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Original Article

Surgery Section

Observational Study Comparing the Measurement of Abdominal Aortic Aneurysm (AAA) Diameter in Different Morphology with Ultrasound and CT Scan

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ABSTRACT

Introduction: Ultrasound (US) is the gold standard imaging modality used to measure the diameter of Abdominal Aortic Aneurysms (AAA), and it is used in the surveillance of AAAs. The use of Computed Tomography (CT) has now become widespread. There has always been disagreement between CT and US, which significantly affects management decisions.

Aim: To examine the agreement between US and CT in measuring aortic diameter. Furthermore, it was used to investigate if size discrepancy between US and CT increases as the AAA size increases.

Materials and Methods: This was a single centre retrospective observational study. It included 212 patients, with infra-renal aorta of diameters ≥3 cm, who had undergone an US of the aorta and a CT aortogram within 90 days of each other. US-measured maximum Antero-Posterior (AP) aortic diameter and CT-measured maximum aortic diameter were considered. Statistical analysis was performed using Bland-Altman plot, paired t-test and Pearson's correlation.

Results: There was a significant disagreement between measurements on CT and US. The mean US measured AP diameter was 5.4 cm (SD1.05), whereas the mean maximum measured aortic diameter on CT was 5.7 cm (SD1.13) ($p<0.001$). We did not find any disagreement between US and CT as the size of the AAA increased, with significant but weak correlation (cc 0.27) ($p<0.001$).

Conclusion: Our results demonstrate that US, on average, underestimates the size of AAAs by 0.3 cm when compared to CT. We failed to demonstrate correlation between increasing aneurysm size and increasing disagreement between CT and US.

Keywords: Aortic bifurcation, Case control study, Computed tomography, Diagnostic imaging, US

INTRODUCTION

Abdominal Aortic Aneurysms are responsible for a substantial public health burden in developed countries [1]. It has been estimated that AAAs causes 1-2 percent of all deaths among men over the age of 65 in the United States [2]. According to the National Health Service (NHS) AAA screening program, there are around 3,000 deaths each year in England and Wales in men aged 65 and above, due to ruptured AAA. Therefore, the National Aneurysm Screening Program in the UK has provided men at age 65 with an access to an abdominal US to detect AAA's since March 2013 [3]. The UK small aneurysm trial recommended that patients with aortic diameter less than 5.5 cm should be managed with best medical therapy and surveillance by regular US scans [4].

Conventional scanning modalities can be used for the diagnosis and follow-up of AAA; however, the most common methods are B-mode ultrasound scanning or CT. In recent years, duplex ultrasound (B-mode with colour flow imaging) has become the main imaging choice for surveillance of AAAs [3], but many are still detected incidentally on CT scans. Although, AAA diameters measured by US and CT correlate to each other but there is a weak agreement, and differences in sizes have been estimated to be as large as 5 mm, between modalities [5]. Over the last 10 years, the development of Endovascular Aortic Aneurysm Repair (EVAR) has meant that CT scans have become essential for the planning of the EVAR procedure and many argue that this should remain the optimal method for post-EVAR surveillance despite the increase in radiation dosage to the patient [6,7].

This potential size discrepancy is concerning, as measurements of AAA size are crucial at all stages of management. Indeed, decision making in asymptomatic AAAs is based primarily on the size of the aneurysm, and very small size differences can significantly affect ongoing management. In today's modern practice it is increasingly common for both US and CT to be used interchangeably for the measurement of AAA size [6,8]. Therefore, this difference between size interpretations has become an increasingly problematic issue. Therefore this study was done to examine the concordance between US and CT in measuring aortic diameter, and also to investigate if size discrepancy between US and CT increases as the AAA size increases.

MATERIALS AND METHODS

This was a retrospective observational study. All patients who underwent CT-aortogram in York Teaching Hospitals NHS Foundation Trust between January 2008 and December 2013 were identified.

The inclusion criteria were patients with size of infra renal aorta equal to or greater than 3 cm on any one of the scans; an US aorta and a CT abdomen with arterial phase contrast within 90 days of each other. Exclusion criteria were patients with post endovascular intervention scans and those with un-reported measurements. For patients who had more than one occasion for comparison, only the first occasion has been included.

US technique: All measurements were performed on patients in the supine position. The scan was performed and reported by radiographers who hold Postgraduate Diploma in medical ultrasound, or radiologists with ultrasound experience. Using a 3.5-MHz B-mode real-time linear array transducer in transverse plane, imaging of the aorta took place along its length from the upper abdomen above the celiac axis to the aortic bifurcation. Imaging the aorta in longitudinal or sagittal plane was from the midline along its length to the aortic bifurcation. Measurement was of the maximum Antero-posterior (AP) diameter of the abdominal aorta (outer wall to outer wall).

