Prospective Study of Accuracy and Outcome of Emergency Ultrasound for Abdominal Aortic Aneurysm over Two Years

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Abstract

Determination of the presence of an abdominal aortic aneurysm (AAA) is essential in the management of the symptomatic emergency department (ED) patient. **Objectives:** To identify whether emergency ultrasound of the abdominal aorta (EUS-AA) by emergency physicians could accurately determine the presence of AAA and guide ED disposition. **Methods:** This was a prospective, observational study at an urban ED with more than 100,000 annual patient visits with consecutive patients enrolled over a two-year period. All patients suspected to have AAA underwent standard ED evaluation consisting of EUS-AA, followed by a confirmatory imaging study or laparotomy. AAA was defined as any measured diameter greater than 3 cm. Demographic data, results of confirmatory testing, and patient outcome were collected by retrospective review. **Results:** A total of 125 patients had EUS-AA performed over a two-year period. The patient population had the following characteristics: average age 66 years, male 54%, hypertension 56%, coronary artery disease 39%, diabetes 22%, and peripheral vascular disease 14%. Confirmatory tests included radiology ultrasound, 28/125 (22%); abdominal computed tomography, 95/125 (76%); abdominal magnetic resonance imaging, 1/125 (1%); and laparotomy, 1/125 (1%). AAA was diagnosed in 29/125 (23%); of those, 27/29 patients had AAA on confirmatory testing. EUS-AA had 100% sensitivity (95% CI = 89.5 to 100), 98% specificity (95% CI = 92.8 to 99.8), 93% positive predictive value (27/29), and 100% negative predictive value (96/96). Admission rate for the study group overall was 70%. Immediate operative management was considered in 17 of 27 (63%) patients with AAA; ten patients were taken to the operating room. **Conclusions:** EUS-AA in a symptomatic population for AAA is sensitive and specific. These data suggest that the presence of AAA on EUS-AA should guide urgent consultation. Emergency physicians were able to exclude AAA regardless of disposition from the ED. **Key words:** abdominal aortic aneurysm (AAA); emergency ultrasound (EUS); emergency physician; accuracy. ACADEMIC EMERGENCY MEDICINE 2003; 10:867–871.

Rupture of an abdominal aortic aneurysm (AAA) is a highly lethal vascular emergency.[1] With 60% of patients dying before ever reaching the hospital, those who "arrive alive" have a greater than 50% operative mortality.[2,3] This is in contrast to an elective repair mortality rate of 1% to 5%.[1,4] Mortality is directly related to the timeliness of diagnosis before rupture and definitive repair.[1] Because the clinical symptoms of AAA (abdominal, flank, and back pain and syncope) are extremely nonspecific, diagnosis often can be delayed.[5] If AAA can be ruled out, other less emergent diagnoses or disposition may be pursued.

For these reasons, it is important that emergency physicians have immediate access to an imaging modality that is readily available, noninvasive, accurate, and preferably portable. Bedside emergency ultrasound of the abdominal aorta (EUS-AA) offers a direct and accurate solution. When available, EUS-AA is rapid, noninvasive, and repeatable. Previous studies have shown the accuracy of ultrasound for the detection of AAA by multiple specialties.[6–8] We hypothesized that EUS-AA by emergency physicians could accurately determine the presence of AAA and guide consultation in a symptomatic population.

METHODS

Study Design. This prospective, observational study was undertaken at an urban tertiary community hospital emergency department (ED) with more than 100,000 annual patient visits. Institutional review board approval was obtained in expedited fashion for collection of data in this study.

Study Setting and Population. The ED is a referral center for cardiovascular emergency patients from a two-state, seven-county region. Board-certified emergency medicine (EM) attendings and EM residents deliver emergency care. Consultation and further imaging are available 24 hours a day through

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hospital departments including radiology, cardiology, and obstetrics/gynecology.

Ultrasound training was initiated in 1997 for the Department of Emergency Medicine faculty and residents under the direction of the emergency ultrasound director. Ultrasound lectures, including those on abdominal aortic and vascular emergencies, were integrated into the curriculum at that time. Subsequent ultrasound credentialing for the EM faculty was obtained through the hospital. Senior EM resident and EM attending physicians who performed EUS-AA in this study had at a minimum introductory emergency ultrasound education, and each had performed 50 emergency ultrasounds before the study.

