in the clinic

Abdominal Aortic Aneurysm

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CME objective: To review the screening and prevention, diagnosis, treatment, and practice improvement for abdominal aortic aneurysm.

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An aneurysm is a failure of the arterial wall that results in a balloon-like dilatation of a segment of the artery. Aortic aneurysms constitute the 14th leading cause of death in the United States and the 10th leading cause of death in older men, who are the principal victims (1). Diagnosis of abdominal aortic aneurysm (AAA) is important because the natural history is that of continued enlargement with potentially catastrophic consequences. Because the condition may be entirely asymptomatic, and when symptoms are present, they may be nonspecific, the internist is often the first to evaluate the patient. Thus, understanding the disease, optimal diagnostic methods, and management are crucial for primary care practitioners.

Approximately 80% of aortic aneurysms occur between the renal arteries and the aortic bifurcation. Abdominal aortic aneurysm is present in more than 5% of older men who have smoked. Each year in the United States, AAA rupture causes 4500 deaths; another 1400 deaths result from the 45 000 repair procedures done to prevent rupture (2).

Screening and Prevention

What factors increase the risk for AAA?

Smoking is the most important reversible risk factor for AAA. In the largest screening study (3), a history of cigarette smoking accounted for 75% of all AAAs 4.0 cm or greater in diameter. The association with AAA is stronger for current smokers than for former smokers, increases with number of years smoked, and decreases with the elapsed time after quitting. After adjustment for other risk factors, AAA is several times more common in men than in women. Other factors associated with AAA include age, white race, and family history of AAA (see Box). Abdominal aortic aneurysm is less common in patients with diabetes (3).

In a cross-sectional screening study, 126 196 veterans age 50 to 79 years underwent ultrasonography to detect AAA. Aneurysms 3.0 cm or greater in diameter were present in 4.2% of participants. The principal positive associations with AAA were age, smoking, male sex, white race, family history of AAA, and atherosclerotic diseases. This study first described the surprising and still unexplained inverse association of AAA with diabetes (3).

What is the natural history of AAA?

The natural history of AAA is to enlarge slowly over a period of years. Abdominal aortic aneurysms of 4.0 to 5.5 cm enlarge at a mean rate of 0.3 cm per year, with less than 25% enlarging 0.5 cm or more per year (4, 5). Larger AAAs enlarge faster. The rate of enlargement for 3.0- to 4.0-cm AAAs is one half that of 4.0-to 5.5-cm AAAs (6), and one half again faster for AAAs greater than 5.5 cm (7). The enlargement rate differs among individuals and is faster with advancing age and continued smoking.

Most AAAs never rupture, but when rupture occurs, the mortality rate is 80% (8). As a AAA enlarges, the risk for rupture increases. The rupture rate for AAAs of 4.0 to 5.5 cm in diameter is 0.7% to 1.0% per year (4, 5), higher than with AAAs less than 4.0 cm. The rupture rate for small AAA is higher in women than in men (9). Men and women have equivalent rupture rates for AAAs greater than 5.5 cm (10). Rupture rates of AAAs greater than 5.5 cm in otherwise healthy patients are unknown and unlikely to be known in the future because of

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3. Lederle FA, Johnson GR, Wilson SE, et al. The aneurysm detection and management study screening program: validation cohort and final results. Aneurysm Detection and Management Veterans Affairs Cooperative Study Investigators. Arch Intern Med. 2000;160:1425-30. [PMID: 10826454]
4. The UK Small Aneurysm Trial Participants. Mortality results for randomised controlled trial of early elective surgery or ultrasonographic surveillance for small abdominal aortic aneurysms. Lancet. 1998;352:1649-55. [PMID: 9853436]

general agreement that these patients need treatment. However, in patients with AAA greater than 5.5 cm who are unfit for surgery, the rupture rate is high (7).

A 5-year prospective longitudinal study followed 198 patients with AAA 5.5 cm or greater who were not repaired electively because of high operative risk or patient refusal. More than one half of the patients died during the study, 30% within 1 year of enrollment. The rate of probable AAA rupture was 10% per year in the entire cohort, and more than 25% at 6 months for AAA 8.0 cm or greater. Whether these rates apply to healthier patients is unknown, but they are useful for decision making in high operative risk patients (7).

Who should clinicians screen for AAA and how should screening be done?

The U.S. Preventive Services Task Force (USPSTF) now recommends one-time screening with ultrasonography to detect asymptomatic AAA in 65- to 75-year-old men who have ever smoked (11). The USPSTF does not make a recommendation for nonsmoking men and recommends against screening women.

Medicare covers abdominal ultrasonography to screen for AAA for men who have ever smoked and anyone with a family history of AAA. Screening should take place at the Welcome to Medicare visit, which must occur within 6 months after beginning Medicare insurance coverage.

The USPSTF based its recommendation to screen for AAA on a solid body of evidence. Four randomized trials of AAA screening have reported results. These trials randomly assigned one half of patients from a population list to receive an invitation for ultrasonography screening. Of these, 60% to 80% attended the screening. Of the men who were screened, 4% to 8% had AAAs 3.0 cm in diameter or larger, and the frequency of elective AAA repair was several-fold greater in the invited groups than in the uninvited control groups. In a meta-analysis of these 4 trials performed for the USPSTF, men invited to undergo screening had a lower rate of AAA-related mortality (odds ratio, 0.57 [95% CI, 0.45 to 0.74]) (12).

Risk Factors for Abdominal Aortic Aneurysm

- Older age
- Smoking
- Male sex
- White race
- Family history of abdominal aortic aneurysm
- Occlusive atherosclerotic disease

In the Multicentre Aneurysm Screening Study (MASS) conducted in the United Kingdom, 67 770 men age 65 to 74 years were randomly assigned to ultrasonography screening for AAA or usual care. Patients with AAA 5.5 cm or larger were referred for elective repair. After a mean 7 years of follow-up, deaths related to AAA were significantly reduced from 196 in the control group to 105 in the invited group. All-cause mortality was lower in the screened group; the difference was of borderline statistical significance (13).

