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Paper

Evaluation of angiography as the sole imaging study for the proximal aortic neck prior to EVAR

Stephen A Badger, Nityanda Arya, William Loan, Chee V Soong

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ABSTRACT

Background: Angiographic assessment is an alternative to computerised tomography (CT) prior to endovascular aneurysm repair (EVAR). We evaluated angiography in aortic neck morphology assessment as an alternative investigation.

Methods: Patients admitted for elective or emergency EVAR were assessed by pre-operative CT and intra-operative angiography. The proximal and distal aortic neck diameters, and neck length were measured. Measurements were expressed as median (95% CI).

Results: 35 patients (20 male) were assessed from August 2003 to January 2005 for elective (26) and emergency (9) EVAR. In the overall group, the proximal neck diameter was 22.0mm (21.0-23.0) on CT, and 20.7mm (19.3-22.3) on angiography. The distal neck diameter was 23.0mm (22.0-24.0) on CT, and 22.3mm (20.3-24.6) on angiography, while the neck length was only slightly greater on angiography [23.0mm (17.5-28.4)] relative to CT [23.0mm (20.0-28.0)]. The stent-grafts deployed were oversized by 26.8% (± 14.8%) relative to the CT measurements, and 33.7% (± 15.6%) relative to angiographic measurements. Good correlation was found for all three measurements between CT and angiography.

Conclusions: Angiography alone is inadequate for endovascular aneurysm repair. Although it has timesaving potential, the accuracy achieved is not sufficient to use alone.

Key words: Angiography, computerised tomography, endovascular, aneurysm repair

INTRODUCTION

Endovascular repair (EVAR) of an abdominal aortic aneurysm (AAA) has become an acceptable alternative to conventional open repair in both the elective and emergency situation. Although the effectiveness of EVAR in fit elective patients has been confirmed, the same has not been demonstrated for ruptured AAA (rAAA) patients. This is despite a few specialist centres reporting significantly better results in comparison to conventional open repair[1-3]. However, these results are based on the use of EVAR in treating stable contained ruptured AAA, with benefits in the unstable patients remaining ambiguous[4]. It is in the latter group of patients, where mortality is highest, that the value of EVAR should be evaluated.

A major trepidation with the use of EVAR in unstable rAAA patients is how to assess anatomical suitability and calculate accurate sizing of the stent-graft. Contrast enhanced computerised tomography (CT) scanning is the investigation of choice for many, with the additional advantage of revealing other abdominal pathology causing symptoms. But this investigation will lead to unnecessary delay in haemorrhage control, which is vital to the survival of these patients. On-table angiography has been suggested as an alternative, although it only provides luminal dimensions with possible underestimation of the true vessel diameter[1,3].

Since commencing a policy of assessing all ruptured AAA for endovascular repair, angiographic measurements of neck dimensions have become an integral part of our practice. The aim of this study therefore, was to evaluate whether angiographic measurements of the aneurysm neck are accurate enough to complement or replace CT measurements for EVAR, particularly with unstable emergency patients in view.

PATIENTS AND METHODS

Patient recruitment

Patients were prospectively assessed when admitted for elective and emergency endovascular repair of their aneurysm. All elective patients had AAA over 55mm in maximum diameter, while emergency patients were defined as those with a definite leaking or ruptured AAA. Emergency

Vascular and Endovascular Surgery Department, Level 5 South, Belfast City Hospital

Lisburn Road, Belfast, BT9 7AB, United Kingdom.

Correspondence to Mr SA Badger

Stephen@Badger.tc

aneurysm repair was considered on all-comers, except in the presence of advanced dementia, terminal cancer, end-stage cardiorespiratory or renal disease and by patient choice. Assessment and analysis was performed upon consecutive elective and emergency patients, who had repair conducted jointly by one particular consultant vascular surgeon and one consultant interventional radiologist, both of whom had considerable experience in EVAR over several years.

The patients had morphological assessment made by both pre-operative CT and intra-operative angiography. Three morphological measurements were compared. The proximal neck diameter was measured immediately below the lowest renal artery, from adventitia to adventitia. The distal neck position was taken as the transition between parallel vessel walls and diverging walls. This is by its nature slightly subjective, but is a relatively identifiable reference point and was identified with good reliability, as there was very little inter-observer variation in bottom neck measurements. The neck length was taken as the distance between proximal and distal neck. Two experienced consultants in the endovascular team, blinded to the CT results, independently made the measurements of the angiogram. All endovascular aneurysm repairs, in this study, were performed using a Talent (Medtronic, Watford, UK) stent-graft, sized according to the pre-operative CT measurements. The normal unit protocol is to oversize the stent-graft by 20%, based on CT proximal neck diameter. However, this may prove to be slightly increased in the emergency setting, due to a limited stock of stent-graft sizes[5].

