Reliability and Accuracy of Simple Visual Estimation in Assessment of Peripheral Arterial Stenosis

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ABSTRACT

Purpose: To evaluate reliability, accuracy, and agreement of simple visual estimation (SVE) in determining the degree of peripheral arterial stenosis compared with calibrated measurements.

Materials and Methods: In 2 sessions, 23 interventionists with a wide range of experience and subspecialty training reviewed 42 angiographic images of lower extremity and carotid arteries (21 iliofemoral arteries and 21 carotid arteries). An independent physician measured all lesions using manual calipers. Intrarater and interrater reliability were assessed by intraclass correlation. A ± 5% error was considered the threshold for accuracy, and weighted κ statistics were computed to assess agreement with respect to the degree of stenosis (< 50%, nonsignificant; 50%–80%, significant; > 80%, severe).

Results: Intrarater reliability of SVE was 0.99, and interrater reliability was 0.83. Accuracy varied from 52.8% for images of severe stenosis to 26.5% and 18.1% for significant and nonsignificant stenosis, respectively ($P < .001$). Agreement between SVE and caliper with regard to degree of stenosis was good (weighted κ 0.56) overall with correct classification ranging from 92.6% for severe stenosis to 53.4% and 68.2% for significant and nonsignificant stenosis, respectively ($P < .001$). Misclassification of nonsignificant and significant stenosis was more frequent for carotid arteries than for lower extremities.

Conclusions: Despite high reliability, SVE of peripheral arterial stenosis has limited accuracy in determining the exact degree of stenosis. Although severe stenosis is readily identified by SVE, arterial stenosis of < 80% is frequently overestimated, especially for carotid arteries, and should be confirmed by caliper assessment.

ABBREVIATIONS

NASCET = North American Symptomatic Carotid Endarterectomy Trial, SVE = simple visual estimation

Thousands of peripheral vascular interventional procedures are performed annually to characterize, prevent, and treat catastrophic and lifestyle-limiting consequences of atherosclerosis leading to arterial stenosis (1–3). In the case of carotid artery stenosis, accepted criteria exist for levels of stenosis severity and the proper method of measurement, as outlined in the North American Symptomatic Carotid Endarterectomy Trial (NASCET) (4). In addition, in 2011, the Society of Vascular Surgery published updated guidelines for management of extracranial carotid disease recommending carotid endarterectomy as the first-line treatment for symptomatic patients with 50%–99% stenosis and for asymptomatic patients with 60%–99% stenosis (5).

Although these imaging criteria have been established in carotid disease, no authoritative equivalent exists for the evaluation of the lower extremities. Despite new imaging techniques and protocols with computed tomography angiography, magnetic resonance (MR)

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angiography, and duplex ultrasonography, the decision to intervene in peripheral arterial disease and the choice of treatment are made based on clinical signs and symptoms, such as severe claudication or ulceration, and are tailored based on the patient's condition (6–8). In the lower extremities, a quick "eyeball" or simple visual estimation (SVE) of the degree of stenosis is often used to determine if treatment is necessary.

Whether SVE is sufficiently accurate is a matter of debate (9,10). Several previous studies examined the accuracy of SVE using a small number of readers reviewing a large number of images (11–13); however, these studies did not involve readers across several subspecialties, which limits their findings from being widely applicable. Also, the accuracy of estimation in relation to physician experience is unknown. The purpose of this study was to evaluate the reliability, accuracy, and agreement of SVE compared with manual caliper measurements with regard to the stenosis severity using a diverse group of readers.

MATERIALS AND METHODS

Institutional review board approval was obtained; the need for patient informed consent for inclusion in the study was waived. A retrospective review of the electronic medical records system was performed in accordance with Health Insurance Portability and Accountability Act guidelines.

Arteriograms

A panel of three physicians selected the arteriograms to represent a range of anatomy encountered in clinical practice. Arteriograms were obtained using a ceiling-mounted Allura Xper FD20 flat detector system (Philips Research, Eindhoven, The Netherlands). Only angiographic images devoid of subtraction artifacts with well-defined vessel edges were selected after removal of patient identifiers. There were 42 uniplanar angiographic images of atherosclerotic lesions arbitrarily selected, including 21 images of iliofemoral arterial lesions and 21 images of carotid arterial lesions (Table 1).

Caliper Measurements

Independent of the readers, an interventional radiologist with 20 years of experience measured each image for degree of stenosis with a manual caliper. The measurements on the carotid artery images were obtained at the site of the most severe stenosis and at the site of the distal internal carotid artery according to NASCET criteria. In iliofemoral arteries, measurements were obtained at the site of the most severe stenosis and at the site of the normal-appearing distal segment to calculate the minimal residual lumen and distal lumen. Percentage of stenosis was calculated as $100 \times [1 - (\text{minimal residual lumen/distal lumen})]$.

Performance of SVE

SVE was performed on the 42 selected images by 23 interventionists. Different subspecialties including interventional radiologists (13 readers), neurointerventionalists (2 readers), interventional cardiologists (4 readers), and vascular surgeons (4 readers) were represented, and years of experience ranged from 1 year (fellows) to 42 years (Table 2). SVE was performed twice with an interval of 3 weeks between assessments to provide data for estimating intrareader and interreader reliability. Images were shuffled between readings to avoid recognition.

Readers were asked to evaluate each image by recording the percent stenosis (to the nearest integer) using only SVE with no further instructions. An independent observer was present at all readings and entered the findings into a database at the time of assessment.

Criteria for Reliability, Accuracy, and Agreement of SVE

SVE was evaluated in terms of reliability, accuracy, and agreement in relation to caliper measurements using the following criteria: Intrareader reliability was defined as the correlation between the first and second SVE for each image-rater pair. Interrater reliability was defined as the correlation among estimates from different raters for the same image at the same time (first or second assessment). Accuracy was defined as a visual estimate within ± 5% of the caliper measurement. Agreement was determined by whether the SVE and caliper measurement of an image placed it in the same category of significance of stenosis with categories defined as follows: < 50%, nonsignificant; 50%–80%, significant; and > 80%, severe. These thresholds were chosen in

Table 1. Caliper Measurements of Stenosis for 42 Arteriograms by Anatomic Site and Stenosis Category

		Not Significant (< 50%)				Significant (50% to < 80%)				Severe (≥ 80%)			
		Images		Caliper % Stenosis		Images		Caliper % Stenosis		Images		Caliper % Stenosis	
	All N	n	%	Median	Range	n	%	Median	Range	n	%	Median	Range
All	42	13	31.0	38	24–49	22	52.4	70.5	53–79	7	16.7	85	80–90
Lower extremity	21	10	47.6	37	24–49	9	42.9	62	53–79	2	9.5	85.5	82–89
Carotid	21	3	14.3	43	39–45	13	61.9	72	54–79	5	23.8	85	80–90