A recent meta-analysis of longer-term outcomes from the screening trials reported a small but statistically significant reduction in all-cause mortality in the invited patients (odds ratio, 0.97 [95% CI, 0.94 to 0.99]) (14).

These trials, added to those of smaller studies, form the basis of the USPSTF recommendation for AAA screening (11). They were not limited to smokers and did not report their results by such subgroups as smoking status because the authors had little information about the control groups. The first trial included 9342 women, who did not benefit from screening. However, the number of

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8. Adam DJ, Mohan IV, Stuart WP, et al. Community and hospital outcome from ruptured abdominal aortic aneurysm within the catchment area of a regional vascular surgical service. J Vasc Surg. 1999;30:922-8. [PMID: 10550191]

AAA-related events in women was too small (10 ruptures in the screened group vs. 9 in the control group after 10 years of follow-up) to draw firm conclusions about the effect of screening in women (15).

Several screening programs have reported the findings of repeat screening (16, 17). Aneurysms were less frequent and smaller than on the initial screening, which is not surprising because the initial screening would have detected the long-standing and therefore larger AAAs that had developed over the preceding years. Consequently, most authors and the USPSTF have concluded that one-time screening after age 65 is sufficient.

What should clinicians tell patients to help them decrease their risk for AAA?

Because the association with AAA is substantially stronger for current smokers than former smokers, it is reasonable to assume that smoking cessation will reduce the risk for AAA. Clinicians can cite increased risk for AAA as another reason for patients to stop smoking.

Screening and Prevention... Abdominal aortic aneurysm is the 10th most common cause of death in older men. Smoking is its most important modifiable risk factor, and former smokers have a progressively smaller risk for AAA than current smokers. Randomized trials show that screening substantially reduces the risk for AAA-related mortality. The USPSTF recommends one-time abdominal ultrasonography screening for male smokers age 65 to 75 years.

CLINICAL BOTTOM LINE

Diagnosis

How does AAA present?

Before rupture, AAAs are nearly always asymptomatic. Detection occurs after abdominal palpation, radiologic imaging for other purposes, or imaging tests done to screen for AAA. This section focuses on diagnosing ruptured AAA, because it happens infrequently in a physician's career and is one of the true emergencies of medical practice.

Ruptured AAA is a leading cause of sudden death (18). Its most frequent findings are pain and tenderness in the abdomen, flank, groin, or back. Other common symptoms include urinary retention, constipation, urge to defecate, hypotension, transient syncope, sudden collapse, and shock.

Misdiagnosis of ruptured AAA remains disturbingly common, despite descriptions of its varied presentations dating back more than a century. Although ruptured AAA usually presents with catastrophic vascular collapse, it can present with normal blood pressure and hematocrit, although leukocytosis is usually present. Many physicians are unfamiliar with the syndromes of symptomatic unruptured AAA, in which abdominal, flank, or back pain precedes rupture, and contained AAA rupture, in which the hematoma is sealed off in the retroperitoneum. Either of these syndromes can persist for days or, rarely, weeks before uncontained rupture leads to death (19). The clinician must be suspicious of the possible presence of AAA when encountering such symptoms in the appropriate context. Intervention can be lifesaving.

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How should clinicians use the history and physical examination in diagnosing AAA?

Unruptured AAA

Although unruptured AAAs are almost always asymptomatic, a history of heavy tobacco use or a family history of AAA should heighten awareness in older persons, particularly men. The only physical examination maneuver of demonstrated value is abdominal palpation to detect a widened aortic pulsation or "pulsatile mass".

Physicians who care for older patients should become proficient at measuring the width of the aorta between the 2 index fingers. The width of the aortic pulsation provides the key evidence of AAA, not its prominence or force, the presence of bruits, or other findings. Palpating an AAA seems to be safe: No one has reported rupture immediately following palpation. However, abdominal palpation misses many AAAs 5.0 cm or larger in diameter and is even less sensitive for smaller AAAs or in obese patients.

A systematic review pooled 15 studies involving 2955 participants not previously known to have AAA. Each was screened with both abdominal palpation and ultrasonography, which served as the diagnostic reference standard. The sensitivity of abdominal palpation ranged from 29% for AAA 3.0 to 3.9 cm, to 50% for AAA 4.0 to 4.9 cm, and 76% for AAA 5.0 cm or greater. The positive predictive value of palpation for detecting AAA 3.0 cm or greater was 43%. Abdominal obesity seemed to decrease the sensitivity of palpation. The authors concluded that abdominal palpation had moderate sensitivity for detecting AAAs large enough to be referred for surgery, but could not be used to exclude AAA (20).

On the basis of the estimates from this systematic review, a negative physical examination reduces the odds that the patient has an AAA 5.0 cm or larger by approximately 25%. On the other hand, if the examiner feels a pulsatile mass, imaging confirmation, usually ultrasonography, is mandatory.

Signs and Symptoms of Ruptured AAA

- Pain in the flank, abdomen, groin, or back
- Abdominal, flank, or back tenderness
- Gastrointestinal dysfunction (constipation, distention, bleeding, urge to defecate)
- Urinary dysfunction (retention, difficulty voiding, renal colic)
- Syncope
- Hypotension and shock

Ruptured AAA

The diagnosis of ruptured AAA can be obvious or difficult. The most important prerequisite is a high index of suspicion, especially in an older man who has smoked. Physicians must know the various presentations and be particularly suspicious when the patient's condition seems more serious than would be typical with an alternative explanation for flank or abdominal pain, such as pyelonephritis, diverticulitis, or lumbar disk herniation. The Box lists signs and symptoms of ruptured AAA.

