Emergency Department Ultrasound Scanning for Abdominal Aortic Aneurysm: Accessible, Accurate, and Advantageous

Marie Kuhn, MD, FACEM*
Robert L. L. Bonnin, MBBS, FACEM*
Michael J. Davey, MBBS, FACEM*
Jane L. Rowland, MBBS*
Suzanne Le P. Langlois, MBBS, FRACR‡

From the Departments of Emergency Medicine, and Radiology,‡ Royal Adelaide Hospital, Adelaide, South Australia, Australia.*

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Address for reprints: *Marie Kuhn, MD, FACEM, Emergency Department, Royal Adelaide Hospital, North Terrace, Adelaide, South Australia 5000; Australia; +61 8 8222 5063, fax +61 8 8222 4171; E-mail mkuhn@mail.rah.sa.gov.au.*

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Study objective: This study was conducted to determine whether emergency physicians with relatively limited training and experience can accurately identify the presence or absence of abdominal aortic aneurysms (AAAs) by performing bedside ultrasound scanning, and to assess the potential impact of ultrasound scanning on clinical management.

Methods: Patients in whom AAAs were suspected, including those patients older than 50 years presenting with abdominal/back pain of unclear origin or presumed renal colic, were eligible for study entry. Consenting adults had ultrasound scanning by an emergency physician who was not responsible for their primary care. Treating physicians remained blinded to the results unless an unexpected AAAs was discovered. Scan accuracy was ascertained by comparing our ultrasound results with preselected gold standards. The clinical impact of the ultrasound studies was determined by comparing the preultrasound and postultrasound assessment sheets that detailed the presumed diagnosis, proposed investigations and therapies, and patient disposition.

Results: Our convenience sample includes 68 scans for AAAs; findings of 26 scans were positive, 40 scans yielded negative findings, and 2 scans were indeterminate. Scan interpretations were 100% accurate. The ultrasound results would have improved the care of 46 patients without adverse sequelae. Ultrasound scanning served primarily to exclude AAA in patients who proved not to have aneurysms; however, scans also provided significant benefits for those with AAAs and improved patient management plans.

Conclusion: Relative neophytes can perform aortic ultrasound scans accurately. These scans appear useful as a screening measure in high-risk emergency department patients; they may also aid in rapidly verifying the diagnosis in patients who require immediate surgical intervention.

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INTRODUCTION

The prevalence of abdominal aortic aneurysms (AAAs) particularly in men older than 55 years, is increasing, and deaths caused by ruptured AAAs have increased dramatically.[1] Many patients who present to the emergency department with a ruptured AAA are unaware of their aneurysmal disease. Only a minority present with the classic triad of abdominal/flank pain, shock, and a pulsatile abdominal mass.[2] Thus, it is not surprising that ruptured AAA is frequently misdiagnosed at the patient's initial presentation.[3] As might be expected, delays in diagnosis are often associated with disastrous consequences.[4,5]

Misdiagnosis occurs more frequently in those presenting with atypical symptoms and signs.[3] Patients with leaking AAAs may present with a colicky pain that radiates from the flank to the groin accompanied by hematuria. Understandably, their condition is often misdiagnosed as renal colic. Equally confounding clinical scenarios may lead to misdiagnoses such as gastrointestinal bleeding, diverticulitis, or acute myocardial infarction.

The presence of a pulsatile abdominal mass is neither a sensitive nor specific means of detecting an AAA.[6,7] A recent summary of the reported efficacy of abdominal examination indicates that palpation detects only 39% of all AAAs.[6] Sensitivity improves with increases in aneurysmal diameter except in patients who are obese and those with ruptured AAAS.[6] Conversely, the presence of a pulsatile abdominal mass does not invariably indicate aneurysmal disease; in one series, normotensive patients with tender pulsatile abdominal masses were most frequently found to have para-aortic masses transmitting the pulsations of a normal-caliber aorta.[7] Consequently, the overall reported positive predictive value of palpating a widened aorta is only 43%.[6]

Hypotension, although helpful in prompting the diagnosis of AAA, is an overwhelmingly poor prognostic factor.[5] Normotensive patients presenting with contained bleeding are the group most likely to survive emergency repair of a ruptured AAA.[4] Hence, the onus is on the emergency physician to entertain the diagnosis of AAA before hypotension develops.

