Does This Patient Have Abdominal Aortic Aneurysm?

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In the physical examination of abdominal aortic aneurysm (AAA), the only maneuver of demonstrated value is abdominal palpation to detect abnormal widening of the aortic pulsation. Palpation of AAA appears to be safe and has not been reported to precipitate rupture. The best evidence on the accuracy of abdominal palpation comes from 15 studies of patients not previously known to have AAA who were screened with both abdominal palpation and ultrasound. When results from these studies are pooled, the sensitivity of abdominal palpation increases significantly with AAA diameter ($P<.001$), ranging from 29% for AAAs of 3.0 to 3.9 cm to 50% for AAAs of 4.0 to 4.9 cm and 76% for AAAs of 5.0 cm or greater. Positive and negative likelihood ratios with 95% confidence intervals (CIs) using a cutoff point for AAAs of 3.0 cm or greater are 12.0 (95% CI, 7.4-19.5) and 0.72 (95% CI, 0.65-0.81), respectively, and for AAAs of 4.0 cm or greater are 15.6 (95% CI, 8.6-28.5) and 0.51 (95% CI, 0.38-0.67). The positive predictive value of palpation for AAA of 3.0 cm or greater in these studies was 43%. Limited data suggest that abdominal obesity decreases the sensitivity of palpation. Abdominal palpation specifically directed at measuring aortic width has moderate sensitivity for detecting an AAA that would be large enough to be referred for surgery but cannot be relied on to exclude AAA, especially if rupture is a possibility.

JAMA. 1999;281:77-82 www.jama.com

CLINICAL SCENARIOS

Case 1

A 60-year-old man requests a physical examination because a friend recently died suddenly from a ruptured abdominal aortic aneurysm (AAA). Your examination reveals nothing abnormal. After reassuring the patient, you are left wondering whether you might have missed an AAA large enough to warrant surgical repair.

Case 2

A thin 80-year-old woman notes that she can feel her abdomen pulsating against her belt. While examining her abdomen, you find an easily palpable, strongly pulsating aorta that you measure to be about 2 cm wide. You wonder if you should order an ultrasound examination.

Case 3

You are asked to see a 75-year-old man with 12 hours of right flank and abdominal pain, constipation, urinary frequency, urgency, dysuria, and leukocytosis and who is about to be sent home on treatment for pyelonephritis. Deep palpation of the abdomen is difficult, but you faintly discern a large pulsatile mass. You order computed tomography which confirms an AAA with bleeding into the retroperitoneum, and the patient is taken to the operating room.

WHY IS PHYSICAL DIAGNOSIS OF AAA IMPORTANT?

Abdominal aortic aneurysms cause more than 10 000 deaths each year in the United States,[1] and many of these deaths should be preventable through timely diagnosis and treatment. Abdominal aortic aneurysms usually remain asymptomatic while slowly enlarging over a period of years or even decades. About a third will eventually rupture, an event associated with a mortality rate of 80%.[2] Important risk factors for AAA include age, male sex, and smoking.[3]

Abdominal palpation was the original method of AAA detection. When ultrasonography and computed tomography became available, it was clear that they were more accurate than palpation, and these became the procedures of choice for confirming the diagnosis of AAA and for measurement of AAA diameter. A variety of studies have shown the sensitivity and specificity of ultrasonography and computed tomography to be close to 100%.[4-8] Since then, the importance of abdominal palpation has been limited to identifying patients who should have confirmatory imaging studies. In one recent report, 31% of all AAAs diagnosed at a university hospital were originally detected by routine physical examination.[9]

The first scenario addresses the issues of screening (or case finding) to detect AAA and the subsequent management of asymptomatic AAA, 2 subjects

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of considerable debate in recent literature. While most of the discussion of screening has focused on the use of ultrasound, the only study to consider both methods found screening with abdominal palpation to be more cost-effective.[10] In a review of the periodic physical examination, abdominal palpation for AAA was one of the few maneuvers recommended for older men.[11] The Canadian Task Force on the Periodic Health Examination noted that abdominal palpation of men older than 60 years was prudent,[12] but both the Canadian and the US Preventive Services Task Forces gave each AAA screening method a *C* rating (poor evidence to include or exclude from the periodic health examination), and some authors have judged the accuracy of abdominal palpation for AAA to be insufficient for screening.[13]

Management is based on observations that the risk of AAA rupture (and hence the need for elective repair) increases with the diameter of the aneurysm. The diameter of asymptomatic AAA above which repair should be offered to good surgical candidates is the topic of ongoing clinical trials,[14] and current recommendations range from 4.0 to 6.0 cm, with 5.0 cm the cutoff point most commonly used.[15] Patients with AAAs that do not yet warrant repair are followed up with ultrasound once or twice a year to detect enlargement that might warrant repair.