A pulsatile mass may be present but is often absent and should not be relied on to confirm rupture. Although ruptured AAAs tend to be large, palpating one can be difficult because of abdominal tenderness, guarding, and intestinal distention due to ileus. Studies of ruptured AAA that include postmortem diagnoses of rupture have reported that a pulsatile mass is palpable only about 50% of the time (20), which means that a negative examination is very unreliable. Table 1 describes the differential diagnosis of pulsatile mass and ruptured AAA, and Table 2 lists the history and physical examination elements for ruptured and unruptured AAA.

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Table 1. Differential Diagnosis of Pulsatile Mass and Ruptured Abdominal Aortic Aneurysm

Disease	*Characteristics*	*Notes*
Pulsatile mass		
Normal aorta	Examiner may be misled by prominent pulsation or subcutaneous fat	Clinical observation*
Para-aortic nodes	Mass adherent to normal aorta that can transmit the aortic pulsation	
Ruptured abdominal aortic aneurysm†		
Gastrointestinal disease (such as diverticulitis, bowel ischemia, pancreatitis, penetrating duodenal ulcer, malignant conditions)	Abdominal pain, constipation, leukocytosis	The expanding hematoma can cause gastrointestinal symptoms by compressing the bowel. Reduced blood pressure and obstruction of aortic branch arteries can compromise blood supply to the gastrointestinal and urinary tracts.
Urinary tract disease (such as stones, infection)	Flank pain, urinary retention, leukocytosis	The expanding hematoma can compress the ureters. Reduced blood pressure and obstruction of aortic branch arteries can compromise blood supply to the urinary tract.
Spinal diseases (such as herniated disk, bony metastases, lower extremity neuropathy)	Severe back pain, nerve impingement syndromes	
Incarcerated hernia	Inguinal mass with pain and tenderness	AAA often diagnosed at surgery for incarcerated hernia‡

AAA = abdominal aortic aneurysm.
** Nusbaum JW, Freimanis AK, Thomford NR. Echography in the diagnosis of abdominal aortic aneurysm. Arch Surg. 1971;102:385-8. [PMID: 5553311]*
† Lederle FA, Parenti CM, Chute EP. Ruptured abdominal aortic aneurysm: the internist as diagnostician. Am J Med. 1994;96:163-7. [PMID: 8109601]
‡ Khaw H, Sottiurai VS, Craighead CC, Batson RC. Ruptured abdominal aortic aneurysm presenting as symptomatic inguinal mass: report of six cases. J Vasc Surg. 1986;4:384-9. [PMID: 3761483]

Table 2. History and Physical Examination Elements for Abdominal Aortic Aneurysm

Category	*Element*	*Sensitivity, %*	*Specificity, %*	*Likelihood Ratio Positive*	*Likelihood Ratio Negative*
Unruptured abdominal aortic aneurysm					
History	Usually asymptomatic				
Physical examination	Abdominal palpation				
	AAA ≥3.0 cm	39	97	12.0	0.72
	AAA ≥4.0 cm	60		15.6	0.51
	AAA ≥5.0 cm	76			
	All AAA	≤81	99.2		
Ruptured abdominal aortic aneurysm					
History	Pain in abdomen, flank, or back	80–100			
	Constipation	22			
	Urinary retention	22			
	Syncope	26			
Physical examination	Abdominal palpation for pulsatile abdominal mass	40–60			
	Hypotension	50–70			
	Abdominal tenderness	70–90			
	Ecchymosis anywhere between diaphragm and knees				

AAA = abdominal aortic aneurysm.

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What imaging studies and other laboratory tests should clinicians order to evaluate patients with suspected AAA?

Unruptured Aneurysm

Ultrasonography is the preferred test for diagnosis and surveillance of AAA in asymptomatic patients. It is safe, accurate, and relatively inexpensive. When the examination is adequate, ultrasonography has a sensitivity and specificity of nearly 100%. Bowel gas may cause an inadequate study, but a repeated examination after fasting is usually successful. Lack of precision (usually <0.5 cm) may misclassify some patients (21). Many international organizations have concluded that diagnostic ultrasonography has no verified adverse effects (22) and therefore no contraindications.

In an ultrasonography screening study (23), 4176 men age 65 to 73 years had aortic diameter measurements by 2 different examiners. The mean interobserver difference was 0.1 mm, a high degree of agreement.

Other tests have a very limited role. Plain abdominal radiography occasionally identifies AAA by showing calcium deposits in the aneurysm wall, but has low sensitivity and does not provide an adequate measurement of AAA diameter. Computed tomography (CT) may be useful when ultrasonography fails to visualize the aorta clearly.

Ruptured Aneurysm

Table 3 lists laboratory and other studies for demonstration of AAA. Diagnosing a ruptured aneurysm means demonstrating extravascular blood in the retroperitoneum or

Table 3. Laboratory and Other Studies for Demonstration of Abdominal Aortic Aneurysm Rupture

Test	*Sensitivity, %*	*Specificity, %*	*Notes*
Abdominal ultrasonography	4		Using operative findings and clinical outcome as gold standard*.
Computed tomography	79	77	Using operative findings as gold standard†.
	77	100	Differences between studies probably result from the small number of patients.
	90	93	
	94	95	
MR, MRA, angiography			Time is of the essence in the diagnosis of rupture. MR, MRA, and angiography offer no advantage over computed tomography and take more time. Therefore, they are rarely if ever used for this purpose; therefore, operating characteristics have not been reported.
Leukocyte count >11 x 10^9 cells/L Hemoglobin <11 g/dL	70		Using operative findings, computed tomography, or autopsy as gold standard‡.

MRA = magnetic resonance angiography.

