Reliability of Ultrasound Diameter Measurements in Patients with a Small Asymptomatic Popliteal Artery Aneurysm: An Intra- and Inter-observer Agreement Study

I. Zwiers [a,*], C.M.T. Hoogland [b], A.J.C. Mackaay [c]

[a] Cardiovascular Center, Maastricht University Hospital, The Netherlands
[b] Vascular Center, Flevo Hospital, Almere, The Netherlands
[c] Department of Surgery, Meander Medical Center Amersfoort, The Netherlands

---

WHAT THIS PAPER ADDS
This study provides the first data about the reproducibility of diameter measurements with ultrasound in patients with a small popliteal artery aneurysm. It provides the limits of agreement between measurements which can be used as a criterion of change in size.

Background: In this study the intra- and inter-observer variability of ultrasound measurements of the diameter of the popliteal artery were tested in a group of patients under surveillance for a small (diameter 10—20 mm), asymptomatic popliteal artery aneurysm (PAA).
Methods: From a group of patients under ultrasound surveillance for bilateral, asymptomatic PAAs, 13 consecutive patients agreed to participate in the study and provided informed consent. The maximum diameter of the popliteal arteries was assessed by a vascular technologist. The same assessment was repeated by a second vascular technologist, unaware of the results of the first measurement. After a week, this protocol was repeated. The intra- and inter-observer reliability of this measurement was calculated using intra-class correlation coefficients (ICCs) and Bland and Altman plots.
Results: Of the 10 patients with bilateral and three patients with unilateral PAA, 12 completed the 2 week protocol. A total of 86 measurements were analyzed. The mean diameter of the popliteal arteries was 13.5 ± 3.4 mm. The ICC for the intra-observer reliability of observer 1 was 0.96 (95% CI 0.92—0.99), $p < .001$ and of observer 2 was 0.98 (95% CI 0.95—0.99), $p < .001$. The ICC for the inter-observer reliability for the first measurements was 0.96 (95% CI 0.90—0.98), $p < .001$ and for the second measurements 0.97 (95% CI 0.94—0.99), $p < .001$. The Bland—Altman plots showed random error, while 95% of the variation was between 0.016 and 0.16, $p > .47$. The absolute magnitude of the systematic error of both observers was less than 0.135 mm (median 0.00).
Conclusion: Ultrasound measurement of the maximum diameter of the popliteal artery is reproducible; hence, it is suitable for making a clinical treatment decision. Its use for surveillance of small, asymptomatic PAAs is justified.

INTRODUCTION

Although the incidence of a popliteal artery aneurysm (PAA) is low, 0.1—2.8%,[1—5] there is a considerable risk of limb threatening complications including thrombosis or embolization. In 68—74% of the patients an untreated PAA will lead to complications within 5 years.[1,4,6,7] The aneurysm can spontaneously occlude or lead to embolization. Complications can also occur after interventions, including thrombolysis or acute bypass surgery.

The risk of complications increases considerably when the diameter of the popliteal artery exceeds 20 mm.[8] There is still debate about the threshold diameter for treatment.[9,10] For this purpose, reliable measurements are mandatory. Patients with a small asymptomatic PAA (10—20 mm in diameter) undergo duplex surveillance approximately twice a year.

Available imaging techniques to measure the diameter of the popliteal artery include ultrasound, computed

---

tomography angiography (CTA), and magnetic resonance imaging (MRI). CTA and MRI are almost exclusively used when planning treatment of the PAA.[11] Ultrasound is inexpensive, non-invasive, and can be repeated easily without harm to the patient.[12,13] In clinical practice, ultrasound is the method of choice to visualize the anatomy of the blood vessel including dilatation and to measure the diameter. B-mode image is used to visualize the blood vessels, while flow patterns and patency can be assessed with Doppler and color flow imaging. However, the reliability of ultrasound measurements is operator dependent.[14,15]

There are no published data on the reproducibility of ultrasound measurement of the diameter of a PAA. The aim of this study was to investigate the intra- and inter-observer agreement of ultrasound measurements of the maximum diameter in patients with a small asymptomatic PAA, in order to establish its reliability and reproducibility as a method for surveillance.