CT analysis: Data sets were acquired using Siemens Somatom sensation 16×0.75 collimation. A pre-endovascular aortic repair protocol was used which included an arterial phase starting from the aortic arch down to the pubic symphysis. Non-ionized contrast (100 mL) was injected at a rate of 4 mL/second with 1 mm slices (0.7 spaced). All the CT scans were reported by consultant vascular radiologists.

STATISTICAL ANALYSIS

Basic statistical analyses for the frequencies were performed. Bland and Altman plot were used to assess the level of agreement between US and CT measurement [9]. Paired t-test was performed to test mean difference. Pearson's Correlation was performed to assess for correlations. SPSS software version 19 was used to perform the analysis.

This study was approved by local research group and clinical effectiveness team with no ethical approval needed as the study did not involve any intervention.

RESULTS

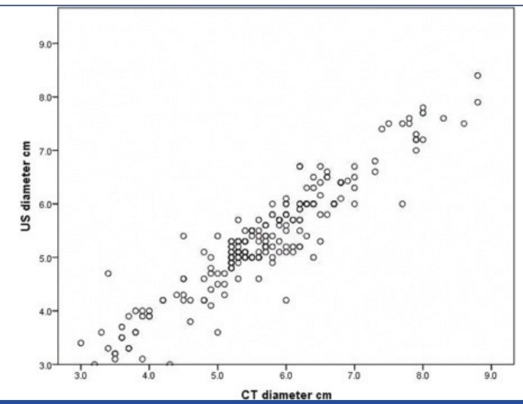
The study included 212 patients (33 females, 179 males). The mean age at the time of the scanning was 76 years (standard deviation of 8.6, range 54 to 99 years). The mean interval between scans was 35.6 days (Std. deviation 25.5 days). In our study 46% (97) of the cases had the two scans within 30 days [Table/Fig-1].

Characteristics	Total (n=212)
Gender	
Male	179 (85%)
Female	33 (15%)
Age (mean±SD)	76±8.6 years
US diameter (mean±SD)	5.4±1.05 cm
CT diameter (mean±SD)	5.7±1.13 cm
Days between scans (mean±SD)	35.6±25.4 days

[Table/Fig-1]: Characteristics of the study participants.

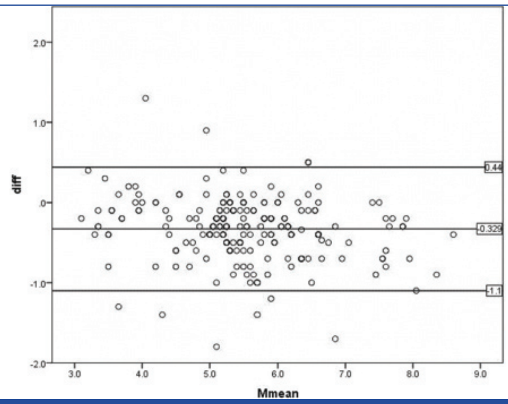
The mean US measured AP diameter was 5.4 cm (SD1.05), range from 3.0 to 8.4 cm. The mean maximum measured aortic diameter on CT was 5.7 cm (SD 1.13), range from 3.0 cm to 8.8 cm [Table/Fig-1]. Paired T-test was performed to assess the difference in diameters between US and CT and it showed mean difference of -0.329 ($p<0.001$). More than half of the cases had aortic diameter equals or greater than 5.5 cm on CT, 57% (121) compared to 41% (88) on US AP measurement.

In our sample there was a significant positive correlation between aortic diameter recorded on CT and the aortic diameter recorded on US [Table/Fig-2]. Pearson correlation test showed p-value <0.001 with correlation coefficient of 0.938.



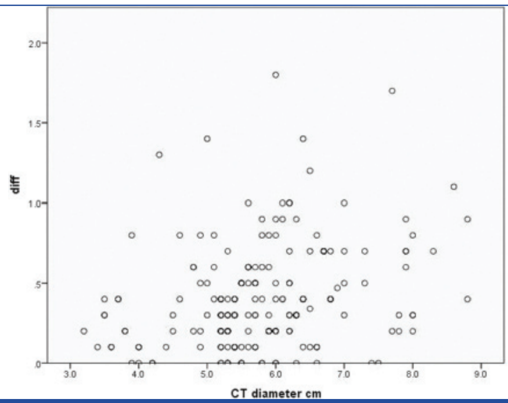
[Table/Fig-2]: Correlation between CT diameter and US diameter.

