The Journal of Emergency Medicine, Vol. 29, No. 4, pp. 455–460, 2005

0736-4679/05 $–see front matter

ELSEVIER

doi:10.1016/j.jemermed.2005.02.016

Ultrasound in Emergency Medicine

ACCURACY OF EMERGENCY MEDICINE ULTRASOUND IN THE EVALUATION OF ABDOMINAL AORTIC ANEURYSM

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□ **Abstract—This study assesses the accuracy of Emergency Medicine (EM) residents in detecting the size and presence of abdominal aortic aneurysms (AAAs) using EM ultrasound (EUS) compared to radiology measurement (RAD) by computed tomography (CT) scan, magnetic resonance imaging (MRI), angiography, or operative findings. There were 238 aortic EUS performed from 1999–2000; 36 were positive for AAA. The EUS finding of "AAA" had a sensitivity of 0.94 (0.86–1.0 95% confidence interval [CI]) and specificity of 1 (0.98–1.0 95% CI). Mean aortic diameter among patients with AAA identified by EUS was 5.43 ± 1.95 cm and by RAD was 5.35 ± 1.83 cm. The mean absolute difference between EUS and RAD diameters was 4.4 mm (95% CI 3.7–5.5 mm). Regression of EUS on RAD diameters is strongly correlated, with R^2 = 0.92. EM residents with appropriate training can accurately determine the presence of AAA as well as the maximal aortic diameter. © 2005 Elsevier Inc.**

□ **Keywords—ultrasound; emergency medicine; abdominal aortic aneurysm**

INTRODUCTION

In the United States, there are approximately 11,000 cases of ruptured abdominal aortic aneurysm (AAA) per year (1). Of these, it has been estimated that 30% are misdiagnosed (2). The overall mortality rate for patients with ruptured AAA is 80–95% (3,4). Among those who survive to the hospital, the mortality rate is 50–80% (5,6). Once patients present to the emergency department (ED), early diagnosis significantly decreases mortality from 75% to 35% (7). The sensitivity of the clinical evaluation in the detection of *unruptured* AAA is only 50–65% (8). Its accuracy in patients with rupture has not been studied, but is likely to be lower, because many of these patients are hypotensive or unconscious. Less than half of the patients with a ruptured AAA will present with the classic triad of abdominal pain, hypotension, and a pulsatile abdominal mass (9). For these reasons, it is essential to have a rapid and accurate diagnostic test for patients at risk for AAA presenting with symptoms suggestive of this disease.

The present study investigates the ability of emergency medicine (EM) residents to determine the presence of an AAA as well as the accuracy of AAA measurement by ultrasound as compared to measurements made by computed tomography (CT) scan, magnetic

Presented as an abstract at the Society of Academic Emergency Medicine Annual Meeting, St. Louis, May 2002.

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Ultrasound in Emergency Medicine is coordinated by *David H. Adler*, MD, and *Barry Simon*, MD, of the University of California San Francisco, San Francisco, California

RECEIVED: 11 September 2003; FINAL SUBMISSION RECEIVED: 24 November 2004;
ACCEPTED: 9 February 2005