Ultrasound equipment used in the department includes Shimadzu 400 and Shimadzu 450 gray-scale ultrasound machines (Shimadzu, Torrance, CA). A standardized ultrasound data sheet is used prospectively to prompt the emergency physician evaluating a patient with EUS-AA. The imaging protocol of the abdominal aorta (EUS-AA) includes continuous gray-scale ultrasonographic imaging from the diaphragmatic hiatus to the bifurcation of the aorta, in the transverse and sagittal planes. Representative images of the proximal and distal abdominal aorta are measured in both planes, and thermal images are printed for review. All measurements are entered into an ultrasound database. Quality assurance review took place for image quality and patient outcome by the emergency ultrasound director.

Study Protocol and Measurements. Consecutive patients were enrolled over a two-year period. All patients suspected to have AAA underwent standard ED evaluation consisting of EUS-AA, followed by a confirmatory imaging study (radiology ultrasound, computed tomography [CT] of the abdomen, and magnetic resonance imaging of the abdomen [MRI]) or laparotomy. Inclusion criteria included adult patients with symptoms such as abdominal pain, flank pain, back pain, or syncope, if their symptoms or presentation was believed by the EM attending physician to be characteristic of an AAA. Exclusion criteria were patients with known AAA before ultrasound imaging and patients transferred with known AAA. AAA was defined as any measured aortic diameter greater than 3 cm. Demographic data on age, sex, risk factors for AAA, results of confirmatory testing, and patient outcome were collected by retrospective review.

Data Analysis. Standard statistical analyses, including sensitivity, specificity, positive predictive value, negative predictive value, and confidence intervals [CIs], were calculated using standard software packages (Systat, Richmond, CA).

RESULTS

During the two-year study period, 125 patients had EUS-AA. Patients had an average age of 66 years with the following characteristics: male 54%, hypertension 56%, coronary artery disease 39%, diabetes mellitus 22%, and peripheral vascular disease 14%. Confirmatory tests included radiology ultrasound, 28/125 (22%); abdominal CT, 95/125 (76%); abdominal MRI 1/125 (1%); and laparotomy, 1/125(1%). AAA was diagnosed by EUS-AA in 29/125 (23%); of those, 27/29 patients had AAA on confirmatory testing (Figure 1). EUS-AA had 100% sensitivity (27/27) (95% CI = 89.5 to 100), 98% specificity (96/98) (95% CI = 92.8 to 99.8), 93% positive predictive value (27/29), and 100% negative predictive value (96/96) (Figure 2). There were two false-positive studies with the following characteristics: patient no. 1, measured ultrasound aorta diameter of 3.1 cm with a CT scan measurement of 2.8 cm of the distal abdominal aorta; patient no. 2, distal aorta ultrasound measurement of 3.1 cm and the CT reading of "normal caliber."

Admission rate for the study group was 70%. Immediate operative management was considered in 17/27 (63%) patients with AAA; ten patients were taken to the OR, and seven patients were deemed poor surgical candidates. Death during the acute

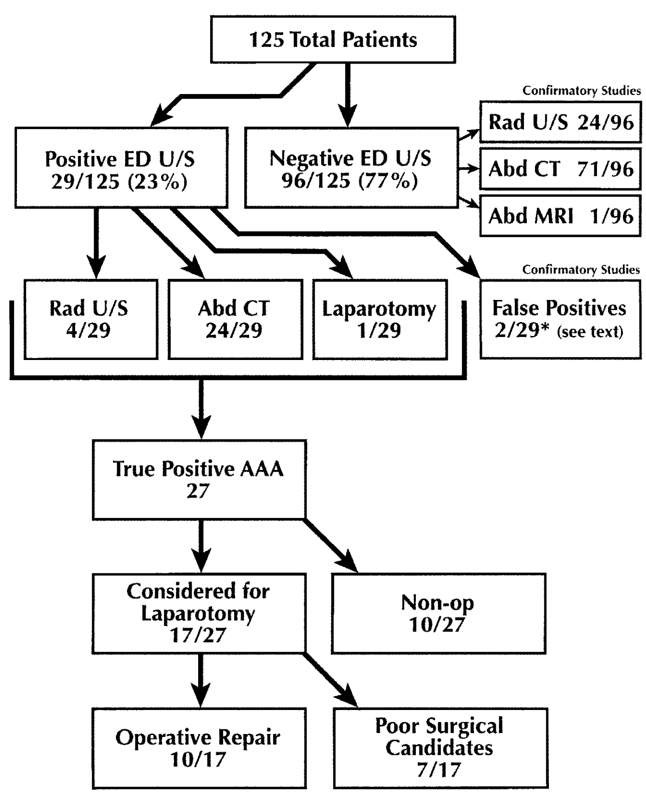

Figure 1. Population outcome analysis. ED U/S = emergency department ultrasound; Rad U/S = radiologic ultrasound; Abd CT = abdominal computed tomography; Abd MRI = abdominal magnetic resonance imaging; AAA = abdominal aortic aneurysm; Non-op = nonoperative.