** Shuman WP, Hastrup W Jr, Kohler TR, et al. Suspected leaking abdominal aortic aneurysm: use of sonography in the emergency room. Radiology. 1988;168:117-9. [PMID: 3289085]*

† Lederle FA, Wilson SE, Johnson GR, et al. Variability in measurement of abdominal aortic aneurysms. Abdominal Aortic Aneurysm Detection and Management Veterans Administration Cooperative Study Group. J Vasc Surg. 1995;21:945-52. [PMID: 7776474]

Adam DJ, Bradbury AW, Stuart WP, et al. The value of computed tomography in the assessment of suspected ruptured abdominal aortic aneurysm. J Vasc Surg. 1998;27:431-7. [PMID: 9546228]

Weinbaum FI, Dubner S, Turner JW, Pardes JG. The accuracy of computed tomography in the diagnosis of retroperitoneal blood in the presence of abdominal aortic aneurysm. J Vasc Surg. 1987;6:11-6. [PMID: 3599277]

Zarnke MD, Gould HR, Goldman MH. Computed tomography in the evaluation of the patient with symptomatic abdominal aortic aneurysm. Surgery. 1988;103:638-42. [PMID: 3375990]

Kvilekval KH, Best IM, Mason RA, Newton GB, Giron F. The value of computed tomography in the management of symptomatic abdominal aortic aneurysms. J Vasc Surg. 1990;12:28-33. [PMID: 2374251]

‡ Lederle FA, Parenti CM, Chute EP. Ruptured abdominal aortic aneurysm: the internist as diagnostician. Am J Med. 1994;96:163-7. [PMID: 8109601]

22. Barnett SB, Ter Haar GR, Ziskin MC, et al. International recommendations and guidelines for the safe use of diagnostic ultrasound in medicine. Ultrasound Med Biol. 2000;26:355-66. [PMID: 10773365]

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abdomen, which requires the resolving power of CT or magnetic resonance imaging (MRI). If treating the ruptured AAA is a realistic option, obtain one of these tests immediately when you suspect ruptured AAA and the patient is hemodynamically stable.

Computed tomography has 80% to 90% sensitivity for rupture (24). One study (25) demonstrated the difficulty of interpreting images in patients with suspected rupture. The authors found that multiple readings of CT agreed only moderately well about the presence of rupture (K = 0.59 interobserver, 0.69 intraobserver). Ultrasonography has low sensitivity for rupture (26) but could increase the probability of the diagnosis by detecting a previously undiagnosed AAA.

How do testing strategies differ depending on the initial presentation of AAA?

Unruptured Aneurysm

When asymptomatic AAA is suspected (usually on the basis of abdominal palpation or plain radiography findings), abdominal imaging with ultrasonography or CT will confirm the diagnosis. Ultrasonography is preferred because it does not expose the patient to radiation and is less expensive.

Suspected AAA Rupture

When the presentation strongly suggests a ruptured AAA and the patient is hemodynamically stable, obtain CT or MRI immediately, and be prepared for the occasional ruptural AAA patient who has cardiovascular collapse in the radiology suite (19). For a patient with abdominal pain and shock, obtain surgical consultation urgently to consider taking the patient directly to the operating room. Abdominal ultrasonography can then be obtained while resuscitation procedures are underway.

When suspicion of AAA rupture is lower, as in an elderly male smoker with new onset of abdominal or back pain and clinical indicators of another diagnosis, physicians should still strongly consider obtaining abdominal ultrasonography. Although ultrasonography will not reliably diagnose rupture, finding an AAA in these patients will alert the physician to pursue further evaluation with CT or MRI.

What other disorders should clinicians consider in patients with suspected AAA?

Occasionally, para-aortic lymph nodes and lymphoma are large enough to masquerade as AAA on abdominal palpation, ultrasonography, and even CT (27, 28). A variety of acute disorders of the gastrointestinal tract, urinary tract, and spine can produce symptoms similar to ruptured AAA, but the first priority should be to exclude rupture rather than pursue these less serious conditions. Misdiagnoses resulting from similarities between ruptured AAA and other conditions have been documented (19, 29).

Diagnosis... Most AAAs are diagnosed as an incidental finding during a physical examination. The most important factor in successfully diagnosing ruptured AAA is remembering to think of it in a person with new abdominal or flank pain. Although ultrasonography is an excellent test for unruptured AAA, making a definite diagnosis of ruptured AAA requires showing blood in the retroperitoneum or abdomen, which requires CT or MRI.

CLINICAL BOTTOM LINE

What lifestyle modifications should clinicians recommend to patients with AAA?

Smokers with AAA should receive assistance with smoking cessation, which could help prevent disease progression. Data from the UK Small Aneurysm Trial group demonstrate that, compared with former smokers, AAA enlarged more rapidly in current smokers (30) and was more likely to rupture (9, 31).

What is the role of drug therapy in the management of patients with asymptomatic AAA?

Medical treatment to reduce the rate of enlargement of small AAAs is an area of active research, but no treatments have been proven effective. Targets of therapy include several purported pathophysiologic mechanisms, including hemodynamics, inflammation, and protease activity. Doxycycline, statins, and angiotensin-converting enzyme inhibitors have shown promising results, but all remain unproven and are not recommended outside of randomized trials.

Antihypertensive Agents

In the only large trials (32, 33), the β-blocker propranolol did not slow the rate of AAA enlargement. However, increased mean blood pressure is associated with increased risk for AAA rupture (9), so AAA is yet another reason to treat hypertension, which should be managed with the usual therapy.