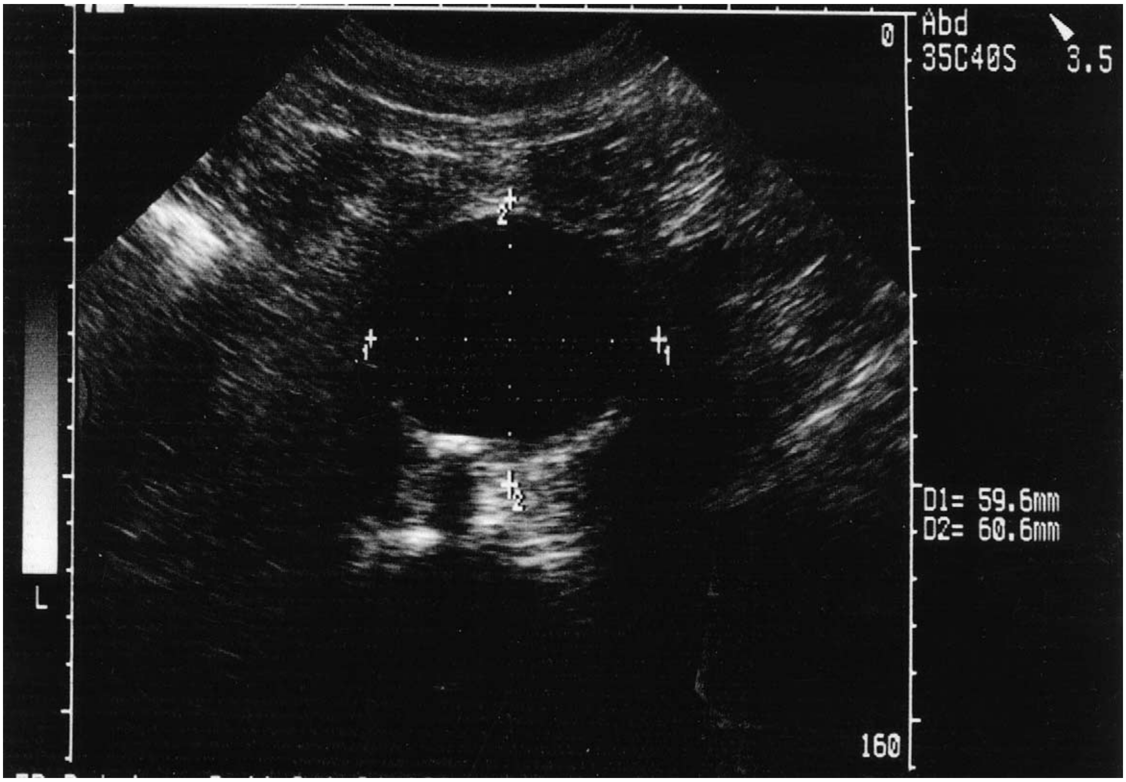

Figure 1. Transverse view of an abdominal aortic aneurysm measuring approximately 6 cm in the antero-posterior and transverse dimensions.

resonance imaging (MRI), or angiography conducted by the Department of Radiology.

MATERIALS AND METHODS

This study was conducted at two urban tertiary care academic medical centers with a combined annual ED volume of 60,000 patients, between October 1999 and October 2000. Patients were included if they were older than 55 years and had at least one of the following symptoms: abdominal, back, flank or chest pain, or hypotension, as well as clinical suggestion of AAA. Patients who presented with a known, stable AAA were excluded. EM residents sought to determine whether an AAA was present based on the criterion of a maximal aortic diameter in the transverse plane of $>$ 3.0 cm (Figure 1). If no AAA was identified, EM residents were asked to make a qualitative assessment to identify other emergent aortic abnormalities.

All emergency ultrasound (EUS) scans were performed by 3rd year EM residents who had learned EUS during their residency and had completed at least 150 emergency ultrasound scans of any type defined by ACEP (10). The residency training curriculum includes a mandatory 23-day ultrasound rotation in the second year of a PGY 1–3 program. The rotation consists of didactic/cognitive and experiential components. The didactic/cognitive training is comprised of lecture, videotape review, and structured reading from ultrasonography textbooks and journal articles. Hands-on training requires the completion of 150 EUS scans. The rotation provides basic training in six of the "primary applications" of EUS, as described elsewhere (10). All scans performed by residents were subject to quality assurance review by experienced emergency ultrasonographers at a later time. In the absence of complete visualization of the entire abdominal aorta, the largest viewed diameter was taken as the maximal aortic diameter. Emergency medicine faculty supervision ranged from very limited experience with ultrasound to quite extensive and was not controlled for in the study.

All patients received a further imaging study from the Department of Radiology (RAD) unless the patient was determined to be unstable and needed immediate operative repair. In these circumstances, no further imaging studies were performed. All RAD studies were interpreted by board-certified radiologists. There were no restrictions placed on the treating clinician about the type of imaging study performed after EUS.