Computerised tomography angiography measurements

CT scans were performed using a Philips MX8000 four-slice helical scanner (Philips Medical Systems, Eindhoven, Netherlands). Non-ionic intravenous contrast was injected at 3ml per second by preference at the ante-cubital fossa. An automatic bolus tracking system was used to ensure optimum vessel opacification. Axial images were reconstructed at 1.6mm intervals. Measurements of orthogonal (perpendicular to the scan axis) diameter were performed on helical CT scan data sets on a Brilliance workstation (Philips Medical Systems, Eindhoven, Netherlands).

The shortest diameter was measured to avoid the distortion caused by vessels turning in relation to plane of the scan. It is possible to reconstruct images axial to a curved portion on the aorta, although the accuracy of this is not verified. At present we prefer to use the scan plane axial images to eliminate a source of potential variability. All measurements were made at the same workstation using the same measurement software and optimum windowing to reduce any artefact.

Angiographic measurements

Angiography was performed using a Philips Integris V5000 system (Philips Medical Systems, Eindhoven, Netherlands) and either Iomeron 270 or Visipaque 270 contrast solution, depending on the patient's renal function according to our institutional protocol. Measurements were performed using integrated software on the angiography system, following calibration with a graduated pigtail catheter. Measurements were made across the aortic neck, perpendicular to the aortic neck axis, at sites comparable to the proximal and distal neck measurements taken at CT. In an attempt to simulate the extreme urgency of dealing with unstable ruptured aneurysm patients, only one angiogram was made in postero-anterior projection. While an automatic measurement package is available on the angiography system, it is not reliable in detecting the aortic wall in the presence of stent-graft delivery systems and catheters. Measurements were therefore limited to those taken by manually positioning cursors on a digitally subtracted image. A measurement of the neck length was also made and taken to be the distance between the proximal and distal neck. Additional measurements, such as iliac and aneurysm sac diameters were not included in this study.

Statistical analysis

Statistical analysis was performed using SPSS (Version 13, SPSS Inc, Chicago, Il, USA). The age of the patients was described in terms of mean age in years (± standard deviation). The aortic neck measurements in mm was expressed as median and 95% confidence intervals (CI). Correlation between the two investigative modalities for the measurements was determined using Spearman's rank correlation coefficient, with a p value of less than 0.05 considered significant.

RESULTS

Patient profile

Thirty-five patients (20 male) were assessed, prior to EVAR, by CT and angiography, from August 2003 and January 2005. These included both elective (26) and emergency (9) patients and the overall mean age was 77.7 (± 6.75) years old.

Comparison of neck dimensions of the overall group

The median proximal neck diameter on CT was 22.0mm (21.0 – 23.0mm), while angiographic measurement was 20.7mm (19.3 – 22.3mm). When assessed by statistical correlation, there was a close relationship of results for the proximal neck diameter ($r = 0.71$, $p<0.0001$) (Figure 1). The median diameter of the distal neck was 23.0mm (22.0 – 24.0mm) on CT, while that by angiography was 22.3mm (20.3 – 24.6mm; $p = 0.29$). Correlation of these measurements was also significant ($r = 0.65$, $p<0.0001$) (Figure 2). The median neck length was 23.0mm (20.0 – 28.0mm) on CT and by angiography was 23.0mm (17.5 – 28.4mm; $p = 0.76$). The correlation between the measurement for the neck length, as demonstrated in Figure 3, although significant was weaker, reflecting possible apparent foreshortening on X-ray ($r = 0.55$, $p=0.004$) (Figure 3).

Comparison of neck dimensions of the elective cases

The median proximal neck diameter on CT was 21.5mm (20.0 – 23.0), while the angiographic measurement was 20.0 (18.5 – 21.5). Close correlation was found in this group of patients ($r = 0.70$, $p<0.0001$). The median diameter of the distal neck was 24.0mm (23.0 – 25.0) on CT, while by angiography was 22.3mm (19.6 – 25.1). Significant correlation was calculated ($r = 0.77$, $p<0.0001$). The neck length in this cohort was 22.0mm (19.0 – 26.0) on CT and 23.2mm (15.1 – 29.6) by angiography. Correlation for neck length remained significant ($r = 0.63$, $p = 0.004$).