Antibiotics

Interest in antibiotic therapy is based on evidence of chronic inflammation in AAA, inhibition of proteases and of inflammation by some antibiotics, and possible involvement of *Chlamydia pneumoniae* in the pathogenesis of AAA. Two small randomized trials have reported reduced rates of AAA enlargement in the months following a course of antibiotics, but substantial losses to follow-up in one (34) and baseline differences in the other (35) render the findings inconclusive and preliminary. Antibiotics have many adverse effects, and the benefits in patients with AAA remain uncertain. In large trials, antibiotics intended to prevent hypothesized effects of chlamydia infection on progression of atherosclerosis did not reduce cardiovascular events (36, 37). In addition, long-term use of antibiotics has been associated with an increased risk for breast cancer (38). With uncertain benefits and some known harms, the role of antibiotics in the long-term management of AAA is as yet undetermined.

When should clinicians recommend surgery in patients with asymptomatic AAA?

Elective AAA repair is indicated when the risk for rupture is high enough to balance the risks of surgery. The strongest known predictor of AAA rupture is its maximal external diameter, which is the principal objective criterion for offering elective repair. The rate of enlargement seems as if it should predict rupture, but current evidence provides no support for using this measure. Therefore, the widely used rule is to consider AAA patients for repair only when the AAA exceeds 5.5 cm in diameter.

The United Kingdom Small Aneurysm Trial (UKSAT) (4, 39) and the Aneurysm Detection and Management (ADAM) trial (5) randomly assigned 1090 and 1136 patients, respectively, with AAA 4.0 to 5.4 cm in diameter to immediate elective open repair or periodic imaging surveillance leading to repair when an AAA enlarged beyond 5.5 cm or became symptomatic. The primary outcome, all-cause mortality, was the same in the 2 intervention groups in both trials, as was quality of life, suggesting

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that elective repair of AAA smaller than 5.5 cm did not change health outcomes. Because of these influential trials, elective repair is usually reserved for AAA larger than 5.5 cm.

Do the outcomes of endovascular and open AAA repair differ?

Open surgery is the traditional method of AAA repair. The aorta is exposed and cross-clamped, the aneurysm is opened, lumbar and other tributary arteries are tied off to control back bleeding, a synthetic graft is sewn into place under direct vision, and the aorta is then closed around the graft. Elective open repair is associated with an operative mortality rate of 2% to 5%, considerable morbidity, and a long convalescence (Table 4).

In the National Inpatient Sample, 220 403 hospital discharges in the United States from 2001 to 2004 were for AAA. A total of 45 000 repairs of intact AAA were performed per year, with an in-hospital mortality rate of 4.5% for open repair and 1.0% for endovascular repair. Of the 10 000 patients hospitalized for ruptured AAA each year, 68% had surgery, with a mortality rate of 37.3%. Women had a substantially higher mortality rate than men (2).

Endovascular repair involves introducing an expandable graft system through the femoral or iliac arteries into the aneurysmal region of the aorta and iliac arteries. When the graft is in place, the AAA, which remains intact, is not exposed to arterial pressure, which should prevent it from growing and rupturing. Endovascular repair requires a segment of normal aorta below the renal arteries and also requires iliac arteries that are free of excessive plaque or tortuosity. These requirements exclude about one third of patients.

The advantages of endovascular repair compared with open repair are reduced operative morbidity and shorter initial hospital stay and overall recovery time. However, many studies have found that endovascular repair is more expensive than open repair, due primarily to the high price of the grafts. In randomized trials, endovascular repair of AAA has lower perioperative mortality than open repair, but mortality rates after 2 years are similar (40, 41).

What criteria identify patients who are candidates for endovascular versus open aneurysm repair?

The long-term results of endovascular repair are unknown, although the randomized trials are continuing to monitor outcomes. Because of the uncertainty about long-term results, many physicians recommend open repair in younger patients.

Table 4. Elective Endovascular Versus Open AAA Repair

Variable	*Open Repair*	*Endovascular Repair*
Cost	High	Higher
Proportion of patients that can't undergo procedure	10%–20%	33%
Perioperative mortality rate	2%–5%	0%–2%
Postoperative complications	Relatively low (8%)	High (35%)
Perioperative morbidity	High	Low
Outcomes	Initially worse but equivalent after 2 years	Initially better but equivalent after 2 years
Certainty of very long-term outcomes	Well documented	Not known
4-year reintervention rates*	6%	20%

AAA = abdominal aortic aneurysm.
** Ratzan RM, Donaldson MC, Foster JH, Walzak MP. The blue scrotum sign of Bryant: a diagnostic clue to ruptured abdominal aortic aneurysm. J Emerg Med. 1987;5:323-9. [PMID: 3624839]*

40. EVAR trial participants. Endovascular aneurysm repair versus open repair in patients with abdominal aortic aneurysm (EVAR trial 1): randomised controlled trial. Lancet. 2005;365:2179-86. [PMID: 15978925]
41. Dutch Randomized Endovascular Aneurysm Management (DREAM) Trial Group. Two-year outcomes after conventional or endovascular repair of abdominal aortic aneurysms. N Engl J Med. 2005;352:2398-405. [PMID: 15944424]
42. EVAR trial participants. Endovascular aneurysm repair and outcome in patients unfit for open repair of abdominal aortic aneurysm (EVAR trial 2): randomised controlled trial. Lancet. 2005;365:2187-92. [PMID: 15978926]

The United Kingdom Endovascular Aneurysm Repair trial 1 (EVAR-1) randomly assigned 1082 patients with AAA 5.5 cm or greater to either open or endovascular repair. Postoperative mortality rate (30-day or inpatient) was significantly lower in the endovascular group, but after a median 2.9 years follow-up, all-cause mortality was the same. Postoperative complications occurred 4 times more frequently after endovascular repair (40).

Because endovascular repair is less invasive, vascular disease specialists thought that high-risk patients would have better outcomes with it. However, 2 randomized trials from the United Kingdom suggest otherwise. In one study (42), endovascular repair conferred no all-cause mortality advantage over open repair in the least fit randomized subgroup at 4 years. In the other (43), endovascular repair was not beneficial in patients considered unfit for open repair.

