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Superior Reproducibility of the Leading to Leading Edge and Inner to Inner Edge Methods in the Ultrasound Assessment of Maximum Abdominal Aortic Diameter

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WHAT THIS PAPER ADDS

This large multi-observer study based on ultrasound images from an AAA screening trial shows superior intra- and inter-observer reproducibility of the leading to leading edge (LTL) and inner to inner edge method (ITI) of caliper placement in relation to the aortic wall compared with the outer to outer edge method (OTO). The largest difference in mean aortic diameter was found between OTO and ITI, yielding an estimated almost doubling in AAA prevalence when the OTO was used instead of the ITI. The current study supports a continuation of current screening programs as well as an adaptation by imaging departments to the ITI method.

Objectives: Controversy exists regarding optimal caliper placement in ultrasound assessment of maximum abdominal aortic diameter. This study aimed primarily to determine reproducibility of caliper placement in relation to the aortic wall with the three principal methods: leading to leading edge (LTL), inner to inner edge (ITI), and outer to outer edge (OTO). The secondary aim was to assess the mean difference between the OTO, ITI, and LTL diameters and estimate the impact of using either of these methods on abdominal aortic aneurysm (AAA) prevalence in a screening program.

Methods: Radiologists (n=18) assessed the maximum antero-posterior abdominal aortic diameter by completing repeated caliper placements with the OTO, LTL, and ITI methods on 50 still abdominal aortic images obtained from an AAA screening program. Inter-observer reproducibility was calculated as the limit of agreement with the mean (LoA), which represents expected deviation of a single observer from the mean of all observers. Intra-observer reproducibility was assessed averaging the LoA for each observer with their repeated measurements. Based on data from an AAA screening trial and the estimated mean differences between the three principal methods, AAA prevalence was estimated using each of the methods.

Results: The inter-observer LoA of the OTO, ITI, and LTL was 2.6, 1.9, and 1.9 mm, whereas the intra-observer LoA was 2.0, 1.6, and 1.5 mm, respectively. Mean differences of 5.0 mm were found between OTO and ITI measurements, 2.6 mm between OTO and LTL measurements, and 2.4 mm between LTL and ITI measurements. The prevalence of AAA almost doubled using OTO instead of ITI, while the difference between ITI and LTL was minor (3.3% vs. 4.0% AAA).

Conclusions: The study shows superior reproducibility of LTL and ITI compared with the OTO method of caliper placement in ultrasound determination of maximum abdominal aortic diameter, and the choice of caliper placement method significantly affects the prevalence of AAAs in screening programs.

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INTRODUCTION

An abdominal aortic aneurysm (AAA) is defined as the aortic diameter being larger than or equal to 30 mm.[1] In screening and surveillance of AAA, trans-abdominal ultrasound scanning is the standard imaging modality because of its non-invasive nature, relative availability, relatively high

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reliability, speed, low cost, and because it does not involve ionizing radiation. For screening this may be an acceptable method compared with abdominal palpation.[2,3] However, compared with computed tomography (CT) angiography, which is considered the gold standard in accurate evaluation of maximum aortic diameter,[4] the accuracy and reproducibility of ultrasound assessment is a concern.[5]

Reproducible measurements of the abdominal aorta have emerged as an area of critical importance with screening programs for AAA already established[6,7] or being planned in several countries. In addition, there is an increased number of imaging studies needed for planning elective repair, and surveillance after endovascular aneurysm repair (EVAR).[8,9] Small errors in measurement may impact clinical decision by miscategorising patients, for example inappropriate enrolment into surveillance programs at the 30 mm threshold, delayed surgical referral at the 55 mm threshold, or lack of recognition of expanding AAA after EVAR. Furthermore, with reported mean annual growth rates of 2–3 mm in diameter, a high reproducibility is required to allow detection of small changes in AAA diameter.[1]