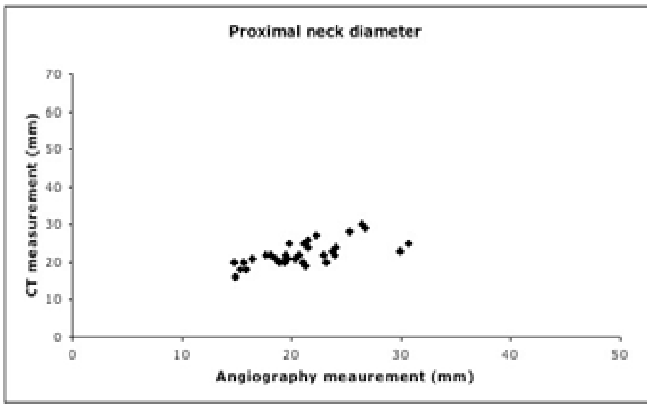

Fig 1: Scatterplot of proximal neck diameter measurements.

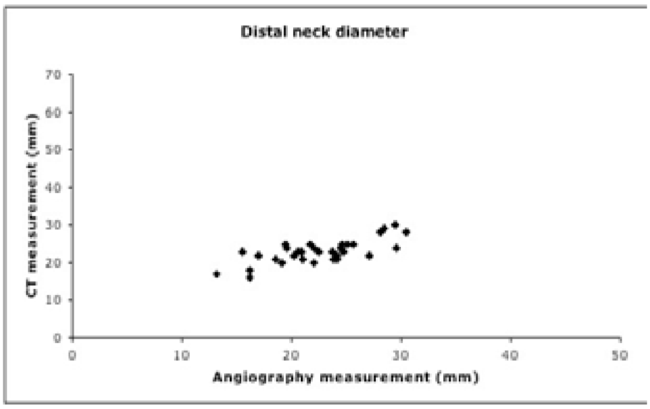

Fig 2: Scatterplot of distal neck diameter measurements.

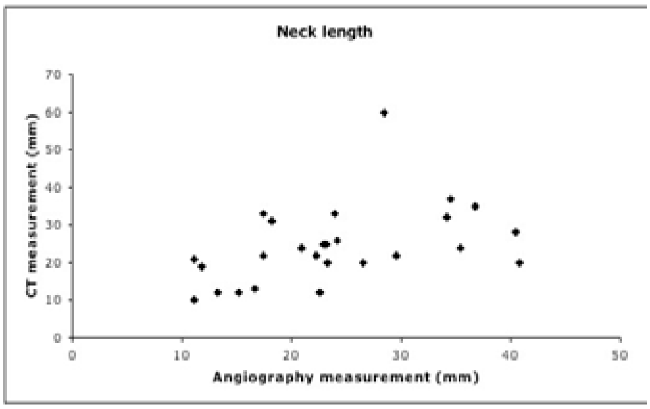

Fig 3: Scatterplot of neck length measurements.

Comparison of neck dimensions of the emergency cases

In the smaller emergency group, the proximal neck diameter was 22.0mm (20.0 – 30.0) on CT and 24.0mm (18.1 – 30.6) on angiography. Significant correlation was demonstrated ($r = 0.80$, $p = 0.03$). The median distal neck diameter was 21.0mm (17.0 – 23.0) on CT, while angiography measured it at 23.9mm (16.2 – 27.0), with correlation found to be significant ($r = 0.92$, $p = 0.0004$). The neck length was measured to be 28.0mm (12.0 – 35.0) on CT and 22.9mm (17.5 – 40.4) on angiography. Correlation was not demonstrated in this ($r = -0.04$, $p = 0.94$).

Stent-graft sizing

The mean size of the stent-grafts used was calculated as 28.2mm (± 3.6mm). They were oversized by 26.8% (± 14.8%) relative to the CT measurements, and by 33.7% (± 15.6%) based on the angiographic methods. If an approximate oversizing of 35% were used for angiographic measurements, no patients would have had a smaller stent-graft than the CT measurement, while only three patients would have had a stent-graft size within 1mm of the CT measurement.

Outcome

In the follow-up period to 2007, one stent-graft migrated in an emergency patient, although without any requirement for secondary intervention. One elective patient had a Type I endoleak, while five elective patients had a Type II endoleak, although only one required lumbar embolisation.