The second scenario represents what has been termed the *students' aneurysm*.[16] Realization that these symptoms and physical findings are normal allows the physician to provide immediate reassurance to the patient and makes further testing unnecessary.

In the third scenario, abdominal palpation may have been lifesaving. Physical examination should not be relied on to exclude the diagnosis of ruptured AAA, and any patient in whom the diagnosis is considered should undergo ultrasonography or computed tomography. However, there are patients whose clinical likelihood of having a ruptured AAA lies below the physician's threshold for obtaining an imaging study and for whom physical examination may therefore be decisive. Many physicians are unfamiliar with the varied presentations of ruptured AAAs, so palpation of a widened aorta may be the first suggestion of the diagnosis.[17]

The importance of the physical examination in these settings depends largely on its accuracy. In this article, the accuracy of physical diagnosis of an AAA is assessed by review and analysis of the available literature. In 1905, Osler[18] observed that "no pulsation, however forcible, no thrill, however intense, no bruit, however loud-singly or together—justify the diagnosis of an aneurysm of the abdominal aorta, *only the presence of a palpable expansile tumour*." Accordingly, most of the literature on physical examination to detect AAA has dealt with abdominal palpation to measure the width of the pulsatile mass representing the aneurysmal aorta, but several other physical signs have been considered. In one study, abdominal and femoral bruits and absent femoral pulses had no predictive value.[8] Another study found that location of the pulsation more than 3.0 cm caudad of the umbilicus was not predictive of AAA.[19] In 1975, Guarino[20] stated that the pulsatile mass of AAA could be distinguished by its being moveable laterally but not cephalad or caudad. This observation was not studied, however, and in the current era of readily available ultrasound, there may be little value in further increasing the specificity of physical examination once a widened aorta is felt. We are aware of no other putative signs of AAA for which published information is available, so the remainder of this article will be limited to consideration of abdominal palpation to detect a widened aorta. Attempts to measure precisely the AAA diameter by abdominal palpation (as opposed to simply differentiating abnormal from normal) have also been studied[4,5,21-23] but are of limited importance now that AAA measurements are routinely obtained more accurately from follow-up imaging studies and so will not be considered further.

METHODS

We searched MEDLINE for articles from 1966 to August 1998 using a search strategy previously developed for the Rational Clinical Examination series that combined 10 exploded MeSH headings (*physical examination*, *medical history taking*, *professional competence*, "*sensitivity and specificity*," *reproducibility of results*, *observer variation*, "*diagnostic tests, routine*," *decision support techniques*, *Bayes theorem*, *mass screening*) and 2 text word categories ("*physical exam$*" and "*sensitivity and specificity*"), and then we took the intersection of this set with aortic aneurysm (exploded). The resulting set, plus articles in our files, references cited by these articles, and references in textbooks, were reviewed for information pertinent to the clinical examination of AAA. Unpublished information was obtained from the authors of some studies.

Series with fewer than 10 patients and those published before 1966 were not considered. No other exclusions (eg, language or publication type) were applied. We assigned each study to a level of evidence based on a system previously developed for this series.[24] Level 1 studies are independent, blind comparisons of sign or symptom results with a criterion standard among a large number (sufficient to have narrow confidence limits on the resulting sensitivity, specificity, or likelihood ratio) of consecutive patients suspected of having the target condition. Level 2 studies are independent, blind comparisons of sign or symptom results with a criterion standard among a small number of consecutive patients suspected of having the target condition. Level 3 studies are independent, blind comparisons of signs and symptoms with a criterion standard among nonconsecutive patients suspected of having the target condition. Level 4 studies are nonindependent comparisons of signs and symptoms with a criterion standard among convenience samples of patients who obviously have the target condition plus, perhaps, healthy individuals. Level 5 studies are nonindependent comparisons of signs and symptoms with a standard of uncertain validity (which may even incorporate the sign or symptom result in its definition) among convenience samples of patients and, perhaps, healthy patients.