Sensitivity and Specificity Data		
	Confirmatory Test Positive	Confirmatory Test Negative
EUS–AA Positive	27	2
EUS–US Negative	0	96
Sensitivity = 100% Specificity = 98%	PPV = 93% NPV = 100%	

Figure 2. Statistical analysis of sensitivity and specificity. EUS-AA = emergency ultrasound of the abdominal aorta; PPV = positive predictive value; NPV = negative predictive value.

hospital admission occurred in three patients without AAA and in three patients with AAA. Table 1 lists the cause of death for AAA and non-AAA groups.

DISCUSSION

The ED diagnosis and management of the patient with a suspected AAA pose several unique challenges. First, presence and expansion of an AAA typically constitute a silent disease.[9] Rupture frequently occurs with little warning and without a specific prodrome.[1] Second, the clinical diagnosis of symptomatic AAA is notoriously unreliable. The physical examination for AAA is neither sensitive nor specific, even when performed by experienced clinicians.[10] In patients with a rapidly expanding or ruptured AAA, the classic triad of abdominal or flank pain, hypotension, and a pulsative abdominal mass is present only in 30% to 50% of cases.[5] In addition, because most AAAs rupture into the retroperitoneum, the expanding hematoma may be contained, and patients may have "normal" or near-normal vital signs on presentation. The differential diagnosis of an ED patient with hypotension, syncope, abdominal pain, flank pain, or back pain is broad. The rapid detection of AAA during resuscitation can alter the management plan and the operative morbidity for AAA.[11]

With a symptomatic patient, the optimal test would allow resuscitation of the patient simultaneous with the rapid and accurate diagnostic evaluation of the patient at the bedside. The optimal test should be able to be performed regardless of facility or time of day, especially in an unstable patient. Even a stable patient with AAA would benefit from early identification to allow operative repair or other vascular procedure to reduce morbidity.[4] We suggest this optimal test is an EUS-AA by trained emergency physicians who are available immediately during any 24-hour period.

The accuracy of bedside ultrasound for the detection of AAA by radiologists and vascular surgeons has been verified through previous studies.[1,12] In the 1980s, vascular surgeons were aware that rapid ED evaluation with B-mode ultrasound was important for diagnosis.[6] Shuman et al.[13] recognized the feasibility and advantage of ultrasound at the bedside in the ED. Although many have recognized that ultrasound can be helpful at the bedside, ultrasound is not always available to ED patients with suspected AAA because of type of facility, time of day, type of imaging available, and departmental privileging. Emergency physicians have taken the imaging of the abdominal aorta as one of their key applications.[14,15]

Case reports have indicated emergency physicians have diagnosed even small ruptured AAAs.[16] Kuhn et al.[17] showed excellent (100%) sensitivity and specificity in a convenience sample of 68 ED patients. Their findings in an Australian hospital with trained emergency physicians showed additional beneficial value for emergency physicians in diagnosis, confidence in diagnosis, investigations, treatment, and disposition.

Our study had several unique attributes. The setting was in a high-volume urban ED with an EM residency. Ultrasound was not a new modality but already had been incorporated into the protocols of the ED. Faculty and residents were familiar with the physics, knobology, ultrasonographic anatomy, and ultrasound differentials of EUS-AA in gray-scale. Our study took place on a susceptible population who was elderly and hypertensive. Most of this population was acutely ill as evidenced by a high admission rate.

The ultrasound techniques included using gray-scale, real-time, B-mode ultrasound with a transabdominal, low-frequency probe. Most adults have moderate-to-large girth, requiring the ability to penetrate through the abdominal wall and organs to the retroperitoneum. Ultrasound examinations were done on nonfasting patients as would be expected in an ED, making the examinations even more difficult. Although bowel gas is often a hindrance, this population could be imaged with standard techniques. Important to this application, the abdominal aorta was visualized proximally and distally because most AAAs are infrarenal. Doppler technology, a technique that assists in determining flow, dissection, and clot, was not yet available on the ultrasound machines in our ED.