The United Kingdom Endovascular Aneurysm Repair trial 2 (EVAR-2) randomly assigned 338 patients unfit for open repair with AAA 5.5 cm or greater to have endovascular repair or observation. All-cause mortality (the primary outcome) and AAA-related mortality were the same in the 2 groups. Ruptures before delayed repair, high operative mortality, and high cross-over rates led to questions about the validity of the findings, but it is the only randomized trial in this patient population (42).

When should clinicians hospitalize patients with AAA?

Clinicians should hospitalize patients for elective aneurysm repair when the diameter of the AAA reaches 5.5 cm. Elective open or endovascular AAA surgery at a high-volume hospital (at least 30 cases per year) is associated with lower operative mortality (44, 45).

Hospitalize patients with suspected AAA rupture immediately for emergency diagnostic testing and possible AAA repair, also preferably in a high-volume hospital (44).

How should clinicians manage patients with suspected ruptured AAA?

If the patient has abdominal pain and shock, surgical consultation should be obtained urgently to decide whether to take the patient directly to the operating room and perform ultrasonography while resuscitation procedures are underway. If an imaging test shows AAA rupture, surgical consultation should be obtained immediately to decide whether to take the patient directly to the operating room. Emergency repair is the patient's only chance for survival, according to case series that show that unrepaired AAA rupture is almost always fatal. Case series have shown a possible survival advantage for endovascular compared with open repair for ruptured AAA, but observational studies of treatments are often unreliable because of confounding by indication and other selection biases. Researchers in the United Kingdom are beginning a randomized trial comparing open with endovascular repair for ruptured AAA.

The syndrome of symptomatic unruptured AAA requires physicians to make a very difficult decision. They should consider this syndrome when the patient has an AAA and abdominal, flank, or back pain but imaging does not demonstrate rupture. The problem is whether to proceed with immediate surgery. Symptoms, the diameter of the AAA, other imaging findings, and the general health of the patient are the main factors to take into account.

43. Brown LC, Greenhalgh RM, Howell S, et al. Patient fitness and survival after abdominal aortic aneurysm repair in patients from the UK EVAR trials. Br J Surg. 2007;94:709-16. [PMID: 17514695]
44. Killeen SD, Andrews EJ, Redmond HP, et al. Provider volume and outcomes for abdominal aortic aneurysm repair, carotid endarterectomy, and lower extremity revascularization procedures. J Vasc Surg. 2007;45:615-26. [PMID: 17321352]
45. Dimick JB, Upchurch GR Jr. Endovascular technology, hospital volume, and mortality with abdominal aortic aneurysm surgery. J Vasc Surg. 2008;47:1150-4. [PMID: 18440178]

When should clinicians consult specialists in managing patients with AAA?

Obtain vascular surgery consultation for asymptomatic AAA 5.5 cm or greater in outside diameter for patients who are possible candidates for repair and for patients with AAA who develop symptoms consistent with rupture.

Cardiology consultation may be helpful before elective AAA repair for advice on whether to do noninvasive testing or coronary angiography in patients with coronary artery disease, diabetes, renal insufficiency, or poor functional status. Algorithms established by the American College of Cardiology/American Heart Association for evaluation before AAA repair identify patients at increased risk for cardiac death following aortic surgery (46, 47). However, in a randomized trial, coronary revascularization before surgery did not improve the perioperative myocardial infarction rate or long-term mortality (48).

The Coronary Artery Revascularization Prophylaxis (CARP) trial randomized 510 patients who were having elective open abdominal surgery for AAA or arterial occlusive disease and who had a coronary stenosis of at least 70% to preoperative coronary revascularization or no revascularization (48). Patients were excluded if they had unstable angina, more than 50% left main disease, ejection fraction less than 20%, or severe aortic stenosis. Revascularization did not improve 30-day operative mortality, myocardial infarction, or long-term mortality rates (mean follow-up, 2.7 years). The findings suggest that cardiac intervention is unnecessary for most patients having elective AAA repair.

How should clinicians monitor patients with an asymptomatic AAA that does not meet the criteria for intervention?

Table 5 lists elements of follow-up for AAA. In patients whose AAA is below the threshold for elective repair, ultrasonography

Table 5. Elements of Follow-up for Abdominal Aortic Aneurysm

Category	*Issue*	*Method of Follow-up*	*Frequency*	*Notes*
History	Development of symptoms	Ask about abdominal, flank, or back pain	As soon as they occur and at each visit	
Physical examination	Enlargement of AAA	Abdominal examination	Each visit	Optional, does not replace ultrasonography
Laboratory testing	Enlargement of unrepaired AAA	AAA diameter by ultrasonography	Every 6 to 12 months, depending on AAA diameter	
Laboratory testing	Status of endovascular graft	Computed tomography	Annually after first year	
Nondrug therapy	Need for surgery	Determine if size of AAA is >5.5 cm; ask about symptoms	Each visit	
Drug therapy	Treatment of concurrent medical problems, such as hypertension	Antihypertensives	Ongoing	Treatment of hypertension of undetermined value for preventing rupture
Patient education	Symptom recognition in patients with AAA under observation	Ask patients to report abdominal, flank, or back pain	Each visit	

AAA = abdominal aortic aneurysm.

46. American College of Cardiology. ACC/AHA guideline update for perioperative cardiovascular evaluation for noncardiac surgery—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1996 Guidelines on Perioperative Cardiovascular Evaluation for Noncardiac Surgery). J Am Coll Cardiol. 2002;39:542-53. [PMID: 11823097]
47. Samain E, Farah E, Lesèche G, et al. Guidelines for perioperative cardiac evaluation from the American College of Cardiology/American Heart Association task force are effective for stratifying cardiac risk before aortic surgery. J Vasc Surg. 2000;31:971-9. [PMID: 10805888]
48. McFalls EO, Ward HB, Moritz TE, et al. Coronary-artery revascularization before elective major vascular surgery. N Engl J Med. 2004;351:2795-804. [PMID: 15625331]

imaging surveillance to assess aneurysm diameter is recommended every 6 to 12 months if the AAA diameter is 4.0 to 5.4 cm and every 2 to 3 years if it is less than 4.0 cm (49).