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To provide consistency in data extraction, AAA was defined as an abdominal aortic diameter of 3.0 cm or greater. There is no widely accepted method of defining the cutoff point between a normal aorta and an AAA. Imaging studies done in clinical practice are often interpreted on the basis of arterial shape (eg, distal widening), but epidemiological studies have generally used the simpler measure of unadjusted infrarenal aortic diameter, which has been shown to be associated with rupture risk.[25] An infrarenal aortic diameter of 3.0 cm is a commonly used, but somewhat controversial, cutoff point in published articles, whereas a diameter of 4.0 cm or larger is clearly diagnostic of an AAA. Adjustment of the cutoff point for such factors as age, sex, and body size has been suggested but appears to have little practical value.[26]

An a priori decision was made to consider intermediate findings on palpation as negative when the uncertainty was due to the aorta being impalpable[27-30] and positive when the findings were considered suggestive of an AAA (as opposed to definite).[8,31]

Sensitivity was calculated as the proportion of affected patients with positive findings, specificity as the proportion of nonaffected patients with negative findings, and a positive predictive value as the proportion of patients with positive findings who were affected. Likelihood ratios were also calculated; the positive likelihood ratio (LR+) is defined as sensitivity/(1 – specificity) and expresses the increase in the odds of having the disease when the finding is positive (LR+ values are ≥1), and the negative likelihood ratio (LR–) is defined as (1 – sensitivity)/specificity and expresses the decrease in the odds of having the disease when the finding is negative (LR– values are 0-1). To avoid division by 0, values for true-positives, false-positives, true-negatives, and false-negatives were increased by 0.5 when computing likelihood ratios.[32] Confidence intervals (CIs) for likelihood ratios from individual studies were computed using the method of Simel and colleagues.[33]

The studies of AAA screening were judged to be of sufficient quality and similarity of design to assess for statistical similarity. The χ^2 tests for heterogeneity of the sensitivity data were not significant (all P values $>.10$), supporting the decision to pool these data.[34] However, assessments of heterogeneity of the effectiveness scores (a measure of the effect size of a diagnostic test result) were of borderline significance (pooled effectiveness, 1.7; $P = .04$ using cutoff of 3.0 cm; pooled effectiveness, 2.1; $P = .06$ using cutoff of 4.0 cm).[32] Therefore, a random-effects measure was used as a conservative method for pooling the results of these studies, and CIs for the pooled likelihood ratios were calculated by the method of Eddy and Hasselblad.[34]

Table 1. Sensitivity of Abdominal Palpation in Series of Patients With Ruptured Abdominal Aortic Aneurysm (AAA)*

Source, y	No. of AAAs	Sensitivity of Palpation, %†	Patient Selection
Pryor,[35] 1972	44	45 (82)	All
Williams et al,[36] 1972	79	97 . . .	Operated on
Ottinger,[37] 1975	40	75 (100)	Diagnosed antemortem
McGregor,[38] 1976	41	44 (51)	Unoperated on at autopsy
Gordon-Smith et al,[39] 1978	83	90 . . .	Operated on
Gaylis and Kessler,[40] 1980	105	87 . . .	Diagnosed antemortem
Donaldson et al,[41] 1985	81	91 . . .	Not stated
Walsh et al,[42] 1992	55	64 . . .	All
Lederle et al,[17] 1994	23	52 . . .	Presented to internist

*All studies provide level 4 evidence (see "Methods" section).
†Numbers in parentheses represent the sensitivity if nonpulsatile masses are included. Ellipses indicate not applicable.

RESULTS

Abdominal Palpation for Ruptured AAA

Several studies have reported the sensitivity of abdominal palpation in patients with ruptured AAA (**Table 1**).[17,35-42] In these studies, it is not clear how often the physical findings suggested the diagnosis of AAA as opposed to being elicited after the diagnosis was made by other methods. The sensitivities tended to be higher when patient selection was limited to those diagnosed antemortem (including operative series). Three series included masses that were described as not pulsatile, and sensitivities with these masses included are reported separately in Table 1. Compared with asymptomatic AAAs, ruptured AAAs tend to be larger, which would be expected to increase sensitivity,[43] but rupture may also be associated with guarding, intestinal distention due to compromised circulation, and loss of integrity of the AAA, which could have the opposite effect.