Scans were performed using either a Sonosite 180plus

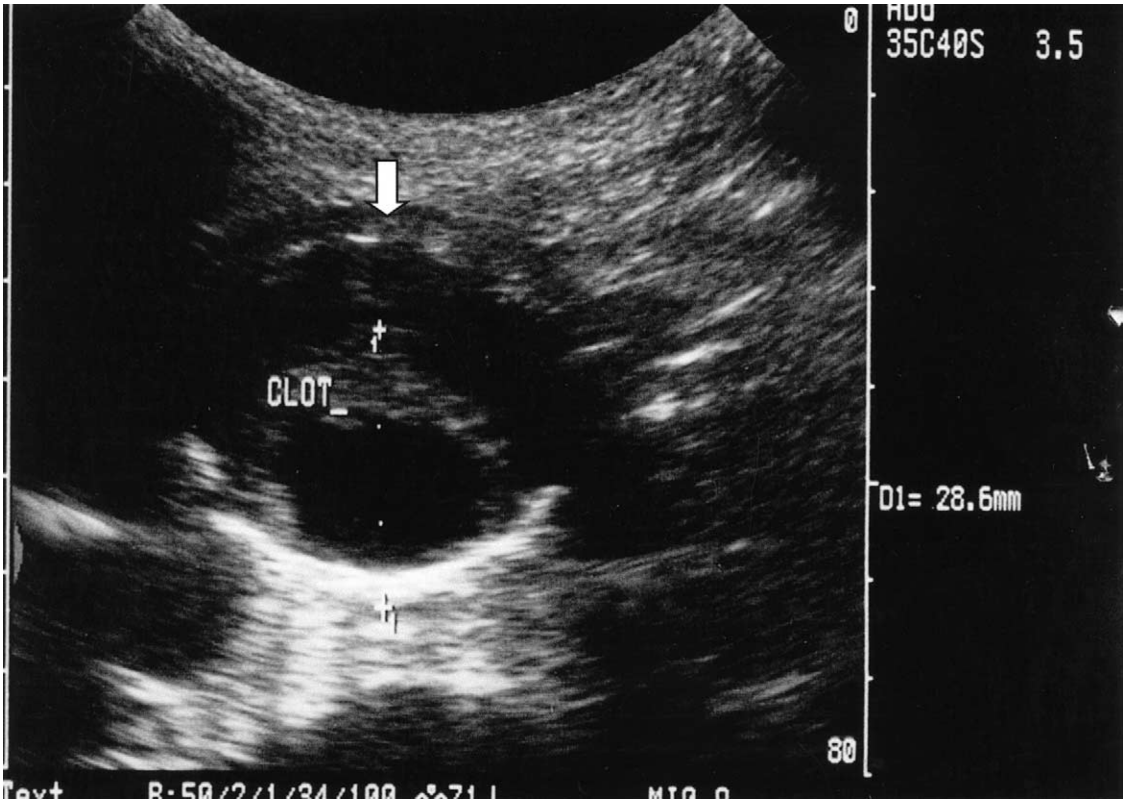

Figure 2. Transverse view of an abdominal aortic aneurysm with the calipers misplaced to measure only 2.9 cm. The intraluminal clot led to the mistaken caliper placement by the resident physician. The arrow marks the true anterior wall of the aortic aneurysm, which was closer to 4.5 cm in AP diameter.

(Bothell, WA) with abdominal probe (2.0–5.0 MHz) or a Siemens Adara (Erlangen, Germany) with abdominal probe (2.0–5.0 MHz). The aortic diameter as measured by EUS and RAD was compared for all aortas with maximal diameter $>$ 30 mm by either method. Aortas with diameter $<$ 30 mm by both methods were not compared with respect to measured diameter. All EUS scan data were recorded with a custom EUS database developed by two of the authors (N.H. and A.D.). Studies of AAA were extracted from this database. This study was approved by the IRB.

Statistics were performed with Microsoft Excel (Microsoft Inc., Redmond, WA) and Stata (College Station, TX); categorical variables were compared with chi square statistics and continuous variables were compared with Student's *t*-test statistics and linear regression.

RESULTS

There were 238 patients enrolled in the study. Follow-up data were obtained on all of them. EUS identified aortic abnormalities in 36 patients: 34 with AAA, one with aortic dissection, and one with "large intraluminal clot." EUS identified the remaining 202 patients as being without emergent abnormalities of the aorta. The criterion standard identified 36 AAA (in the same 36 patients identified as "abnormal" by EUS); 31 of these patients were identified by RAD and 5 in the operating room. The RAD studies performed on this group were 28 CT scans, and one each of MRI, ultrasound, and aortography. There were two patients considered to have significant qualitative abnormalities by the EM residents in whom AAA was not diagnosed. In one patient the EUS diagnosis was aortic dissection, which was confirmed by RAD, but a mildly aneurysmal aorta of 40 mm was also identified on CT scan. In the second case, EUS correctly identified "large intraluminal clot," but the measurement calipers were incorrectly placed so that the aortic diameter was measured at 30 mm (Figure 2). The actual aortic diameter was 45 mm by aortography. Subsequent quality assurance review of the images also demonstrated this aortic diameter. EUS had a sensitivity of 1.0 for aortic abnormality and 0.94 (95% CI 0.86–1.0) for AAA. Specificity was 1.0 (95% CI 0.984–1.0) for both endpoints.

