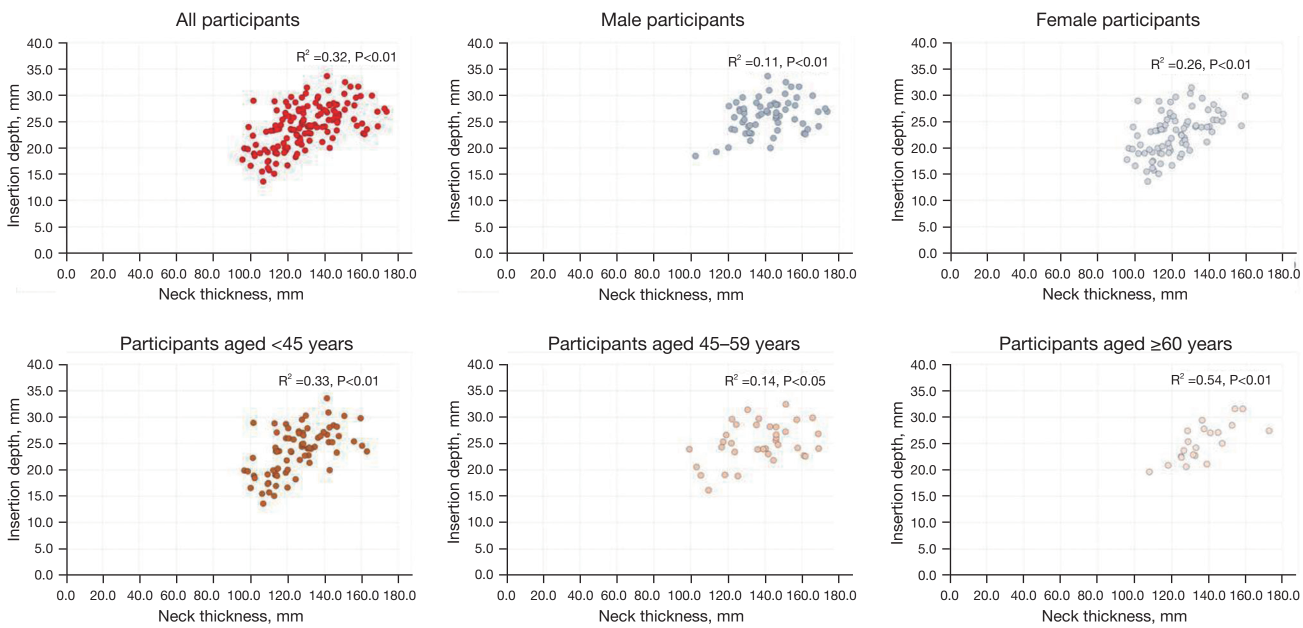

Figure 3 Results of Pearson correlations between insertion depth and neck thickness.

the sternocleidomastoid muscle in the neck CT images, not from the surface of the cartilage. The muscle is usually attached to the cartilage, and the positional relationship between the muscle and the cartilage is fixed compared to the surface insertion point. This may account for the difference between our study and that of Storck *et al.*

The insertion depth determined in this study was 24.2±4.1 mm, which is similar to previous reports. According to Ertekin *et al.* (2), for most people, the insertion depth for CP-EMG examination with concentric needle

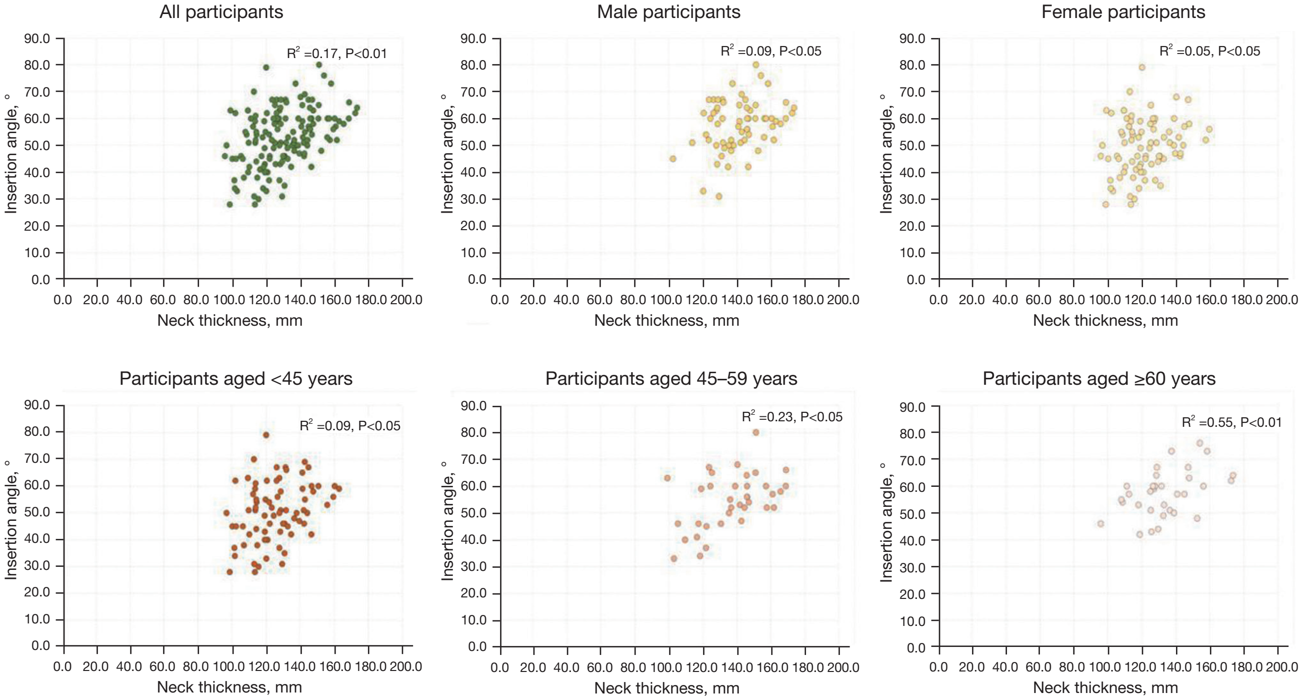

Figure 4 The Pearson correlations between insertion angle (°) and neck thickness for all participants.

