Eur J Vasc Endovasc Surg **17**, 472–475 (1999)
Article No. ejvs.1999.0835

The Validity of Ultrasonographic Scanning as Screening Method for Abdominal Aortic Aneurysm

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Objective: *the sensitivity and specificity of screening for abdominal aortic aneurysms (AAAs) with ultrasonographic scanning (US) is unknown. The aim of the study was to validate US as screening test for AAAs.*
Methods and material: *4176 (76.3%) of 5470 men aged 65–73 attended hospital-based US screening for an AAA at their local hospital. Two observers and one scanner were used. The maximal anterior–posterior (AP) of the dilated aorta, or 2 cm above the bifurcation, and at the crossing of left renal vein was recorded. In 50 cases, blinded measurements were carried out by two observers. An AAA was defined as an AP diameter greater than 29 mm.*
Results: *the standard deviation (S.D.) of the interobserver variability of the distal AP diameter was 0.84. The mean distal AP diameter was 17.9 mm (S.D. 2.92). Combining these data, the estimated diagnostic sensitivity was 98.9%, the estimated diagnostic specificity was 99.9%.*

The interobserver S.D. of the proximal AP diameter was 1.76. The mean proximal AP diameter was 18.4 mm (S.D. 2.45). Combining these data, the estimated diagnostic sensitivity was 87.4%, the estimated diagnostic specificity was 99.9%.
Conclusion: *US seems to be a valid screening method for AAA. Screening for proximal infrarenal aorta aneurysm remains acceptable because the majority of aortic diameters in this segment are so much smaller than the diameters that define an AAA.*

Key Words: Abdominal aortic aneurysm; Screening; Validity; Methods; Ultrasonographic scanning.

Introduction

The increasing incidence of abdominal aortic aneurysms (AAA), combined with the safety of elective surgery, and the inexpensive and reliable diagnosis by ultrasonographic scanning, has stimulated a debate as to whether screening for AAAs should be advocated.

The criteria of a screening programme that should be met have been described by WHO and expanded by others.[1,2] A basic requirement is that the method of screening should be evaluated.

Experience has shown that screening for AAA with ultrasound is fast and inexpensive,[3,4] with acceptance rates between 53–79%.[3–10] Ultrasonographic scanning therefore seems to be a safe, reliable, inexpensive, and acceptable method of screening for AAA.

However, the accuracy of ultrasound scanning as a screening method is unknown.

Methods and Material

From 1994–96, 5470 65–73-year-old men were offered screening at their local hospital, which 4176 of them attended (76.3%). Appointments were made at 5-min intervals, and fasting was not required. No help or compensation was offered for transportation. B mode scans were performed by two alternating observers with one mobile Phillips SDR 1550 scanner (35 kg) and a 4 mHz linear transducer. The aorta was first identified in a longitudinal axis. The transducer was then rotated to an axial plane, and scanning was started as proximal as possible. The anterior–posterior and transverse diameters were measured at the level of the left renal vein. If the vein was not visible, then the most proximal measurement was taken. The distal aorta was then examined. When dilatation was noticed, the maximal anterior–posterior and transverse diameters were measured. When no dilatation was present, the aorta was measured just above the bifurcation. The scanning was not completed until the bifurcation was identified.

An AAA was defined as being an infrarenal aortic

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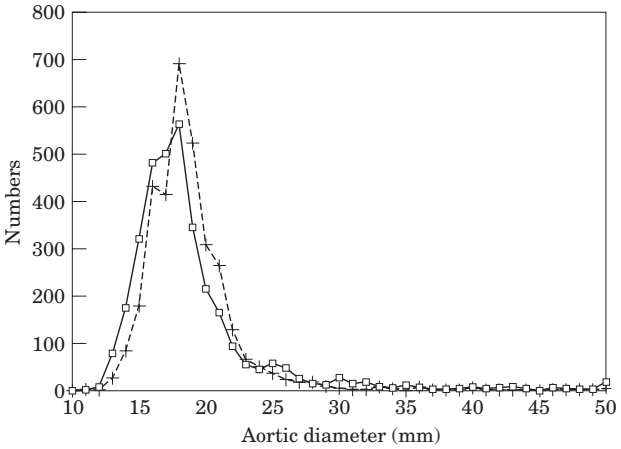

Fig. 1. The distribution of the distal and proximal infrarenal anterior–posterior diameter. (□) Distal; (+) proximal.