Among patients with AAA who had both EUS and RAD, mean aortic diameter was 5.43 $\pm$ 1.95 by EUS and 5.35 $\pm$ 1.83 by RAD. The measured values for aortic

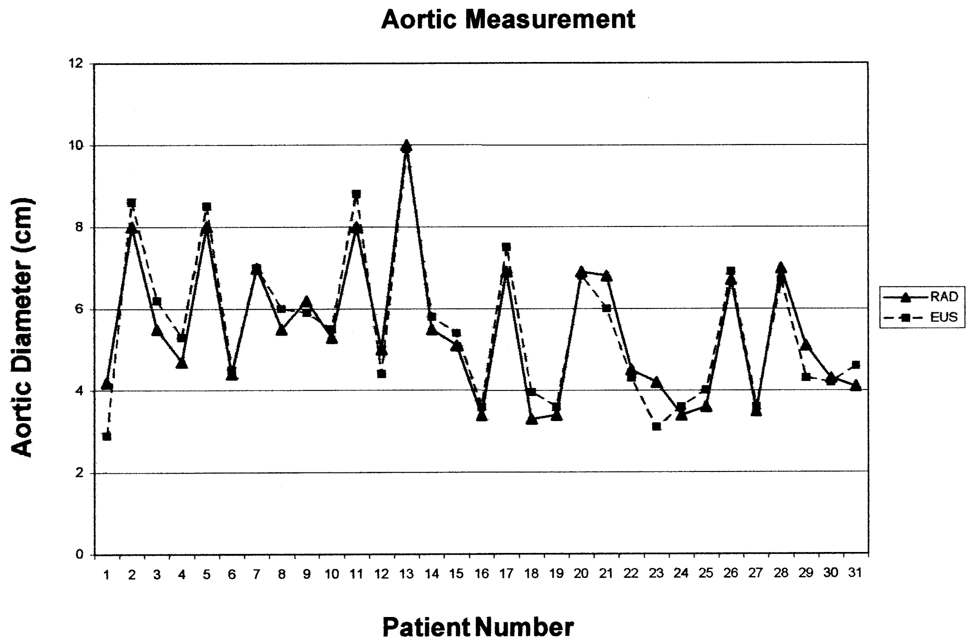

Figure 3. Range of aortic measurements. EUS is the measurement by Emergency Medicine resident-performed ultrasound. RAD is the measurement by the Department of Radiology (imaging studies vary).

diameter for the 31 patients with both EUS and RAD are shown in Figure 3. The mean discrepancy between EUS and RAD was 0.44 cm (95% CI 0.37–0.55 cm) and a range of 0–1.5 cm. Linear regression of EUS on RAD diameters revealed strong linear correlation ($R^2 = 0.92$) with a linear model of $EUS_{diameter} = 1.0222 \times RAD_{diameter} - 0.046$ significant by F test $p < 0.0001$.

Five of the patients with AAA found on EUS had hemodynamic compromise and were taken to the operating room without RAD, where operative findings confirmed the presence of ruptured AAA in all five.

DISCUSSION

Various imaging modalities have been used to evaluate for the presence of AAA. Cross-table lateral plain radiographs were once the most widely used test to evaluate for AAA, but are not sufficiently accurate for a potentially catastrophic disease (11). Abdominal computed tomography (CT) is nearly 100% sensitive and specific and may also serve to identify alternative diagnoses. The disadvantage of CT is expense, in terms of time, personnel, and financial resources; and it necessitates the removal of potentially unstable patients from the resuscitation area (12). Magnetic resonance imaging (MRI) has no advantages over CT scan in the evaluation of AAA, and has additional logistical disadvantages, especially with unstable patients (13). Arteriography provides information about vascular anatomy, but is also cumbersome. Its use has been relegated to selected stable patients. The accuracy of ultrasound in the evaluation of the aorta and AAA has been studied extensively in a variety of ways. Ultrasound performed by radiologists has been shown to measure AAA to within 3 mm of surgical measurements (14). Accuracy has also been compared to CT scan with assessment of intra- and inter-observer reproducibility (15–18).

