INNOVATIONS IN EDUCATION AND CLINICAL PRACTICE

Ultrasonography Performed by Primary Care Residents for Abdominal Aortic Aneurysm Screening

An Innovative Teaching Model

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A prospective pilot study was undertaken to assess a protocol to educate primary care residents in how to personally perform ultrasonography for abdominal aortic aneurysm screening. Resident exams were proctored by a primary care physician trained in ultrasonography and were scored on the level of competence in doing the examination. Patients had ultrasound performed by a resident, followed by repeat examination by the vascular lab. Primary care resident abdominal aortic imaging was achieved in 79 of 80 attempts. Four abdominal aortic aneurysms were identified. There were 75 normal examinations; resident ultrasonography results were consistent with the results of the vascular lab. Ten residents achieved an abdominal aortic ultrasound-independent competence level after an average of 3.4 proctored exams. The main outcome of this study is that a primary care resident, with minimal training in ultrasonography imaging, is able to rapidly learn the technique of ultrasonography imaging of the abdominal aorta.

KEY WORDS: **ultrasonography; abdominal aortic aneurysm; screening; primary care; teaching.**
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Ruptured abdominal aortic aneurysms (AAA) are a significant cause of mortality in the United States, accounting for more than 8,700 deaths in 1990.[1,2] As the population ages, the prevalence of AAA appears to be rising.[1,3,4] AAA is generally defined as a focal dilation of the abdominal aorta of 150% or greater than the normal aortic diameter, which for older men is approximately 20 mm (range of 14 to 30 mm) making an aortic diameter $\geq$30 mm indicative of an aneurysm.[1,3,5–7]

Untreated ruptured AAAs are almost universally fatal.[3] This makes the early asymptomatic diagnosis of AAA and elective surgical repair appear to be far better than emergent surgical intervention to manage aneurysms regardless of chronological age,[3,8,9] even when both early and late surgical complications are taken into consideration. There is a growing body of evidence that AAA-related causes of death are reduced in screened populations.[10]

AAA screening with ultrasound appears to meet the requirements for a good screening test in that there is a significant prevalence of the condition in selected populations, there is a sensitive test for detection available, and there is an effective treatment.[11] The incidence of AAA in the general elderly population is approximately 2% to 3%, which might go undetected if a screening program were not utilized for diagnosis.[11] An effective screening modality exists in the form of ultrasonography (UTZ).[11–15] The use of UTZ has advantages over other modalities because it is safe, with no inherent risks of side effects, noninvasive, and highly accurate (accuracy approaches 100%).[1,3,11–15] Effective treatment exists, with surgical repair of nonruptured abdominal aortic aneurysms carrying an operative risk of 4% (range 1.4% to 6.5%).[1,3,8] Subsequent longevity and quality of life approach normal expectations as compared to the dismal operative mortality associated with ruptured AAAs of 49% (range 23% to 69%) or the inevitably fatal outcome from ruptured AAA that does not make it to operation.[1,3,8] Nevertheless, there appear to be barriers to the implementation of an AAA screening program.[16] Low patient adherence to screening programs based at hospitals has decreased the impact of screening in previous studies.[17] Low adherence is associated with nonparticipation of the primary care practitioner (PCP) in the process and the evaluation being conducted at the hospital rather than at the PCP's office.[17–19] In most studies to date, a skilled sonographer who was not the PCP performed the examination, adding an extra step to care and increasing costs.[7–24] Currently, ultrasonography is used mainly by radiologists, obstetricians, gynecologists, cardiologists, urologists, ophthalmologists, and vascular surgeons, but there is expanding utilization of this imaging technique by emergency department physicians,[25–27] trauma surgeons, and family practice physicians.[16] Yet there is much resistance by some to the introduction of UTZ into the personal scope of practice of PCPs.[16,28,29]

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The aim of this pilot study is to assess a teaching protocol for educating primary care residents (PCRs) in the use of ultrasonography for screening for abdominal aortic aneurysms.

METHODS

This study was approved by the Cedars-Sinai Medical Center (CSMC) Institutional Review Board. The study was performed at Cedars-Sinai Health System (CSHS), a large community-based teaching hospital. The CSHS Ambulatory Care Center (ACC) provides primary and subspecialty care for approximately 9,000 patients and is staffed by house staff (residents in training) with supervision by attending medical staff. The ACC clinic patient population is made up of diverse ethnic groups speaking a wide variety of languages, predominantly Russian, Farsi, English, and Spanish.