The validity and reproducibility of ultrasound assessment of maximum aortic diameter involves a number of factors contributing to the variance: operator skill and training, ultrasound machine and frequency, habitus of the patient, degree of intimal plaque calcification, presence of mural thrombus, aortic curvature, plane of image acquisition, axis of measurement, diameter selection, aortic level, cardiac cycle, and caliper placement.[5] There is no clear consensus on how to determine the maximum aortic diameter with ultrasound.[5,10]

With respect to the variance component of caliper placement, there are principally three ways to place the caliper in relation to the vessel wall in assessment of maximum aortic diameter with ultrasound: 1) leading edge to leading edge (LTL, i.e. outer anterior wall to the inner posterior wall - adventitia to intima), 2) inner to inner (ITI, i.e. inner anterior wall to the inner posterior wall - intima to intima), and 3) outer to outer (OTO, i.e. outer anterior wall to the outer posterior wall - adventitia to adventitia) (Fig. 1). The OTO method is the most commonly used in most imaging departments. Yet in the UK, the National Health Service Abdominal Aortic Aneurysm Screening Programme (NAAASP) uses the ITI method.[11] In parts of Scandinavia LTL is the preferred method,[12,13] as well as the one recommended by the American College of Radiology.[14] The current guideline by the European Society for Vascular Surgery on the management of AAA emphasises the need to clarify which caliper placement method should be used going forward.[1]

Theoretically, the LTL method should provide superior reproducibility as this method uses the vessel walls with the most distinct ultrasound reflection, where sound travels through boundaries from an echolucent to an echodense layer, and therefore at these positions it is the easiest to precisely place calipers.[15] However, in clinical practice many screening patients have abdominal aortic intimal calcification, which offers sharp, clear borders that are brilliant markers for reproducibility. This favours the reproducibility of the inner to inner method. Conversely, a sharp delineation between the outer posterior aortic wall from surrounding tissue is often lacking, which suggests that the OTO method might exhibit the greatest variability.

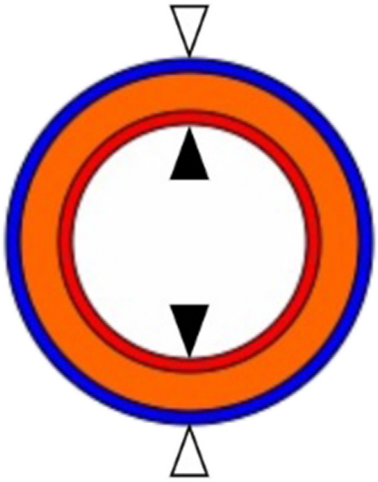

Figure 1. Schematic transverse image of the abdominal aorta. The inner red circle represents the tunica intima, whereas the orange area tunica media and the outer blue circle represents the tunica adventitia. The three principal methods of caliper placement in ultrasound assessment of maximum abdominal aortic diameter are inner to inner edge (ITI, black solid arrowheads), leading to leading edge (LTL, downward black hollow arrowhead to downward solid arrowhead and outer to outer edge (OTO, hollow black arrowheads).

Hence, the primary aims of this study were to determine observer reproducibility of caliper placement in ultrasonographic determination of maximum abdominal aortic diameter with the three principal methods in a screening setting — and whether body size influenced the variations. The secondary aims were to assess the mean difference between OTO, ITI, and LTL diameters, and estimate the impact of using any of the three principal methods on AAA prevalence in a screening program.

MATERIALS AND METHODS

A multi-institutional web based cross-sectional study was conducted after receiving approval from the local ethics committee and the data protection authorities.

Measurement platform

An in house web based platform for facilitating observer performance studies in imaging research was used. This platform provided an environment where image analysis could be conducted over the Internet with an interface, which mimics a Picture Archiving and Communication System (PACS) interface.[16] Hence some of the logistical challenges in observer performance studies in imaging research can be reduced, allowing a larger number of observers to be included in a study.

Ultrasound scans/data

As part of the Viborg Vascular (VIVA) screening trial, specially trained study nurses screened men aged 65–74

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