We plotted the difference between the measurement methods against their mean. In the Bland Altman plot, the mean difference between the measurements was -0.329 which is not close enough to the zero value to indicate good agreement [Table/Fig-3]. In addition, the distribution of the dots was unequal on the both sides of the mean. The plot indicated a weak agreement. There was persistent bias toward larger readings on all CT measurements compared with US.



[Table/Fig-3]: Bland-Altman plots showing weak agreement between CT diameter measurements and US diameter measurement.

We examined all the cases where the aortic diameter on CT was greater than the diameter on US to assess the relation between increase in the diameter and the difference between the two measurements. The Pearson correlation test between the difference and the diameter on CT showed significant weak correlation ($p<0.001$) and correlation coefficient of 0.284 [Table/Fig-4].



[Table/Fig-4]: Correlation between CT diameter and difference in diameter measurements between CT and US.

DISCUSSION

Accurate measurement of AAA size represents a crucially important factor that informs appropriate decision making regarding intervention. This importance has been emphasised by a randomised trial that identified the appropriate threshold beyond which the risk of aneurysm rupture is greater than the risks with surgical treatment [6].

Variations between AAA diameter measurements in the two imaging modalities, at increasing aneurysm size, remain poorly described. It is important therefore to interrogate this relationship before adopting the current practice of using CT to determine threshold for AAA intervention. Manning B et al., reported that CT measurements provide a relative oversize of AAA diameter when compared to the gold standard US measurements. As a secondary outcome they also reported no variability in AAA diameter measurements with increasing AAA size [10]. Sprouse L et al., reported maximal AAA diameter at CT was consistently larger than maximal diameter at US. The mean difference between the two was approximately 1 cm [11].

In our study, we found a significant correlation between the aortic aneurysm diameter measurement, using US and CT. This close correlation is expected. However, this does not describe the agreement between the two modalities of imaging. In 31.1% (66)

of the cases the difference was equal or greater than 0.5 cm. This indicates that the difference between measurements could cause a change in the management plan, such as the interval of surveillance, and regarding whether or not to intervene with surgical or endovascular repair.

In 88.6% (188) of our cases the diameter recorded on the US was smaller than the diameter recorded on CT. We failed to demonstrate a strong correlation between the increase in aneurysm diameter and variability between measurements on CT and US. We compared the mean difference between two groups, one group included patients where the aneurysm was ≥5.5 cm and the second group had the patients where the aneurysm was <5.5. The result was -0.476 cm and -0.303 cm respectively. The two means did not show significant discrepancy and therefore supports the weak correlation between the size of the aneurysm and difference between measurements.

In our sample 57% (121) of the cases reached the threshold diameter for intervention on CT compared to 41% (88) on US. There is a group of patients (n=35, 16.5%) whose aortic diameter on US was less than 5.5 cm (the threshold of intervention), and on CT their aneurysm diameter reach the level of threshold of intervention ≥5.5. This size discrepancy therefore could significantly affect the treatment plan for these patients if decisions are being made on US measurements alone. Indeed our study confirms the findings of other series, which have shown that CT diameter measurements have been consistently greater than measurements of the same aneurysm made by US and there was weak agreement between the both measurements [6,10,11].

Several explanations for the discrepancy between US and CT measurements have been described. The measurements in both modalities come in different axes as in CT maximum diameter is used for reporting the diameter. However, in US the dimensions are usually reported in two planes (A-P and transverse). Based on that the asymmetric aneurysm will produce a CT measurement that is greater than the US measurement. Another factor that might affect the measurement is vessel tortuosity, as the measured axial sections on CT may actually represent an oblique section of an AAA leading to overestimation of size. CT measurements also include the full thickness of the aortic wall, which is not the case in the US measurement [10]. As suggested by Lederle et al., US measurements are less affected by tortuosity, because the position of the US probe can be adjusted to take a true cross section of the aorta which might favour US in producing a more accurate measurement of diameter [12].

LIMITATION

There are a number of limitations in our study. Firstly, the study was retrospective. Secondly, the study involved only one centre. Thirdly, the measurements recorded for both scans came in different axes (for CT the maximum diameter at any dimension has been used which is not the case for the US where all the reports use the anterior-posterior dimension only). Fourthly, there was no blinding of the examiner or reporter for the later imaging modality. Fifthly, the CT and US measurements were not done at the same time and therefore one could make the argument that aneurysm growth between the separate scans would account for the size differences. However, we believe that the advantage of methodology we used is its practicality and close relation to the everyday clinical practice.

CONCLUSION

There is high correlation between the CT and US measurements with weak agreement. There is no relation between size of the aneurysm and the degree of disagreement between CT and US measurements. These results suggest that serial measurements of US or CT can be usefully compared in the context of surveillance. However, this study does not justify the use of US and CT measurements interchangeably for determining thresholds for intervention.

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