The CSMC Internal Medicine (IM) residency training program consists of 99 IM residents and 15 combined medicine/pediatrics residents. The residents, as interns, are required to spend their primary care clinic time in the ACC. Residents in their second, third, and fourth years are allowed to pick from a variety of outpatient sites to continue their outpatient medicine training. During any given month there are approximately 40 PCRs assigned to the ACC medicine clinic. The residents have a variety of inpatient and elective rotations scheduled at CSMC and away. PCR afternoon medicine clinic coverage responsibility generally rotates on a monthly schedule, with PCRs usually scheduled for a month block at a time and then switching to a different service. The PCRs work in teams of four so that continuity of care can be enhanced. All adult patients are assigned to a specific PCR within a given PCR team. Each PCR cares for 5 to 7 patients per afternoon. PCRs with no experience in the use of UTZ were eligible to participate in this study. The study was carried out over an approximately 6-month period, due to UTZ equipment availability. All internal medicine residents who rotated through the ACC during the study period were verbally asked if they would like to participate in this study. Participation was voluntary. PCRs who had prior knowledge of a particular patient's abdominal aortic imaging measurements were excluded from participation. For those PCRs who were eligible and expressed interest in learning ultrasonography, training consisted of viewing a 20-minute videotape of UTZ images of the abdominal aorta, with special attention to anatomical landmarks and technique of identification and measurement of the abdominal aorta. The PCR also received a 1-hour didactic seminar on UTZ and AAAs. The PCR then participated in a 1-hour hands-on training session in which the PCR practiced doing abdominal aortic UTZ on peer volunteers with the supervision of a PCP trained in UTZ. All PCR UTZ training was accomplished during regular clinic patient care hours. The PCR was asked to fit the UTZ training into the confines of his/her clinic schedule. No additional time was provided for PCR education in ultrasonography. The PCR offered the AAA UTZ screening evaluation as part of the regular office visit to eligible patients. All adult patients over the age of 55 in the ACC primary medicine clinic were considered eligible.

Patients were given an information sheet explaining the study. The information sheet was provided in English, Russian, Farsi, and Spanish. Verbal consent was obtained. No preparation or instructions were given to patients regarding eating prior to the study and patients were enrolled without regard to timing of last meal. Patients had a PCR-performed UTZ examination in the supine position. Multiple PCRs were allowed to examine a patient as long as the patient was agreeable, and the PCRs were blinded to all previous study results. PCRs had their choice of 2 different UTZ machines: ATL (Advanced Technology Laboratories, Bothell, Wash) with a 3-Mhz abdominal probe and no color flow doppler capabilities or Acuson 128 (Acuson Computed Tomography, Mountain View, Calif) computed color sonography with variable 3.5-, 4.0-, and 5.0-Mhz probe and color flow doppler capabilities. PCR choice of UTZ machine was generally made on the basis of convenience and availability. The PCR obtained longitudinal, transverse, and antero-posterior UTZ images of the proximal, mid, and distal abdominal aorta between the diaphragm and the iliac bifurcation. External aortic diameter measurements in millimeters were obtained. All PCR exams were proctored by a trained PCP ultrasonographer who rated the PCR's competence on a scale of:

1 = exam unable to complete.
2 = operator required verbal and manual assistance.
3 = operator required verbal assistance only.
4 = operator able to complete exam unassisted (independent).

Study patients then had an examination by a vascular lab technician with verification of all results by a vascular surgeon. Hard-copy images of the PCR-performed UTZ measurements were compared to the control vascular lab UTZ documentation. For the purposes of enhancing sensitivity, specificity, and clinical significance, AAA was defined as any abdominal aortic diameter measurement of 40 mm, an infrarenal aortic diameter (distal diameter) measurement of at least 30 mm, or an infrarenal (distal diameter) to suprarenal (proximal or mid diameter) measurement ratio of 1.5 or greater.[2]

RESULTS

There were 83 PCR AAA UTZ screening exams performed on 74 patients. Three PCR AAA UTZ screening exams were eliminated from analysis due to the lack of a control UTZ exam by the vascular lab.

