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The accuracy of anatomical landmarks for locating the carotid sinus

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Abstract

Background: carotid sinus massage (CSM) is a valuable clinical test for carotid sinus syndrome (CSS) and relies on accurately locating the carotid sinus (CS).

Objective: in this study, we sought to examine the accuracy of using anatomical landmarks for locating the CS.

Methods: consecutive patients (n = 20) were recruited prospectively. Two clinicians, trained in CSM, were asked to locate the CS using anatomical landmarks. A point on the skin overlying the CS was then marked by a vascular technician using ultrasound. Accuracy of techniques was compared using intra-class correlation coefficients and Bland–Altman statistics.
Results: anatomical landmarks underestimated the CS location by 1.5 ± 1.3 cm. Error extremes ranged from 4 cm below to 2 cm above CS using anatomical landmarks. A moderate correlation between ultrasound and anatomical landmarks was found, $r = 0.371$ ($P = 0.031$).
Conclusion: this is the first study to characterise the accuracy of standard anatomical landmarks used in CSM. Results suggest that the point of maximal pulsation has the lowest associated error. Future work should examine CSM yield across this and a range of other methodological factors.

Keywords: *carotid sinus massage, carotid sinus anatomy, carotid sinus syndrome, falls, syncope*

Introduction

Carotid sinus massage (CSM) is a practical clinical test for carotid sinus syndrome (CSS) [1, 2]. CSM is convenient, low cost and functional in nature and requires little cooperation from the patient during testing and is suitable for application in older persons once contraindications are observed [3].

CSM has its limitations [4] and needs standardisation [5]. Duration of stimulation, the magnitude and time course of forces applied and occlusion of internal carotid artery are all thought to influence the response. Strict standardisation of CSM is rare [6], with only duration [7], body position [8] and side of application [9, 10] standardized. This likely contributes to the problem of defining reliable diagnostic thresholds, its reproducibility and the understanding of CSS aetiology [11].

One feature of CSM which has received little attention is the technique for locating the carotid sinus (CS). Locating the CS prior to CSM is performed subjectively by anatomical landmarks [12, 13] at the anterior margin of the sternocleomastoid muscle at the level of the cricoid cartilage or at the point of maximal pulsation between angle of the mandible and the cricoid cartilage. It is well known that CS anatomy tends to be highly variable, especially within elderly individuals [14, 15]. The level of right and left sinuses can differ significantly and in some individuals no carotid bifurcation exists. These factors may therefore influence responses to CSM [14]. In this short report, we examine the accuracy of using anatomical landmarks for locating the CS by comparing the accuracy of this technique to an objective carotid ultrasound measurement.

Methods

Participants

Consecutive patients (n = 20) attending a vascular laboratory were recruited prospectively. All patients had full clinical assessment including carotid doppler ultrasound as part of routine vascular assessment. All subjects attended for a single visit between 0900 and 1600 h. The study had ethical approval from the local ethics committee.

Experimental protocol

Two clinicians trained in CSM were asked to locate the CS using the following two anatomical landmark descriptions:

- Method 1 (ESC guidelines [7]) = 'After baseline measurements, the right carotid artery is firmly massaged for 5–10 s at the anterior margin of the sternocleidomastoid muscle at the level of the cricoid cartilage'.
- Method 2 (Newcastle [13]) = 'The site of maximal pulsation of the right CS, which is located between the superior border of the thyroid cartilage and the angle of the mandible'.

Patients were supine during all testing. Each clinician was blind to the location of the CS. Testing order was randomised. The true location of the carotid sinus (CS_{true}) was then determined by a vascular technician using ultrasound. CS_{true} was defined as the point of maximal dilatation of the internal carotid artery above the level of the carotid bifurcation. The distance of each of the points to the 'true' point and the sternal notch was measured using a set of callipers. This process was performed on both left and right sides for all participants.

Statistical analysis

SPSS©[1] version 14 was used to process study data. All measures were assessed for normality using data histograms and Kolmogorov–Smirnov test statistics, and compared using parametric and non-parametric where appropriate. Spearman's rank correlation coefficient (ϱ) was used to investigate univariate relationships between variables. Bland–Altman plots [16] and intra-class correlation coefficients (ICCs) [17] were used to compare techniques reliability. Significance was calculated at a level of $P \leq 0.05$.

Results

Patient demographics

The median age of subjects was 67 (52–79) years. Three participants had incomplete data.

[1] SPSS Inc. Headquarters, 233 S. Wacker Drive, 11th Floor, Chicago, IL 60606, USA.

Table 1. Comparison between the two anatomical based techniques and the ultrasound method for locating the CS. All distances are reported in cm using the sternal notch as the reference point. SD, standard deviation. Sample size = 17 individuals. CS = Carotid Sinus. ICC = Intra-class correlation coefficient. Method 1 = ESC Guidelines description [7]. Methods 2 = Newcastle approach [13].