This study tested accuracy of our EUS-AA, and we used multiple tests to confirm the accuracy of our findings, including radiographic, ultrasonographic,

TABLE 1. Mortality Data—Cause of Death for Six Patients in the Study

	AAA		No AAA
1	Postoperative AAA repair hypotension	4	Rectal carcinoma
2	Intraoperative cardiac arrest	5	Bowel infarction
3	Intraoperative cardiac arrest	6	Cardiac dysrhythmia

AAA = abdominal aortic aneurysm.

and operative findings. CT was the primary confirmatory test, but radiology ultrasound, angiography, and MRI also were used to a lesser degree. Vascular ultrasound from other specialties has the same imaging advantage of nonionizing evaluation of the aorta but has the limitation of bowel gas.[18] Abdominal CT scan can be considered a more advanced technique for the stable patient that identifies the aorta, the retroperitoneum, and the branch and end arteries for which surgical strategy may be needed.[19] Angiography is helpful for branch vessels but may miss aneurysms because the patent lumen only may be identified. MRI is an accurate technique, but availability and stability of the patient are continuing issues at this time.

We were able to rule out aneurysms with a high degree of accuracy. Our two patients with false-positive results had measurements by CT and ultrasound that differed by a few millimeters but without clinical difference. We would argue those cases show the rigor of adherence to the protocol, as with even "small" aneurysms, imaging tests confirmed relative size. The clinical relevance of this ability cannot be underestimated in terms of ED efficiency. The patient with back pain or nonperitoneal abdominal pain who may have another differential diagnosis as a likely possibility is well served by the rapid rule-out capability of EUS-AA.

The strength of our imaging in this population of patients with symptoms of AAA was the excellent sensitivity, which captured all the aneurysms in the population. One patient received laparotomy based on EUS-AA and clinical condition. The rest of the patients with AAA underwent confirmatory testing, mainly abdominal CT for delineation of branch involvement and to map operative repair. Although we did not have any false-negative results, other studies have indicated that measurements near the predetermined "cutoff" may be inaccurate with an underestimate of the CT diameter by 0.2 to 0.5 cm. Whether this has clinical significance is unknown, and we did not address this issue in this study.

Our high sensitivity allows us to conclude that a rule-out contribution to the patient's evaluation did occur. Of the patients, 14% were discharged. This contribution of a bedside test that takes minutes is valuable in light of the increasing volumes and overcrowding of the ED and the increasing imaging workload of radiologists.

Not all patients with AAA went to the operating room, even if they had clinical and imaging findings necessary for repair of the AAA. Some vascular surgeons may believe that certain patients with comorbidities may not survive the repair. These observations may not be isolated because others have noted sample populations presenting with AAA in which a substantial proportion did not meet conditions for operations.[3] Although most of the patients with "true" AAA did not go to the operating room, the potential end point of operative repair may not be the gold criterion for evaluating the merit of EUS-AA. As contrasted with trauma ultrasound, therapeutic laparotomy may be a more subjective and unrealistic goal regarding the individual patient with AAA. Comorbidities, size of the AAA, and timing of the operation may vary among institutions. With the advent of endovascular stents, there are now other options than open repair for the patient with AAA.

Clinicians interested in using this study to address their own needs for evaluating the presence of AAA should consider the imaging, operative, and interventional vascular resources of their own institution. EUS-AA should integrate and improve the response to a patient with AAA. In addition, emergency physicians who use ultrasound accurately may focus appropriately the work of consultants, including vascular surgeons and radiologists. Foremost, however, we believe that EUS-AA by emergency physicians is a crucial action in the emergency care of the symptomatic patient with suspected AAA.

LIMITATIONS

Our limitations included lack of measurement of interobserver variability in the ultrasound interpretation and in the abdominal CT reading. Time intervals between decision points were not measured in this study. We also did not measure emergency physician decision making by quantifiable measurements. As discussed earlier, although our study showed tremendous accuracy, we did not measure changes in morbidity and mortality of our patient population with our intervention. Future studies may evaluate emergency physician use of ultrasound in evaluating the abdominal aorta without confirmatory testing.

CONCLUSIONS

Emergency ultrasound of the abdominal aorta in a symptomatic population for AAA is sensitive and specific. Our data suggest that the presence of AAA on EUS-AA can guide urgent vascular consultation. Emergency physicians were able to exclude AAA regardless of disposition from the ED.

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