DISCUSSION

The speed with which a ruptured AAA (rAAA) can be effectively excluded from the circulation and haemorrhage stopped, is of utmost importance to the outcome of the patient. However, one of the most vital steps in determining the ultimate success of EVAR for the treatment of rAAA depends upon the ease and accuracy of assessing suitability and sizing the stent-graft. Although ultrasound is the cheapest and simplest diagnostic procedure of AAA, it is not suitable for pre-operative assessment of the aneurysm morphology[6]. Magnetic resonance angiography is becoming increasingly popular for the elective patient, but is unlikely to be useful in emergency settings, because of its restricted availability. CT remains the investigation of choice for both elective and emergency AAA patients. It provides accurate information on the neck length and diameter, neck shape, iliac vessels, as well as providing diagnostic confirmation of a rAAA. CT can also exclude the presence of a ruptured AAA, while angiography may not confirm a clinically suspicious diagnosis.

It has been shown that there usually is sufficient time to assess the average, relatively stable, patient with rAAA by CT scan, prior to proceeding to surgery[7]. Workers at the Southampton General Hospital have found that the median time delay to operation was 159 (16-1450) minutes, with neither the delay nor CT scan influencing the outcome. However, rAAA patients are unpredictable and unstable patients should be offered immediate life-saving surgery, whenever feasible.

The use of contrast angiography to evaluate the anatomical suitability for EVAR, and to size the stent-graft, has been proposed as an option. Nevertheless, most practitioners remain sceptical in view of its limitations. Firstly the magnification artefact, which is determined by the distance from X-ray source to receiver, and body habitus will adversely affect the accuracy of the measurements[8]. The use of calibrated catheters may minimise this artefact by allowing patient-specific determination. Secondly, tortuosity in the plane of the angiogram will cause a foreshortened appearance and diminish the apparent length of the vessel. This is partly illustrated by the weaker correlation of neck length measurements in this study especially in the ruptured cases[9]. The subgroup analysis results in an inconsistent picture with regard to the neck length correlation, but this is due to the smaller numbers in the subgroups. Thirdly, presence of thrombus, may affect the true diameter of the vessel[10,11]. Finally the presence of iliac stenotic disease may be underestimated by projection errors. This however, may be reduced with oblique views[9].

CT overcomes many of these problems, in particular the thrombus effect. However diameter measurements with CT may suffer from methodology errors and observer variability[12,13]. This variability is regardless of the measurement plane used[13]. The elliptical shape of a tortuous vessel on axial CT can result in a cylindrical stent-graft being deployed in a non-cylindrical aortic neck, with the risk of endoleak[14]. However helical CT at small slices, as used in this series, with post-procedure reformatting produces excellent images, not unlike the real object, with the generation of 3D images and linear data along the axis of blood flow[15,16]. Although better results may be gained from 3D images than traditional axial CT, and may be ideal especially for elective EVAR planning, it is impractical in assessing emergency patients[17].

The assessment of the proximal neck morphology is crucial to the success of EVAR. Rose *et al*[18] demonstrated that 80% of rAAA were deemed to be anatomically unsuitable, with 48% having more than two adverse features. Unsuitable neck morphology was the primary reason for exclusion in 76%. This was supported by Wilson *et al* who found that the neck morphology of rAAA was significantly shorter than a similar cohort of elective patients[19].

Our comparative observation demonstrated that angiographic measurements of the neck length are similar. However, the measurements of the neck diameter by angiography are almost 7% smaller than the CT measurements. This resulted in 7% difference in the degree of stent-graft oversizing. Nevertheless, the fact that none of the patients would have received a stent-graft smaller that their CT diameter is encouraging. Accurate sizing of the stent-graft is crucial to successful aneurysm exclusion, future endoleaks and neck dilatation, but a less than perfect fit may reasonably be deemed acceptable in unstable patients who have mortality rates of nearly 100%.

While other investigators have compared angiography and CT, no conclusions have been made regarding stent-graft sizes. Beebe *et al* in 1995 retrospectively studied 50 patients who had either AAA or aorto-iliac-occlusive disease[20]. The conclusions were limited by the magnification artefact and the 8mm CT slices. Resch *et al* in 1999 found that the neck diameter was consistently smaller on angiography, but concluded that neither modality was sufficient alone[21]. Recently Diehm *et al* made the comparison in 21 patients[22]. Unlike this study the main conclusions were centred on intra and inter-observer variation in vessel measurements.