Abdominal Palpation for Asymptomatic AAA

Some studies have reported the sensitivity of abdominal palpation in patients with known asymptomatic AAAs (range of sensitivities, 65%-100%).[4-7,22,23,36,39,44-49] Most of these studies involved patients undergoing preoperative evaluation for elective repair of large AAAs, and many patients were originally identified by physical examination before referral to the study group. The lack of blinding and the preponderance of large AAAs likely resulted in higher sensitivities than would be achieved in most clinical settings.

Other studies have reported the positive predictive value of clinical suspicion for AAAs in a series of patients referred for imaging studies (range of positive predictive values, 15%-91%).[6,13,21,31,48-53] The wide range of values may reflect possible inclusion in some studies of patients with previous diagnostic imaging studies prior to their referral to the study group (falsely increasing positive predictive value) and of patients referred for rule out AAA based on indications other than palpation of a widened aorta (potentially falsely increasing or decreasing positive predictive value). Two studies provide results by age and sex indicating that the highest positive predictive values are obtained in men older than 60 years, with

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Table 2. Abdominal Palpation in Populations Screened for Asymptomatic Abdominal Aortic Aneurysm (AAA)*

Source, y	Range of Patient Age, y	Women, %	No. Screened	No. of AAAs Diagnosed by Ultrasound and Sensitivity of Abdominal Palpation							
				≥3.0 cm (All)		3.0-3.9 cm		4.0-4.9 cm		≥5.0 cm	
				AAA	Sensitivity, %	AAA	Sensitivity, %	AAA	Sensitivity, %	AAA	Sensitivity, %
Cabellon et al,[27] 1983	43-79	33	73	9†	22	NA	NA	NA	. . .	NA	. . .
Ohman et al,[54] 1985	50-88	0	50	3	0	2	0	1	0	0	. . .
Twomey et al,[55] 1986	>50	0	200	14	64	7	43	3	100	4	75
Allen et al,[56] 1987	>65	43	168	3	0	2	0	0	. . .	1	0
Allardice et al,[57] 1988	39-90	25	100	15	33	10	0	3	100	2	100
Lederle et al,[8] 1988	60-75	0	201	20	45	10	40	5	20	5	80
Collin et al,[19] 1988	65-74	0	426	23‡	35	NA	NA	NA	. . .	NA	. . .
Shapira et al,[58] 1990	31-83	36	101	4	0	2	0	0	. . .	2	0
Andersson et al,[59] 1991	38-86	42	288	14	29	NA	NA	NA	. . .	NA	. . .
Spiridonov and Omirov,[60] 1992	17-67	13	163	10	70	3	0	4	100	3	100
MacSweeney et al,[28] 1993	NA	36	200	55	24	33	0	16	44	6	100
Karanjia et al,[61] 1994	55-82	41	89	9	100	2	100	5	100	2	100
Molnar et al,[62] 1995	65-83	53	411	7	43	2	50	3	33	2	50
al Zahrani et al,[29] 1996	60-80	29	392	7	57	1	0	4	50	2	100
Arnell et al,[30] 1996	55-81	0	96	1	100	1	100	0	. . .	0	. . .
Pooled results	. . .	26	2955	194	39	75	29	44	50	29	76

*Includes unpublished information received from authors. All studies used ultrasound and provide level 2 evidence. The pooled results for numbers are sums and for functions are from a random-effects measure and provide level 1 evidence (see "Methods" section). Abdominal aortic aneurysm is defined as at least 3.0 cm by ultrasound. CI indicates confidence interval; ellipses, values cannot be calculated; and NA, data not available.
†No information was given on AAA diameter.
‡Abdominal aneurysms less than 3 cm are included.

low values (<15%) obtained in women and younger men.[13,53]

The best evidence available for assessing the performance of abdominal palpation to detect AAAs comes from series of patients not previously suspected of having AAAs who were screened by abdominal palpation and ultrasound (**TABLE 2**).[8,19,27-30,54-62] In all 15 of these studies, screening was limited to patients at increased risk for AAAs, usually older men with hypertension or vascular disease. Blinding of the examiner was ensured when physical examination preceded ultrasound; this was stated to have occurred in 8 of these 15 studies[8,19,27-30,55,59] and was implied to have occurred in the others. No study stated whether the ultrasonographer was blinded to the physical examination findings.