AP diameter greater than 29 mm. AAA above 50 mm in diameter were referred for CT scanning prior to vascular surgery. Monthly blinded validation studies of the examinations showed a standard deviation (s.d.) of the intra-observer variability of measurements below 0.5 mm.

In 50 attenders, weight, height, and time interval from the last meal were recorded, and blinded measurements were carried out by two observers. The inter-observer variability was calculated as the Spearman correlation coefficient.

The distribution of the aortic diameters were combined with the standard deviation of the inter-observer difference of the measurements, to estimate the number of likely false-negative and false-positive findings. Finally, sensitivity, specificity, and predictive values of the test were calculated.

Results

Visibility of the aorta

The distal part of the infrarenal aorta could be visualised in 99.7% of patients, the entire infrarenal aorta in 98.5%, and the crossing of the left renal vein in 62%.

The visualisation of the distal part of the aorta was unchanged over the three years, but that of the entire infrarenal aorta increased from 98.3% in 1994 to 99% in 1996.

Morphology of the infrarenal aorta

The mean distal and proximal infrarenal anterior–posterior aortic diameter (AP) was 17.9 mm (s.d. 2.92), and 18.4 mm (s.d. 2.45) excluding men with an AAA (Fig. 1). The mean ratio of the distal diameter relative to the proximal AP diameter of non-aneurysmal aortas was 0.97 (s.d. 0.14).

Table 1. Inter-observer reproducibility and variation of the measurements. $n = 50$.

	Distal aortic measurement	Proximal infrarenal aortic measurement
Inter-observer correlation (r)	0.98*	0.77*
Mean difference (mm)	−0.10	−0.88*
s.d. of difference (mm)	0.84	1.76
Variability of measurement (mm)	1.68	3.52
Arimetric mean of difference (mm)	0.42	1.32
s.d. of difference (mm)	0.73	1.45
Arimetric variability of measurements (mm)	1.46	2.90

* $p<0.05$.

Inter-observer variability

The distal aortic measurement showed good reproducibility ($r = 0.98$), a variability of 1.68 mm, and an arimetric variability of 1.46 mm (Table 1). The mean difference was 0.1 mm ($p = 0.77$).

No correlation between inter-observer variability, and the time interval from the last meal, or body mass index was found for the distal measurement ($r^2 = 0.02$ and 0.00, respectively).

The proximal infrarenal aortic measurement showed lesser reproducibility ($r = 0.77$), a variability of 3.52 mm, and an arimetric variability of 2.90 mm. The mean difference was 0.88 mm ($p = 0.001$).

Significant correlation between inter-observer variability of the proximal measurements, and the time interval from the last meal, and body mass index was noticed ($r^2 = 0.12$ and 0.10, respectively).

Estimated sensitivity, specificity, and predictive value of the test

The inter-observer s.d. of ultrasonographic scanning of the normal distal aorta was 0.84 mm. Consequently, the estimated diagnostic sensitivity was 98.9%, the estimated diagnostic specificity was 99.9%, with a 97% predictive value of a positive test for the diagnosis of an AAA (Table 2), and a predictive value of a negative scan of 99.9%. The inter-observer s.d. of ultrasonographic scanning of the normal proximal part of the infrarenal aorta was 1.76 mm. Consequently, the estimated diagnostic sensitivity was 87.4%, the estimated diagnostic specificity was 99.9%, with a 95%

Table 2. The estimated sensitivity, specificity, and predictive value of ultrasonographic screening for abdominal aortic aneurysm in the distal part of the infrarenal aorta.