Ultrasound scanning has a well-established role as an adjunct in the diagnosis of AAA.[1] Ultrasound examinations have been used in asymptomatic patients to screen for AAA and to monitor the progress of aneurysmal disease. In symptomatic patients, bedside scanning by ultrasonographers has proved an effective means of establishing or excluding the diagnosis of AAA.[8] Although computed tomography (CT) and angiography are more likely to detect leaking blood, thereby distinguishing a ruptured AAA from an intact aneurysm, the combination of symptoms and the presence of an AAA on ultrasound scanning rarely results in negative findings at laparotomy.[9]

We believe that bedside aortic ultrasound scanning performed in the ED can serve 2 distinct purposes. First, if used as a widespread screening measure in those at risk for aneurysmal disease, it may prevent the misdiagnoses that so frequently occur. Second, in patients in whom a ruptured AAA is suspected, confirming the presence of an aneurysm by ultrasound scanning might obviate the potentially dangerous trip to the CT scanner, expedite the patient's transport to surgery, or both.

The literature regarding the ability of emergency physicians to perform bedside scans to detect AAA is relatively limited; to our knowledge, there is only one case report detailing the clinical impact of emergency physician–performed ultrasonography for AAA.[10] Our objectives in performing this study were therefore twofold: to determine whether emergency physicians with relatively limited training and experience could accurately distinguish the presence or absence of an AAA, and to assess the potential impact of bedside aortic ultrasound scans on patient management.

MATERIALS AND METHODS

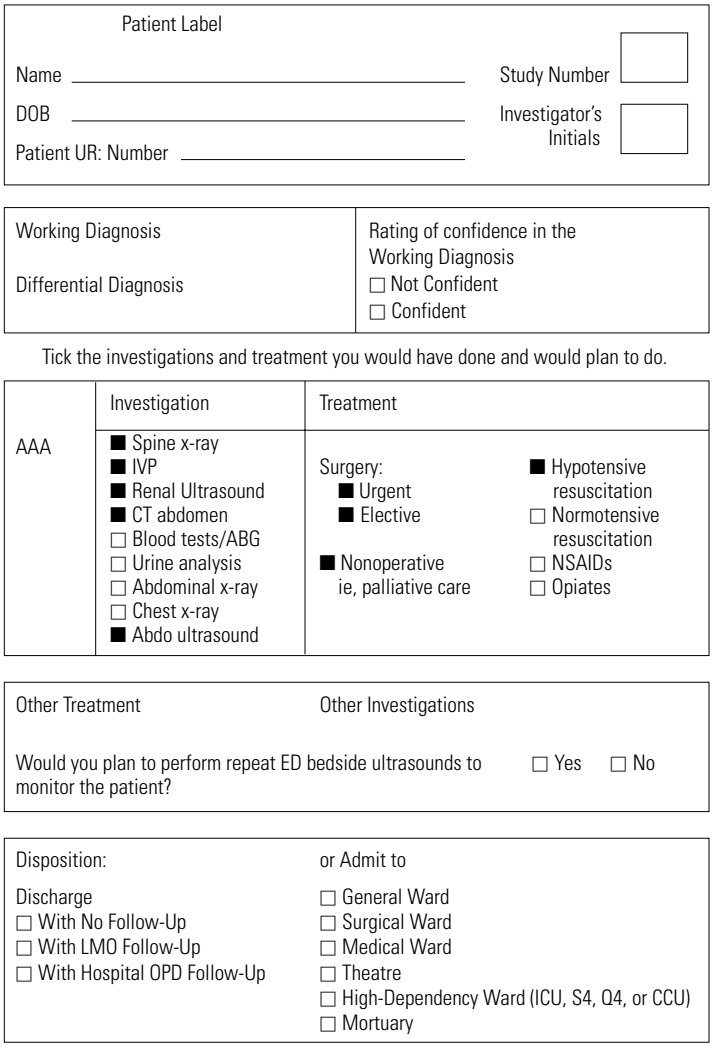
This study was conducted in the ED of an adult academic tertiary referral center serving approximately 48,000 patients per year.

After receiving approval for the study from our hospital's institutional review board, 20 emergency physicians and emergency medicine trainees with 3 or more years of postgraduate experience attended a 3-day ultrasound training course. None of the participants had any prior experience performing or interpreting ultrasound scans. The course was developed, following consultation with 2 of the authors, by Diploma of Medical Ultrasound–qualified educators who normally train ultrasonographers. The course curriculum devoted approximately 2 hours to aortic scans, including review of ultrasound images of

normal and abnormal aortas and hands-on supervised practice scanning the aortas of human models.

After completing the ultrasound workshop, we began to enroll patients on a convenience basis. All patients with presumed AAA and any patient older than 50 years presenting with abdominal pain with or without back pain of unclear origin or with presumed renal colic were eligible for study entry. Patients were excluded if we were unable to obtain consent or if the presence of an AAA had already been established by prior radiologic investigation. Bedside ultrasounds were only performed when a workshop attendee, not responsible for the patient's primary care, was available to perform the scan; the treating physician was not informed of the bedside scan results unless an unexpected AAA was discovered. This policy was established to avoid potential patient mismanagement resulting from poorly performed or misinterpreted scans.