The low level of disease prevalence in these screening studies and the resulting low expectation of disease by the examiner have the advantage of reflecting most clinical settings. A disadvantage is that the small number of AAAs, particularly larger AAAs, limits the precision of the estimates from individual studies. We addressed this problem by pooling data from all studies.

In the pooled analysis, the sensitivity of abdominal palpation increased significantly with the AAA's diameter ($P<.001$, χ^2 for trend), illustrating the previously described effect of disease severity on sensitivity.[43] As seen in Table 2, the pooled sensitivity values range from 29% for AAAs of 3.0 to 3.9 cm to 50% for AAAs of 4.0 to 4.9 cm and to 76% for AAAs of 5.0 cm or greater. As would be expected, these sensitivities are lower than those observed in the series of previously known (and presumably larger) AAAs mentioned above.

The high positive likelihood ratios indicate that the finding of a widened aorta greatly increases the odds that an AAA is present, whereas the negative likelihood ratios indicate that the absence of this finding is only moderately effective in ruling out an AAA. Not surprisingly, the likelihood ratios also indicate that abdominal palpation is a more effective diagnostic test for larger AAAs (LR+, 15.6; LR–, 0.51 using a cutoff point for AAA of ≥4.0 cm vs LR+,12.0; LR–, 0.72 using AAA ≥3.0 cm).

Factors That Affect Abdominal Palpation for AAA

The sensitivities shown in Table 2 apply only to abdominal palpation directed at AAA detection and not to routine abdominal palpation (abdominal palpation as it is routinely done in practice, not necessarily specifically directed at measuring aortic width). Several studies have compared routine physical examination with abdominal palpation directed at AAA detection. In one of the screening studies listed in Table 2, all 5 patients with AAAs considered definite at the study's physical examination and subsequently confirmed by ultrasound had been missed on routine physical examination of the abdomen in the previous 6 months.[8] Another study found that 95 of 188 patients with AAAs considered palpable on physical examination before surgery had been missed on at least 1 physical examination in the 12 months preceding the initial diagnosis.[47] In a third study, 19 of 37 patients with previously undiagnosed but easily palpable ruptured AAAs (all 6-10 cm in diameter) had

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Positive Predictive Value of Palpation, %	Likelihood Ratios (LRS)			
	Cutoff Point: AAA ≥3.0 cm		Cutoff Point: AAA ≥4.0 cm	
	Positive LR (CI)	Negative LR (CI)	Positive LR (CI)	Negative LR (CI)
67	10.8 (1.6-73.3)	0.77 (0.54-1.10)	. . .	. . .
. . .	12.0 (0.3-528)	0.88 (0.61-1.28)	25 (0.6-968)	0.76 (0.34-1.69)
64	21.5 (8.7-53.4)	0.38 (0.19-0.74)	18.5 (8.9-38.8)	0.20 (0.05-0.83)
0	1.6 (0.1-23.0)	0.95 (0.65-1.38)	3.3 (0.3-38.7)	0.81 (0.36-1.81)
100	59.1 (3.4-1018)	0.66 (0.46-0.94)	176 (11.0-2823)	0.08 (0.01-1.19)
35	4.7 (2.5-9.0)	0.61 (0.41-0.90)	4.5 (2.2-9.1)	0.56 (0.31-1.02)
36	9.9 (4.7-20.7)	0.67 (0.50-0.90)	. . .	. . .
. . .	19.6 (0.4-890)	0.90 (0.68-1.21)	33.3 (0.8-1415)	0.84 (0.50-1.39)
31	8.7 (3.2-23.5)	0.73 (0.52-1.01)	. . .	. . .
26	5.1 (2.9-9.1)	0.37 (0.15-0.87)	7.2 (4.6-11.2)	0.07 (0-1.05)
72	6.4 (2.5-16.4)	0.79 (0.68-0.92)	19.1 (7.8-46.6)	0.43 (0.26-0.69)
82	30.8 (9.0-105)	0.05 (0-0.77)	17.3 (6.9-43.2)	0.07 (0-0.97)
33	27.3 (9.1-81.5)	0.57 (0.31-1.05)	22.6 (6.9-73.8)	0.59 (0.30-1.17)
57	62.0 (18.5-208)	0.44 (0.20-0.97)	71.1 (21.8-231)	0.36 (0.13-0.97)
14	11.1 (3.7-33.0)	0.27 (0.02-2.96)	6.5 (0.8-51.6)	0.54 (0.08-3.85)
43	12.0 (7.4-19.5)	0.72 (0.65-0.81)	15.6 (8.6-28.5)	0.51 (0.38-0.67)