		Abdominal aortic aneurysm		
		Present	Not present	
Result of the test	+	165.01	4.99	170
	−	1.78	3969.22	3971
		166.79	3974.21	4141

Sensitivity:	165.01/166.79 = 98.9% (95% CI: 96.2–99.9)
Specificity:	3929.22/3974.21 = 99.8% (95% CI: 98.5–99.2)
Predictive value of a positive test:	165.01/170.00 = 97.0% (95% CI: 92.9–98.9)
Predictive value of a negative test:	3969.22/3971.00 = 99.9% (95% CI: 99.8–99.9)

Table 3. The estimated sensitivity, specificity, and predictive value of ultrasonographic screening for abdominal aortic aneurysm in the proximal part of the infrarenal aorta.

		Abdominal aortic aneurysm		
		Present	Not present	
Result of the test	+	39.76	2.24	42.00
	−	5.73	4065.27	4071.00
		45.49	4067.51	4113.00

Sensitivity:	39.76/45.49 = 87.4% (95% CI: 75.2–95.9)
Specificity:	4065.27/4067.51 = 99.9% (95% CI: 99.8–99.9)
Predictive value of a positive test:	39.76/42.00 = 94.7% (95% CI: 82.6–99.2)
Predictive value of a negative test:	4065.53/4071.00 = 99.8% (95% CI: 99.7–99.9)

predictive value of a positive test for diagnosis of an AAA (Table 3), and a predictive value of a negative test of 99.9%.

Discussion

Visibility of the aorta

Comparison of the visibility with other reports is difficult. The reported visibility of the aorta is 97.5–100% but criteria are usually not defined.[3,4,6,11–14] If their criteria were only to have identified the aorta, our results are quite satisfactory; but if their criteria were to have seen the entire infrarenal aorta, our results are among the poorest reported.

Inter-observer variability of the measurements

Our inter-observer variability of the measurements seem smaller than other studies which have reported variabilities of up to 8 mm/s.[15–21] This could be explained by our strict standards of measurement, and increasing variability with increasing aortic diameter. Pedersen *et al*.[20] reported a very similar inter-observer variability on normal infrarenal aortas. As noticed by Ellis[22] and Pedersen,[20] the proximal measurements have larger inter-observer variability. This could probably be improved by fasting, or by the echo-tracking system, as described by Länne *et al*.,[23] which has a smaller variability of measurement but is too cumbersome for a screening procedure.

Estimated sensitivity, specificity, and predictive value of the test

The exact sensitivity, specificity, and predictive value of the ultrasound scan remains to be defined, because it requires comparison with a golden standard, but which golden standard? CT scans are likely to overestimate the diameter in aortas that are elongated and oblique in the scan plane.

Our estimated diagnostic specificity was close to 100% in both the proximal and the distal aortas. This is important, because it minimises the number of false-positive findings. The lower estimated sensitivity in the proximal measurements is partly caused by the low incidence of AAA (1%) in this segment. However, all the aneurysms in the proximal aorta were also present distally.

Overall, the results suggest ultrasound scanning is an acceptable screening method for AAAs, even in the proximal infrarenal aorta because even here the aortic diameters are so much smaller than the diameters that define an AAA (Fig. 1).

However, it must be emphasised that the estimations are based on the following assumptions:

1. the distribution of the aortic diameter is the same in non-visible as in visible aortas. This may be incorrect, since smaller aortas are more difficult to visualise than large aortas or AAA;
2. the S.D. of the measurements used in the calculations is unbiased, i.e. the variation is random and normally distributed, with zero as the mean variation. Apart from the proximal measurements, this assumption seemed to be correct;
3. the S.D. is independent of the diameter of the aorta, as observed.

Acknowledgements

We thank the Health Administration of Viborg County for financial and practical assistance. The foundation of Asta and Rosa Jensen, The Danish Heart Foundation, and The Danish Medical Research Council is thanked for economic support.

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Accepted 18 January 1999