The scans were performed on an Aloka Flexus model SSD-1100 scanner (Aloka, Tokyo, Japan) using a 3.5- or 5.0-MHz convex transducer. The scans were recorded on videotape and subsequently reviewed by a radiologist who remained blinded to the identities of the patient, the investigator, and the results of any other procedures. Instructions attached to the ultrasound machine advised investigators to identify the location of maximal aortic dilatation in the longitudinal plane and then to measure the diameter in the transverse plane. Measurements of the aortic diameter were recorded as less than 3 cm, 3 to 5 cm,



Patient Label

Name _____ Study Number ☐

DOB _____ Investigator's Initials ☐

Patient UR: Number _____

Working Diagnosis Differential Diagnosis	Rating of confidence in the Working Diagnosis ☐ Not Confident ☐ Confident

Tick the investigations and treatment you would have done and would plan to do.

	Investigation	Treatment	
AAA	■ Spine x-ray ■ IVP ■ Renal Ultrasound ■ CT abdomen ☐ Blood tests/ABG ☐ Urine analysis ☐ Abdominal x-ray ☐ Chest x-ray ■ Abdo ultrasound	Surgery: ■ Urgent ■ Elective ■ Nonoperative ie, palliative care	■ Hypotensive resuscitation ☐ Normotensive resuscitation ☐ NSAIDs ☐ Opiates

Other Treatment Other Investigations

Would you plan to perform repeat ED bedside ultrasounds to monitor the patient? ☐ Yes ☐ No

Disposition:	or Admit to
Discharge ☐ With No Follow-Up ☐ With LMO Follow-Up ☐ With Hospital OPD Follow-Up	☐ General Ward ☐ Surgical Ward ☐ Medical Ward ☐ Theatre ☐ High-Dependency Ward (ICU, S4, Q4, or CCU) ☐ Mortuary

Figure 1.
Preultrasound and postultrasound assessment sheet. The solid boxes indicate the changes in investigations or treatment that were considered clinically significant (this information was not disseminated to those performing the scans).

or more than 5 cm; diameters greater than 3 cm were considered aneurysmal. Investigators were also asked to indicate whether there was evidence of leaking blood.

After the bedside scan was performed, patients underwent other imaging or surgical procedures as previously planned by their treating physicians. These procedures were later used as the gold standard to determine the accuracy of the bedside scan results. For those patients who did not undergo subsequent procedures, the radiologist's review of the ultrasound tapes served as the gold standard. The sensitivity, specificity, and positive and negative predictive values for the investigator's findings were calculated and the 95% confidence intervals (CIs) for these results derived using a statistical programming package (Stata version 3.1; Stata Corporation, College Station, TX).

Investigators were required to complete identical assessment sheets before and after performing the scans (Figure 1). The assessments included the primary and differential diagnoses, the level of confidence in the diagnosis, as well as the planned investigations, treatment, and patient disposition. The preultrasound assessment was to be based on all information available before the scan; the postultrasound assessment incorporated the scan results.

The potential impact of the ED scans was ascertained by comparing the preultrasound and postultrasound assessment plans. The initial comparison was performed by one of the authors (RB), who remained blinded to the patients' outcomes and to the results of the gold standard tests. Any changes in diagnosis, level of confidence in the diagnosis, and patient disposition were considered significant. Predetermined criteria were applied to calculate whether changes in investigations or treatment were important (Figure 1).

The preultrasound and postultrasound assessment plans and gold standard test results for those patients with significant changes in diagnosis or management plans were then collated by the same author (RB). The plans were subsequently presented, in random order, to 2 other authors (MK and MD) who, based on the gold standard test results, arranged the plans such that the second plan would provide better patient care. If the second plan corresponded to the postultrasound plan, the scan was considered to have had a positive impact; if it corresponded to the preultrasound plan, a negative impact was recorded.

The results were analyzed to determine whether the clinical impact derived from changes in diagnosis, management plans, or both factors, and whether the impact occurred in patients with or without disease. Percentages were calculated for each of these finding and 95% CIs were derived using Stata 3.1 software.