undergone physical examination in the previous 24 months, but the diagnosis had been missed.[63] Abdominal aortic aneurysms enlarge at a mean rate of 0.2 to 0.5 cm per year,[25,64] so the time interval was unlikely to have been an important confounder in these studies.

Obesity also appears to limit the effectiveness of abdominal palpation. In one study, patients with AAAs missed at palpation had significantly greater mean abdominal girth than patients with AAAs detected at palpation (111 cm vs 96 cm, $P<.01$), and, when abdominal girth was less than 100 cm, 6 of 6 AAAs were detected at palpation compared with 3 of 12 AAAs that were detected when abdominal girth was 100 cm or more ($P<.01$).[8] Another study noted that 23% of the patients "were too obese for us to feel the aortic pulse."[30] We are aware of no reports discussing whether AAA is excluded more reliably when the aorta is palpable and considered to be normal than when the aorta cannot be adequately palpated.

How to Perform Abdominal Palpation to Detect AAA

Abdominal palpation should be conducted while the patient is supine with his/her knees raised with a relaxed abdomen. The examiner first feels deeply for the aortic pulsation, usually found a few centimeters cephalad of the umbilicus (the umbilicus marks the level of the aortic bifurcation) and slightly to the left of midline. The examiner then positions both hands on the abdomen with palms down, placing an index finger on either side of the pulsating area to confirm that it is the aorta (each systole should move the 2 fingers apart) and to measure the aortic width. A generous amount of abdominal skin should be included between the 2 index fingers, and it is often easier, initially, to probe for 1 side of the aorta at a time.

It is the width, and not the intensity, of the aortic pulsation that determines the diagnosis of an AAA; a normal aorta is often readily palpable in thin patients or those with loose abdominal muscles. The aorta is normally less than 2.5 cm (1 in) in diameter, and aortas larger than this (after allowing for skin thickness) warrant further investigation, usually with ultrasound. Physical examination to detect AAAs is rarely warranted in persons younger than 50 years due to the low frequency of disease in this group.

There are no known risks associated with palpation of the abdominal aorta. We found no reports of AAA rupture attributed to physical examination, and a textbook author noted that he was "unaware of rupture during examination of any of several thousand abdominal aortic aneurysms seen over four decades."[65]

We are aware of no educational studies examining methods of learning AAA palpation. In our experience, however, accurate palpation is readily learned through practice and feedback. We have found that physicians can become proficient after comparing their findings with ultrasound measurements in a few patients with AAAs and a few controls.

BOTTOM LINE

The only physical examination maneuver of demonstrated value for diagnosis of an AAA is abdominal palpation to detect a widened aorta. Palpation of AAA appears to be safe and has not been reported to precipitate rupture.

Positive findings on abdominal palpation greatly increase the likelihood that an AAA, particularly a large AAA, is present. Even so, the positive predictive value of 43% (Table 2) indicates that less than half of all high-risk patients (and fewer low-risk patients, such as most women and young men) suspected of having an enlarged aorta on abdominal palpation will be found to have an AAA. However, this may not be of great concern because ultrasound provides a safe and relatively inexpensive confirmatory test.

Abdominal palpation will detect most AAAs large enough to warrant surgery, but it cannot be relied on to exclude the diagnosis. The sensitivity of palpation appears to be reduced by abdominal obesity and by routine abdominal examination not specifically directed at measuring aortic width. When a ruptured AAA is suspected, imaging studies such as ultrasonography or computed tomography should be performed regardless of physical findings.

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Acknowledgment: The authors thank Andreas Laupacis, MD, and Kavita Nanda, MD, for their helpful reviews of the article.

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