As noted previously, a large randomized trial (5) showed that imaging at intervals of 6 months was equivalent to a strategy of immediate repair of AAAs measuring 4.0 to 5.4 cm. Observational studies that monitored enlargement rates suggest that surveillance intervals of up to 3 years are safe for smaller AAAs (6, 50, 51). In deciding when to recommend repair, physicians should remember that errors of up to 0.5 cm in measuring the diameter of an AAA are common with abdominal ultrasonography or CT (21).

How should clinicians monitor patients after aortic aneurysm repair?

The monitoring strategy depends on the method of AAA repair. After open repair, the graft failure rate is very low (about 0.3% per year), and no specific follow-up is recommended (5, 52, 53). Endovascular repair is associated with more late graft problems (for example, endoleaks, graft migration or kinking, continued AAA enlargement) and resulting reinterventions. In the EVAR-1 trial (40), 20% of patients randomly assigned to endovascular repair required reintervention within 4 years compared with 6% of those randomly assigned to open repair. Current practice, which is derived from the device approval trials but not based on comparative trials, is to perform CT at 1, 6, and 12 months after endovascular repair and then annually for the rest of the patient's life. This strategy is a considerable burden for both patients and vascular surgeons; is expensive; and results in substantial radiation exposure, especially with the commonly used triphasic CT protocol. Alternative follow-up methods are under active investigation.

Treatment... Elective repair of AAA is indicated when the external diameter reaches 5.5 cm. Below that size, randomized trials show that repair does not improve outcomes. Smoking cessation treatment and control of high blood pressure are indicated. Surveillance abdominal ultrasonography is indicated for aneurysms smaller than 5.5 cm, with more frequent surveillance as the diameter approaches 5.5 cm. The choice between open elective repair and endovascular repair is difficult. Endovascular repair has less mortality and morbidity in the perioperative period but all-cause mortality and other outcomes are equivalent by 2 years, and the very long-term outcomes of endovascular repair are unknown. The treatment for ruptured AAA is immediate repair, either open or endovascular.

CLINICAL BOTTOM LINE

49. American Association for Vascular Surgery. ACC/AHA 2005 guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): executive summary a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease) endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. J Am Coll Cardiol. 2006;47:1239-312. [PMID: 16545667]

50. Grimshaw GM, Thompson JM, Hamer JD. A statistical analysis of the growth of small abdominal aortic aneurysms. Eur J Vasc Surg. 1994;8:741-6. [PMID: 7828753]

51. McCarthy RJ, Shaw E, Whyman MR, et al. Recommendations for screening intervals for small aortic aneurysms. Br J Surg. 2003;90:821-6. [PMID: 12854107]

52. Hallett JW Jr, Marshall DM, Petterson TM, et al. Graft-related complications after abdominal aortic aneurysm repair: reassurance from a 36-year population-based experience. J Vasc Surg. 1997;25:277-84; discussion 285-6. [PMID: 9052562]

What do professional organizations recommend about the care of patients with AAA?

The U.S. Preventive Services Task Force (USPSTF) recommends one-time screening for AAA with ultrasonography in men age 65 to 75 years who have ever smoked (11). It does not recommend for or against screening in 65- to 75-year-old men who have never smoked. The USPSTF recommends against routine screening in women.

The Joint Council (54) recommended 5.5-cm diameter as the appropriate threshold for elective repair in most patients, on the basis of the finding of 2 randomized trials (4, 5, 39) that patients did not benefit from repairing AAA less than 5.5 cm in diameter. However, the Council also recommended repair of smaller AAA in various patient groups, including women, younger patients, and patients of surgeons whose operative mortality rate is low. The last recommendation is based on weak evidence (observational studies) and personal opinion and conflicts with randomized trial evidence that repair of small aneurysms confers no benefit.

The American College of Cardiology and the American Heart Association's peripheral arterial disease guideline (49) contains a number of well-supported recommendations about AAA, including one-time ultrasonography screening in men age 65 to 75 years old who have ever smoked or have a first-degree relative with AAA; advice to stop smoking; open or endovascular repair of AAA 5.5 cm or larger in diameter; imaging surveillance of AAA 4.0 to 5.4 cm at 6- to 12-month intervals and 2- to 3-year intervals for AAA less than 4.0 cm; and immediate evaluation and repair of ruptured AAA. However, the guideline contains several recommendations that conflict with randomized trial findings, including long-term β-blockade to slow the rate of AAA enlargement. The guideline also states that "Repair can be beneficial in patients with infrarenal or juxtarenal AAAs 5.0 to 5.4 cm in diameter," an opinion that prompted a letter of dissent from the directors of the 2 randomized trials (55).

How should clinicians educate patients with AAA?

Patients with AAA should know about the course, management, and prognosis of AAA and important self-management issues, including the importance of smoking cessation, the need to report symptoms immediately, the scheduling of regular follow-up visits for surveillance before repair and after endovascular repair, and the available surgical options. Physicians have a responsibility to provide them with this information.

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54. Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery. Guidelines for the treatment of abdominal aortic aneurysms. Report of a subcommittee of the Joint Council of the American Association for Vascular Surgery and Society for Vascular Surgery. J Vasc Surg. 2003;37:1106-17. [PMID: 12756363]
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in the clinic
Tool Kit
Abdominal Aortic Aneurysm

PIER Modules
www.pier.acponline.org
Access the following PIER module: Abdominal aortic aneurysm. PIER modules provide evidence-based, updated information on current diagnosis, treatment, and management, in an electronic format designed for rapid access at the point of care.