Our data, although based upon small patient numbers, suggests that angiography alone will underestimate the diameter of the aneurysm neck, and is therefore inadequate for elective cases. However, it may be argued that in the emergency situation, especially with an unstable patient, it can be used if the stent-graft is oversized by a greater margin. In addition, the poor correlation of neck length measurements may result in patients inappropriately being offered EVAR. There is no doubt that the time delay in obtaining CT scans to assess unstable patients with suspected rAAA has been a major disconcerting factor in offering EVAR as a treatment of choice. By avoiding this time delay, angiography may allow patients to be assessed quicker on the operating table. In addition, angiography can be performed with the patient fully prepared for surgery and an occlusion balloon in place for those deemed very unstable. The caveat to this lies in the fact noted earlier that 80% of rAAA patients are thought to be EVAR unsuitable. However, after performing the angiogram, surgery can proceed either as EVAR or open repair. Unfortunately, despite these theoretical attractions, our results would indicate that angiography is less than ideal for assessing aortic anatomy and cannot be justified in its current state to determine EVAR suitability and in sizing stent-grafts, particularly when most patients can undergo CT scan, even in the emergency situation.

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Corrections.

1. In Hedley Whyte J, Milamed D. Lobar Pneumonia treated by Musgrave Park Physicians. *Ulster Med J* 2009;**78(2):**119-128, there was a small typographical error: on page 125, the first line of the legend to Fig. 9, the year of Prof Maxwell Finland's death was shown as 1982. The correct year is 1987.

2. In Johnston PC, Donnelly DK, Morrison PJ, Hunter SJ. DiGeorge syndrome presenting as late onset hypocalcaemia in adulthood. *Ulster Med J* 2008;**77(3):**201-2, there was a typographical error in the second author's middle initial. It should have read Donnelly DE.

3. In O'Donnell ME, McCavert M, Carson J, Mullan FJ, Whiteside MW, Garstin WI. Non-epithelial malignancies and metastatic tumours of the breast. *Ulster Med J* 2009;**78(2):**105-112, the figure legends for figs 2-4 were transposed and incorrectly printed in the print edition and are reproduced correctly below. The figures are correct, and the online edition has the correct legends.

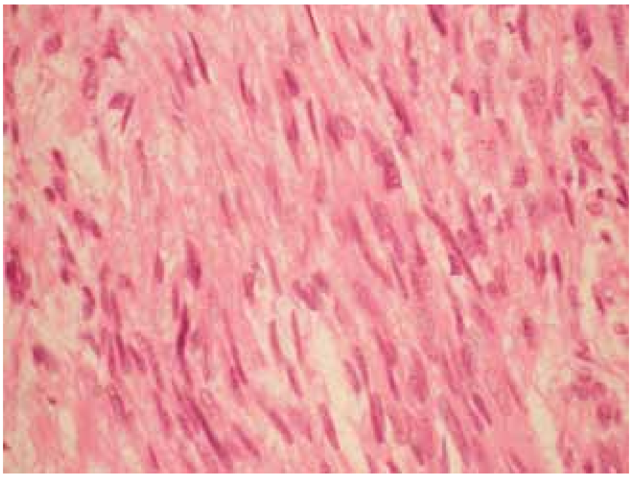

Fig 2. Breast sarcoma (H&E x 200). This field shows large spindle shaped cells with nuclear pleomorphism and eosinophilic cytoplasm. There is no differentiation which would indicate the cell of origin.

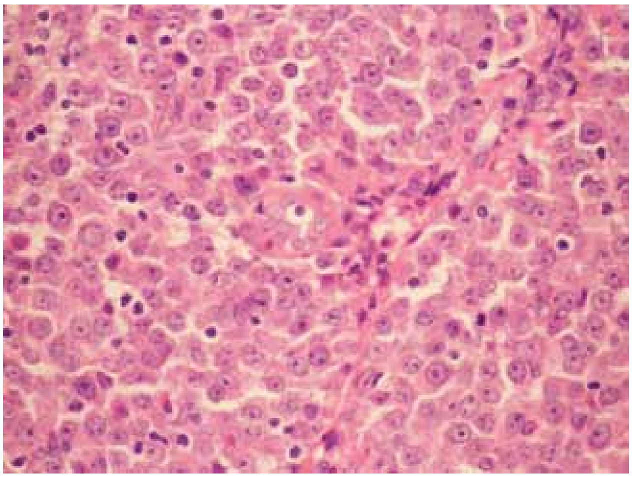

Fig 4. Multiple myeloma deposit right breast (H&E x 200). This field shows large atypical plasma cells many of which are showing immunoblastic differentiation with large central nucleoli.