electrode is about 20–40 mm. The electrode insertion depth reported by Akkin *et al.* (8) was 26.5 mm. We found that the insertion depth in men was greater than in women, with an average of 26.1 mm for men and 22.6 mm for women. This is likely because the larynges of men are larger than those of women (26). Thus, the electrode insertion depth from the neck skin to the CP muscle is greater in men than in women. However, the insertion depth was not correlated with age or gender in the GLM, the insertion depths were only positively correlated with neck thickness in this study. This discrepancy may be due to the relatively small sample size and wide range of ages.

It should be noted that, in clinical settings, the patient's position will mostly likely be different during a CT scan compared to during CP-EMG concentric needle electrode insertion where swallowing and breathing excursions can interfere with proper insertion trajectory. Minor changes in head flexion or rotation will significantly alter the calculations. To minimize the impact of these factors, the imaging and concentric needle electrode insertion procedures were standardized as much as possible. For example, the posture of the neck during the CT was the same as the posture during the swallowing EMG; both were performed with the patient in a supine position and the head kept upright. This way, the actual concentric needle electrode insertion angle and depth in the swallowing EMG can refer to the simulated concentric angle and depth measured on the CT image. By following these guidelines, variability between the simulated and actual procedures should be reduced.

The shape and positional variations of the vasculature in the anterior compartment of the neck can be visualized through use of CT images prior to puncture. The measurements taken from the images provide information on the means to avoid damaging important structures. It also provides a way to avoid puncturing the sternocleidomastoid, which would otherwise cause discomfort while swallowing, thus improving tolerability. Prior to percutaneous localization of the cricopharyngeal muscle, a coagulation test is performed on patients with abnormal vessels of the neck. The electrode insertion operation is performed only after normal results are returned. This ensures that any bleeding that results from puncture of a vessel during needle insertion can be managed via compression. Furthermore, a concentric needle electrode with a diameter of about 0.46 mm or a cross sectional area of 0.07 mm^2 is used (27). In most cases, the needle's path will pass through the thyroid gland; however, the concentric needle electrode used in CP-EMG is thinner compared to the 10 mL syringe needle (0.7 mm diameter) used for thyroid puncture. Moreover, Akkin *et al.* (8) pointed out that the diameter of the concentric needle electrode is small, thus the risk of thyroid hemorrhage or hematoma is small. In our study, immediately after the concentric needle electrode was withdrawn, pressure was applied along the concentric needle electrode entry path for 3 minutes to staunch any bleeding.

Since the recurrent laryngeal nerve is located in the tracheoesophageal groove and is very close to the cricopharyngeal muscle, it may be in the path of the concentric needle electrode. To avoid puncturing the nerve during insertion, the insertion speed is gradually slowed once the needle is 5 mm from reaching the cricopharyngeal muscle, according to the depth measurement obtained from the simulated path. At this time, the patient was instructed to pronounce /a/. If the patient's voice changes, the concentric needle electrode direction is adjusted to avoid the recurrent laryngeal nerve; if the patient's voice is normal, the concentric needle electrode is advanced slowly until the EMG signal of the cricopharyngeal muscle appears. Additionally, the concentric needle electrode tip is beveled, which causes less damage to the recurrent laryngeal nerve than other needle electrode tips. Based on the above analysis, we believe that simulated concentric needle electrode insertion method based on cervical CT, combined with the use of concentric electrode concentric needle electrodes, can maximize safety for cricopharyngeal muscle electromyography.

Conclusions

Based on the results of this study, in conjunction with the findings of previous research, we suggest that CP-EMG examination include electrodes with a length greater than 25 mm. Additionally, when the intersection of the anterior border of the sternocleidomastoid muscle and the superior border of the cricoid cartilage is used as the electrode insertion point, the electrode should be horizontally deflected towards the posterior medial edge of the cricoid cartilage by about approximately 55°, and the insertion depth should be approximately around 25 mm. If CT imaging is available, a more precise angle and depth may be determined. Using the results of this research may add a degree of safety for the CP-EMG operation.

Limits and prospects

Although the concept of pre-interventional computer simulation is becoming increasingly widespread, it is not a universal tool. In this context, planning a trajectory on a still image in a fixed position does not completely reproduce real life situations. Even if the patient's posture is standardized, it will not be exactly the same as during the CT examination. The neck does not have a flat surface and calculating the angle may not be simple, especially in the different planes of space.

In this study, the simulated insertion point was located at the level of the superior border of the cricoid cartilage. Due to anatomical differences, the cricopharyngeal muscle could be displaced slightly up or down from the main body of the cricoid cartilage and the criteria for defining the level of the CT scan used in the work might not have been valid for all participants. In the future, we will verify further the significance of the differences between inserting the needle at the level of the lower and the upper edges of the cricoid cartilage. The simulated concentric needle electrode insertion method developed in this study is being applied in clinical practice and the insertion path will be continuously optimized to further verify the feasibility and effectiveness of the method.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-22-1388/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of Yueyang Hospital. Informed consent for this retrospective analysis was waived.

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