METHODS

Patients

Patients were selected from a group already scheduled for a 6 monthly surveillance visit at the Department of Surgery in the Meander Medical Center, Amersfoort, The Netherlands, for bilateral small, conservatively treated, aneurysms of the popliteal artery. Recruitment to the study was between September and November 2011. Patients who, in the surveillance interval, had undergone unilateral thrombosis (1 thrombosed PAA at time of inclusion, diameter 17.2 mm) or surgical ligation of their PAA were also included. Following the Dutch Multidisciplinary Guidelines for Cardiovascular Risk Management 2011, all vascular patients received ASA, or acenocoumarol, and were treated for hypertension, dyslipidemia, diabetes, and/or coronary artery disease. In addition all patients were instructed to stop smoking. Patients unwilling or not able to participate were excluded.

In an interview supported by a written statement, the procedure of the reproducibility study was explained to the patient. They were asked for informed consent for these measurements at two consecutive sessions. Permission to perform the study was granted by the institutional ethics review board.

Procedure

Following the protocol, all scheduled diameter measurements were performed by the same two registered vascular technologists each with more than 10 years' experience. The second technologist was unaware of the results of the first. Both technologists repeated their measurements after 1 week. This period was chosen because it was unlikely the PAA diameter would have changed and the technologists would not recall the results from the previous investigation. Patient characteristics, risk factors, and medication were recorded on entry to the surveillance program.

Ultrasound

Patients were examined in the lateral decubitus position. In general, the diameter of the vessel is measured in transverse view, with an angle of 90 degrees to the long axis of the blood vessel. In the presence of elongation transverse plane measurement might overestimate the diameter because of obliquity. By scanning the popliteal fossa and medial lower thigh, the popliteal artery was identified in the transverse and longitudinal planes throughout its length to ascertain the maximum diameter and angulation. The transverse diameter was recorded in millimeters to one decimal place during systole, and leading edge to leading edge (LELE; from the outer edge of the anterior wall to the inner edge of the posterior wall).

For all measurements, a Philips ultrasound system, type iU22 with a 12—5 MHz linear array transducer, was utilized (Philips, Eindhoven, The Netherlands). The results of the measurements were stored on the hard disc of the system and in a digital file.

Statistical analysis

To assess the intra- and inter-observer agreement of the measured diameters, one way random intra-class correlation coefficients (ICC) with the 95% confidence intervals (CI) were calculated. Bland—Altman plots were used to perform the absolute magnitude of the measurement error and to calculate limits of agreement to detect random and systematic differences. With simple linear regression the slopes were tested on zero slope. The limits of agreement indicate the absolute magnitude of score deviation and were calculated as the mean difference between observers or occasions ± 2 standard deviations. When the deviations between observers are random, the limits indicate the range between which 95% of the deviations lie. For statistical analyses SPSS software, version 20 was used.

RESULTS

Thirteen consecutive male patients with a mean age of 70.9 ± 8.9 years were recruited with the usual characteristics of cardiovascular patients, as presented in Table 1. In nine patients (69%) there was a concomitant abdominal

Table 1. Patient characteristics.

Variable	Mean $\pm$ SD, or N (%) ($n = 13$)
Male sex	13 (100)
Age (years)	70.9 $\pm$ 8.9
Abdominal aortic aneurysm	9 (69)
Risk factors	
Hypertension	7 (54)
Hyperlipidemia	5 (38)
Smoking	3 (23)
Diabetes mellitus	4 (31)
Cerebrovascular disease	2 (15)
Coronary artery disease	5 (38)
PAA diameter (mm)	13.5 $\pm$ 3.4

PAA = popliteal artery aneurysm.