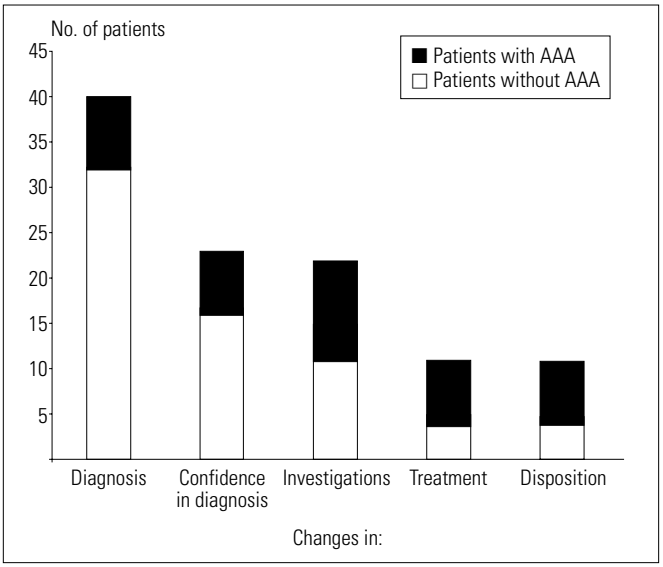
RESULTS

Between September 1997 and December 1999, we performed 68 bedside aortic scans. The results of these scans were compared with CT scans in 28 patients, with formal ultrasound studies in 19, angiography in 1, and laparotomy in 9. In the remaining 11 instances, the radiologist's review of the videotaped scans served as the gold standard.

The aorta was visualized in 66 of the 68 patients who had ultrasound scanning; in 2 patients (who proved not to have AAAs), overlying gas shadows obscured the aorta. Of the 66 interpretable scans, 26 yielded true-positive and 40 true-negative findings. Thus, our sensitivity was 100% (CI 87 to 100), specificity 100% (CI 91 to 100), positive predictive value 100% (CI 87 to 100), and negative predictive value 100% (CI 91 to 100). An aortic leak was correctly identified in 3 cases, was missed in 5 cases, and noted in 1 case where the finding was not substantiated by the formal ultrasound report.

The ED scans would have improved the care of 46 patients and would not have adversely affected any patient. In patients without aneurysmal disease, the scans served primarily to exclude the diagnosis (Figure 2). In

Figure 2.
Beneficial impact of ultrasound scanning on the assessment and management of 68 patients.



patients with AAAs, the ultrasound examinations appeared to benefit all aspects of patient care: improving diagnostic accuracy, eliminating additional investigations, improving treatment decisions, and expediting the patients' transfer to surgery (Figure 2).

In 2 patients, a clinically inapparent aortic aneurysm was discovered on the ED scan. In both instances, the study was unblinded, the findings confirmed by CT scan, and the patient referred to the vascular surgeons. Neither of these patients had CT evidence of rupture.

DISCUSSION

In 1988, Shuman et al[8] reported their 2-year experience "with rapid, emergent sonography performed in the emergency department." Ultrasonographers were on call to present immediately to the ED whenever paramedics or emergency physicians requested their services for patients with abdominal or back pain, pulsatile masses, and hypotension or tachycardia. Rapid bedside ultrasonography was performed before the surgeon's examination of the abdomen. Thirty-two of the 60 patients in their study proved to have AAAs; 31 of the 32 were identified on ultrasound examination. One patient, with a ruptured AAA at laparotomy, had an indeterminate scan because of "marked obesity and overlying bowel gas." Leaking blood was identified in only 1 of the 24 patients noted at surgery to have extraluminal blood.

We found the aorta relatively easy to visualize in most patients, and our findings to date would indicate that emergency physicians can perform this service with a level of accuracy similar to that reported by Shuman et al.[8] However, the strength of our results is limited by our small sample size. In addition, as this was a convenience sample, some investigators may have enrolled only those patients who they anticipated would be easy to scan, thus biasing our sample. Given the high number of positive findings in our series, it is more likely that investigators selectively enrolled patients in whom there was a high clinical suspicion of AAA. This bias may have inflated the potential clinical impact of the scans. We therefore think it would be useful to extend this study, preferably using a format that includes all eligible, consenting patients.

Performance of bedside aortic scans by emergency physicians, rather than ultrasonographers, might ensure 24-hour availability of this service. It also could address the needs of patients, not included in Shuman et al's[8] study, who present without the classic triad of signs and symptoms. An unfortunate patient, seen in our ED while this study was in progress but not referred for ED ultrasonography, was discharged with a diagnosis of renal colic. He returned several hours later, hypotensive from a ruptured AAA, and did not survive emergency surgery. Sensitized by this experience, our medical officers became more liberal in their referral of patients, and we have already detected by ultrasonography 2 AAAs that were not clinically apparent. We therefore believe that bedside aortic scans by emergency physicians will have a significant impact on patient care, and should be incorporated into the standard management of patients older than 50 years of age who present with abdominal/back pain.

Our findings indicate that aortic scans, to determine the presence or absence of AAA, can be accurately performed by emergency physicians with relatively limited training and experience. We have found that bedside aortic scans serve not only to rapidly verify the diagnosis of AAA in patients who require emergency surgical intervention, but widespread use of aortic scans in the high-risk ED population may prove a very useful screening measure.

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