PCR UTZ imaging of the abdominal aorta was achieved in 79 out of 80 attempts or 98.8% of exams undertaken. Of the 79 UTZ examinations performed by PCRs, 4 AAAs were identified by PCR and confirmed by control vascular lab

Table 1. Results of PCR-Performed UTZ for Diagnosing AAA as Compared with Control Imaging

PCR positive, vascular lab positive, 4	PCR Positive, vascular lab negative, 0
PCR negative, vascular lab positive, 0	PCR negative, vascular lab negative, 75

PCR, primary care residents; UTZ, ultrasonography; AAA, abdominal aortic aneurysm.

imaging. There were 75 negative examinations confirmed by control vascular lab imaging. No AAAs were missed by the PCRs. Incidental left hydronephrosis was found in 1 patient (Table 1).

Of the PCRs who rotated through the ACC during the study period, 16 PCRs were motivated and interested enough in learning ultrasonography to undergo the initial didactic and hands-on training. The number of UTZ study exams conducted by each PCR ranged from 1 to 11, with the average being 5 (see Table 2). One PCR UTZ study was not completed due to bowel gas obscuring the aorta and the PCR received a skill level rating of 1. The vascular lab was also unable to complete this study and ultimately this case was eliminated from analysis. Three PCR studies were eliminated from analysis due to no control imaging studies being obtained. Four PCR UTZ examinations (5% of all studies analyzed) required manual as well as verbal assistance by the proctor to complete (competence level 2). Forty PCR UTZ exams (51% of all studies analyzed) required verbal assistance only by the proctor to complete (competence level 3). Thirty-five PCR UTZ exams were proctored at a competence level of 4 or PCR abdominal aortic UTZ screening independence. Six PCRs did not achieve competence level 4, meaning they did not achieve total abdominal aortic UTZ exam independence during the study. Of the 10 PCRs who did achieve a skill level of 4, the average number of UTZ exams needed to achieve this skill level was 3.4.

DISCUSSION

In this study, a protocol for training internal medicine residents in the use of UTZ for screening for AAAs was evaluated. This pilot study demonstrates that a PCR, with very little formal training, can learn to use UTZ for examination and measurement of the abdominal aorta in order to diagnose an abdominal aortic aneurysm. The proctoring method described allowed the PCR to rapidly gain (usually within 4 exams) independence in the use of UTZ for AAA screening. True sustainability of this skill would need to be assessed over a longer period of time, such as years.

Of the 80 UTZ imaging studies attempted by the PCRs, 79 were completed. The low patient "dropout rate" of 1.25% in our study (and that due to excessive bowel gas) helps to confirm what other studies have found: that although nothing-by-mouth (NPO) status prior to an abdominal UTZ exam may be optimal, this does not appear to be necessary for adequate AAA screening.[15]

Of the 16 initial motivated PCRs, 10 (63%) were able to achieve a skill level of 4, and 6 PCRs (38%) were able to maintain this skill level. This rate of achievement of competence in a nonmandated procedure compares very favorably with our experience in training residents in flexible sigmoidoscopy (CSMC ACC Flexible Sigmoidoscopy Clinic, pooled data, unpublished, 1996–2000). The low number of PCRs who actually showed a sustainable competence skill level was related mainly to the fact that

Table 2. Number of UTZ Exams Conducted by Individual PCRs, Number of PCR Exams Needed to Achieve a Proctor Skill Level Rating of 4, Average PCR Skill Level for Exams after Achievement of Skill Level 4, and Range of Skill Level after Achievement of Skill Level 4

PCR	Number of UTZ Exams Performed	Number of UTZ Exams Needed to Achieve Skill Level of 4	Average Skill Level after Achieving Skill Level of 4	Range of Skill Level Following Achievement of Skill Level 4
1	6	5	4	4
2	14	1	3.9	3–4
3	4	Not achieved	N/A	N/A
4	6	2	3.5	3–4
5	5	4	4	4
6	5	4	4	4
7	1	Not achieved	N/A	N/A
8	4	4	4	4
9	6	3	3.2	3–4
10	5	Not achieved	N/A	N/A
11	2	Not achieved	N/A	N/A
12	4	4	4	4
13	10	5	3.8	3–4
14	1	Not achieved	N/A	N/A
15	1	Not achieved	N/A	N/A
16	9	2	4	4

UTZ, ultrasonography; PCR, primary care resident.

most PCRs rotated away from the ACC before they had spent adequate time and enrolled an adequate number of patients in the study. Only PCRs who had several blocks of rotations consecutively at CSMC were able to achieve competence in this skill. There was proctor assistance introduced in the competence levels 1 through 3 PCR exams. This proctor assistance did not affect the 35 PCR exams scored at a competence level of 4. Coupling the 35 PCR competence level 4 exams with the Table 1 data that all of the PCR results were consistent with the vascular lab results suggests that a PCR can rapidly learn the technique of UTZ imaging of the abdominal aorta.