Technique	*N*	Left CS Mean ± SD	*P* value	Right CS Mean ± SD	*P* value	Average Mean ± SD	*P* value
Ultrasound (cm)	17	7.8 ± 1.1	–	7.7 ± 1.2	–	7.7 ± 1.0	–
Method 1 (cm)	17	6.4 ± 1.4	$P < 0.0001$	6.0 ± 1.5	$P < 0.0001$	6.2 ± 1.3	$P < 0.0001$
Method 2 (cm)	17	7.1 ± 1.4	$P = 0.023$	6.9 ± 1.2	$P = 0.003$	7.0 ± 1.2	$P = 0.004$
Technique	*N*	Left CS ICC	Sig.	Right CS ICC	Sig.	Average ICC	Sig.
Method 1	17	0.15	$P = 0.089$	0.172	$P = 0.04$	0.153	0.057
Method 2	17	0.297	$P = 0.025$	0.305	$P = 0.016$	0.307	0.015

Comparison of techniques

Table 1 shows the results when we compare each method to the gold standard ultrasound technique. Method 1's estimate of the location of the left CS was 1.3 ± 1.5 cm lower than the ultrasound location ($P < 0.0001$), while Method 2 was found to be 0.7 ± 1.4 cm ($P = 0.023$) below the gold standard. The difference between Method 1 and Method 2 estimates was also significantly different by 0.64 ± 1.0 cm ($P < 0.001$). The location of the right CS was found by Method 1 to be 1.7 ± 1.6 cm lower than the ultrasound location ($P < 0.0001$), while Method 2 was found to be 0.8 ± 1.4 cm ($P = 0.003$) below the gold standard. The difference between Method 1 and Method 2 estimates for the right CS was also significantly different by 0.9 ± 1.3 cm ($P < 0.001$).

Correlations between each method and the ultrasound gold standard were low to moderate. Method 1 was not significantly correlated to the ultrasound technique for either left ($r = 0.25$; $P = 0.153$) or right ($r = 0.311$; $P = 0.074$) CS, while Method 2 was significantly correlated with the ultrasound technique for both measurements taken from the left ($r = 0.376$; $P = 0.028$) and right ($r = 0.44$; $P = 0.009$) CS.

The intra-class correlation coefficients ICC (2, 1) for absolute agreement between methods are tabulated in Table 1. As can be seen, absolute agreement between each of the anatomical landmark techniques and the ultrasound method is significant in all cases except Method 1. In general, relatively low agreement was found ranging from 0.15 to 0.305.

From Bland–Altman analysis, Method 1 has a bias of 1.3 ± 1.5 cm and limits of agreement of (1.64 to −4.25 cm) in locating the left CS and a bias of 1.7 ± 1.6 cm and limits of agreement of (1.5 to −4.84 cm) in locating the right CS. Method 2 has a bias of 0.618 ± 1.41 cm and limits of agreement of (2.15 to −3.38 cm) in locating the left CS and a bias of 0.7794 ± 1.359 cm and limits of agreement of (1.87 to −3.44 cm) in locating the right CS.

Discussion

The main findings of this work are as follows: (i) the level of agreement between ultrasound and anatomical landmarks for locating the CS is moderate. (ii) anatomical landmarks which rely on the point of maximal pulsation for the identifying the CS location are more accurate.

Although there are significant correlations and small errors between anatomically guided methods and the ultrasound approach, the level of absolute agreement between techniques is moderate at best. The ICC coefficient measures the proportion of total variance which is explained by between individual variations and thus is a reasonable measure of technique reliability [17] with ICC coefficients >0.8 are required for a technique to be considered interchangeable [17]. Our results demonstrate a low to moderate ICC (0.15 to 0.307). This would suggest that anatomical landmarks alone are not sufficiently accurate to guide the clinician to the correct location of the CS as determined by ultrasound. The limits of agreement provide a further measure of precision [16]. For example, in locating the right CS, the difference between Method 2 and the gold standard can range from 1.87 cm above to −3.44 cm below the CS.

Two practical points must be mentioned which may influence the interpretation of this result. Firstly, CSM is a functional test. Anecdotal evidence suggests that clinicians repeat CSM if a false negative or atypical response is found or suspected. The anatomical errors identified here will only become important in the situation where a cardiovascular response cannot be elicited [14]. Secondly, CSM at any instant in time applies a strain stimulus to an area equivalent to one or two finger widths. It is a dynamic stimulus moving over an approximately 2–4 cm range. Its accuracy ultimately depends on a number of factors including the initial location error, finger size, range and rate of motion during CSM and applied pressures.

Our second finding suggests that although both methods had wide limits of agreement and some associated biases, Method 2 had significantly less errors, had higher ICC values, was less biased and had on average narrower limits of agreement compared to Method 1. No physiological rational has been provided in literature for why the point of maximal pulsation has been chosen as a landmark for the CS bifurcation [6]. Studies investigating arterial blood flow dynamics at the carotid bifurcation, suggest pressures and flows at a bifurcation are turbulent due to a flow divider effect [18] resulting in locally circulating and oscillating flows at the CS, with maximal deformation occurring at the intersection of the two carotid branches [19].

Of course the apparent inaccuracies seen here in locating the CS through routine clinical methods may not necessarily have any impact on CSM yield. A limitation of this study is that it was not designed to test yield against alternative approaches of choosing the initial stimulus location. However, we believe that this is the first time inaccuracies in choosing the stimulus location have been estimated, and that this work demonstrates that a further study designed to test variations in CSM yield is warranted. A further limitation is that a definition of the true point of the CS is difficult to determine non-invasively. In our study, we assumed an anatomical definition i.e. to be point of maximal dilatation of the internal carotid artery above the level of the carotid bifurcation. Whether or not this corresponds to the point of maximal baroreceptor sensitivity has not been determined definitively.

Conclusion

This is the first study to characterise the accuracy of standard anatomical landmarks used in CSM. Results suggest that the point of maximal pulsation has the lowest associated error. Future work should examine CSM yield across this and a range of other methodological factors.

Key points

- Anatomical landmarks used to locate the CS are moderately accurate.
- Results suggest that the point of maximal pulsation has the lowest associated error.
- CSM yield should be determined across range of methodological factors.

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Conflicts of interest

None declared.

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