In 1988, Shuman et al. investigated the accuracy of ultrasound performed by radiologists who were called to the ED by radio before the arrival of patients with suspected acute AAA. They demonstrated that an "abbreviated" ultrasound examination at the bedside accurately diagnosed AAA in most patients presenting with hypotension, abdominal or back pain, and pulsatile abdominal mass (19). They correctly identified 21 of the 22 patients who needed emergency surgery. This protocol approximated typical Emergency Medicine practice patterns and answered the exigencies of this time-sensitive, unstable, and potentially catastrophic disease.

Recent technical advances have improved the detail and resolution of ultrasound images whereas equipment has become easier to operate, lighter, more mobile, and increasingly affordable. As a result, ultrasonography has been appropriated by increasing numbers of clinicians as a component of their practice domain. In EM, ultrasound has the potential to provide real-time information about unstable diseases at the bedside, concurrent with other components of evaluation and resuscitation. Due to these qualities, it has been advocated that practicing emergency physicians should develop skill in EUS: the ability to both obtain ultrasound images and interpret them at the patient's bedside (10). EUS seems particularly well-suited to the evaluation of acute AAA, especially in view of the practical impediments to obtaining timely ultrasound evaluation by ultrasound technicians and radiologists who are not present in most hospitals for most of the 168 h of the week. The intuitive benefits of rapid bedside sonographic diagnosis of AAA have been corroborated empirically (20). EUS of the aorta is listed as a "primary application in emergency ultrasound" in the American College of Emergency Physicians guidelines on this topic (10).

Despite these developments, little is known about the training requirements necessary for emergency physicians to attain proficiency in EUS. In 2000, Kuhn et al. demonstrated that emergency physicians with only a 3-day ultrasound course and 2 h of practice scanning could correctly identify the presence of AAA in patients in the ED, resulting in improved accuracy, decreased additional diagnostic tests, and expedited transfer to surgery (21). The present study extends these findings to EM residents, showing that they can be trained to perform EUS with accurate recognition and measurement of the aorta. The ultrasound training program consisted of a relatively short dedicated rotation that included exposure to a number of other focused emergency ultrasound applications.

In the present study, EM residents were able to identify clinically significant aortic abnormalities with a sensitivity of 1.0, confirming previous published reports of high sensitivity for sonographic identification of both aortic abnormality and AAA. The sensitivity of 0.94 found in this study for detecting AAA is not significantly different from that reported by Shuman (0.97, 95% CI not reported) and Kuhn (1.0, 95% CI 0.87–1.0) and Tayal (1.0, 95% CI 0.895–1.0) (19,21,22).

Because the likelihood of aortic rupture is proportional to aortic diameter, accurate measurement is essential in determining whether an elderly patient's abdominal or back pain is due to acute AAA or some other disease (23). In the present study, EM residents were able to measure aortic diameters to within 4.4 mm of other imaging studies. This degree of accuracy is consistent with numerous previous studies investigating the accuracy of measurement of the aorta by both CT scan and ultrasound. One such study, which examined the accuracy of radiologists, found that in more than 15% of cases, an individual radiologist using CT and ultrasound had a $\geq$ 5-mm discrepancy between measured maximal aortic diameters as determined by ultrasound and CT (14). Several other studies have shown a variance in aortic measurements of up to 10 mm when comparing sonographic measurements with CT scan, surgical findings, or a repeat ultrasound (15–17). These findings comport with those of the present study, and confirm the reliability of bedside sonographic measurements performed by resident emergency physicians.

Finally, this study confirms the accuracy of ultrasound in a large group of patients with a lower prevalence of disease than those investigated by Kuhn et al. (19). This setting reflects typical emergency practice in which large numbers of elderly patients are evaluated with non-specific abdominal and back complaints, many of which are due to etiologies other than AAA. Despite the fact that specificity might have been anticipated to be lowered in this milieu, this was not borne out by the data.

LIMITATIONS

No mechanism existed to determine if all eligible patients were enrolled, so it is uncertain what proportion of patients who met the entry criteria was not enrolled. This may have led to selection bias. Our residents received more extensive training than may currently be the case in the average Emergency Medicine residency program, which may limit extrapolation of these results to all EM residents. There may have been some input by attending emergency physicians into EUS findings and this was not specifically controlled for, although we feel this did not change the resident measurements. Future prospective studies of this topic might investigate the results of EUS on an intention to treat basis.

CONCLUSION

Emergency Medicine residents with appropriate training can accurately determine the presence of AAA. Similar to previous investigations of ultrasound in the hands of sonography technicians and radiologists, EUS accurately measures aortic diameter in patients with AAA.

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