Physicians can rapidly learn to perform focused, organ-specific UTZ evaluations designed to answer specific questions.[25–32] This type of examination is limited in scope and detail in contrast to the radiologist-read examination, which is more detailed.[28] Most patients do not need a thorough UTZ exam in order to answer specific questions such as whether they have an AAA,[30] hydronephrosis with renal colic,[31] or, after blunt abdominal trauma, hemoperitoneum.[32] The availability of UTZ equipment, which is small, lightweight, portable, noncomplex, highly accurate, and inexpensive makes it possible to place the tool UTZ in the hands of the PCP.[33] The ultrasonography equipment used in this study cost $50,000 to $100,000 and has been subsequently replaced with new equipment, which cost approximately $15,000 but has far better imaging capabilities, is more portable, and is easier to use. UTZ screening of the aorta for AAAs takes very little time and could be incorporated into the routine physical exam of specific patient populations, such as male smokers over the age of 70 who are at greatest risk for AAA. Placing the tool of UTZ in the hands of the PCP would enable the PCP to immediately and quickly screen for AAA using UTZ, and this would ultimately minimize the morbidity and mortality from this deadly disease.

This study brought out several issues that may be a factor in training primary care residents in ultrasonography for AAA screening. It appears necessary to allow specific time for initial PCR UTZ training that is separate from patient care time. It may be necessary to lighten the PCR's patient care schedule to allow the resident physician adequate time (approximately an additional 30 min per patient) during the training period and to have a 3- to 4-month period available in their training schedule in which they are stationed in a particular ambulatory care setting so they can become familiar with the equipment and protocol, and have adequate time to enroll enough patients in the protocol to become competent in the skill. The number of patient exams needed to achieve competence in this skill appears to be in the range of 5 to 10, with additional studies helping to solidify the skill. PCRs must have an adequate chance to continue to use the skill if they are expected to maintain competence in the skill.

This study may be directly applicable to training PCPs in the use of UTZ for AAA screening; in fact, training of PCPs may be associated with greater success, since many of the logistical challenges of training residents would be less likely to arise in routine practice. Patient-physician language barriers made patient recruitment difficult in this study. A PCP's general patient population is likely to be able to communicate easily with the PCP, enhancing the opportunity to perform enough exams to attain an independent abdominal aortic UTZ screening competence level and to maintain this level. The PCR training schedule impacted upon this study, with some PCRs rotating away from the ACC clinic before completing enough exams to achieve AAA UTZ screening independence. This is unlikely to be a factor for PCPs trying to learn this skill.

This pilot study has several limitations. The low number of PCRs participating in this study limits the ability of this study to definitively establish the true learning curve. The low number of patients with true AAAs in this study hampers the ability of this study to determine if PCRs truly can accurately diagnose AAA in a variety of settings, especially when considering unsupervised settings. This study does not attempt to validate that AAA screening is beneficial to society, nor does this study try to clarify the incidence of aneurysms within selected populations. In addition, this study does not examine the outcome of patients who had negative ultrasound screening examinations; therefore, we cannot comment upon the accuracy of ultrasound as a screening test, only upon the results of ultrasound measurements made by PCRs compared with those of the vascular lab experts.

This pilot study reports favorable results, suggesting that it would be beneficial to conduct a larger study on the feasibility and accuracy of UTZ performed by PCPs for specific diagnostic questions such as the ability of a PCP to measure the abdominal aorta accurately and diagnose AAA. Although PCRs are not the same as PCPs, the experience of this study should be applicable to educating PCPs on UTZ screening of AAAs. In conclusion, the main outcome of this study is that a PCR, with minimal training in UTZ imaging, is able to rapidly learn the technique of UTZ imaging of the abdominal aorta. The results of this study may be applicable to PCP-performed UTZ imaging of the abdominal aorta for screening of AAAs. Larger studies are needed to verify these results and to examine other issues relevant to UTZ use by primary care residents and physicians.

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