Patient Education Resources
www.annals.org/intheclinic/AAA.html
Access the Patient Information material on the following page for duplication and distribution to patients.
www.medicinenet.com/abdominal_aortic_aneurysm
Abdominal Aortic Aneurysm index from Medicinenet.com

Clinical Guidelines
www.annals.org/cgi/reprint/142/3/198.pdf
U.S. Preventive Services Task Force on screening for AAA

Quality Measures for AAA
qualityindicators.ahrq.gov/downloads/iqi/iqi_guide_v31.pdf
Guide to Inpatient Quality Indicators, from the Agency for Healthcare Research and Quality (AAA is discussed on pp. 25, 26, 39, and 40)
www.qualitymeasures.ahrq.gov/summary/summary.aspx?doc_id=12739
Abdominal aortic aneurysm repair, from the National Quality Measures Clearinghouse

in the clinic

WHAT YOU SHOULD KNOW ABOUT ABDOMINAL AORTIC ANEURYSM

In the Clinic
Annals of Internal Medicine
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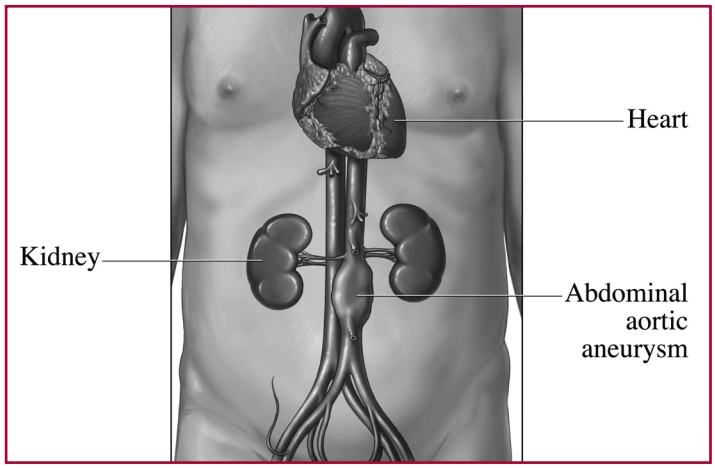
What is an abdominal aortic aneurysm?

Blood moves from the heart to other parts of the body through arteries. The abdominal aorta is the main artery in the belly, which is also called the abdomen. An abdominal aortic aneurysm (AAA) occurs when the wall of the aorta gets too big. This is caused by a weakening of the wall of the aorta. If the enlarged aorta breaks, blood can then leak into the body.



Is AAA a big problem?

Yes. It is the 14th most common cause of death in the United States. In older men, it is the 10th most common cause of death.

What are the symptoms of AAA?

There are no symptoms of AAA until it breaks. If blood does leak out, there may be pain in the back or belly, weakness, or fainting.

How is AAA found?

The doctor may feel the AAA when pressing on the belly. The best way to find AAA is by doing a test called an ultrasonography of the abdomen.

Who should have a screening test for AAA?

A screening test is done to look for a disease when there are no symptoms. Experts recommend that older men who smoke should have a screening test for AAA. Experts do not recommend a screening test for other people.

Who is most likely to have an AAA?

Cigarette smoking makes the chances of having an AAA greater than anything else. Being older, of white race, male, and a smoker all add to the risk for having an AAA.

If screening finds AAA, what should be done?

The greatest chance that the AAA could break is if it is larger than 2 in (5.5 cm). If it is smaller than 2 in, the doctor will do an ultrasonography test, tell the patient to stop smoking, and treat the patient's high blood pressure. If the AAA is 2 in or more, doctors usually do surgery to fix it.

For More Information

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Web Sites With Information on Abdominal Aortic Aneurysm:

www.medem.com/medlib/article/ZZZVTBUUBZE
JAMA Patient Page: Aortic Aneurysms

www.medicinenet.com/abdominal_aortic_aneurysm
Abdominal Aortic Aneurysm index from Medicinenet.com

Patient Information

CME Questions

MKSAP
MEDICAL KNOWLEDGE Self-Assessment Program

1. A 75-year-old asymptomatic man undergoes his annual examination. He is obese and has a long history of smoking, hypertension, and chronic kidney disease (creatinine level, 2.7 mg/dL [238.73 μmol/L]). His medications are furosemide, ramipril, atorvastatin, and aspirin.

   On physical examination, the blood pressure is 170/78 mm Hg bilaterally, and pulse rate is 70/min and regular. There is a 2/6 holosystolic murmur heard at the apex with radiation to the axilla. There is a soft systolic abdominal bruit and a mildly tender midline pulsatile mass. There are bilateral femoral bruits with absent distal pulses. Laboratory studies show a total cholesterol level of 200 mg/dL (5.17 mmol/L), HDL cholesterol level of 32 mg/dL (0.83 mmol/L), and LDL cholesterol level of 132 mg/dL (3.41 mmol/L). The patient is encouraged to stop smoking.

   In addition to increasing the antihypertensive medications, what is the most appropriate next step in this patient's management?

   A. Abdominal radiograph
   B. Abdominal computed tomography scan with contrast
   C. Abdominal ultrasound
   D. Contrast aortography

2. A 74-year-old woman undergoes a routine evaluation. She is a smoker and has hypertension, hypercholesterolemia, and type 2 diabetes mellitus. Last year, she had an asymptomatic 4.4-cm infrarenal abdominal aortic aneurysm diagnosed during an ultrasonography for suspected gallstones, at which time she was encouraged to stop smoking. She is petite, active, asymptomatic, and compliant with her medications, which include atenolol, glyburide, metformin, lisinopril, and aspirin.

   On physical examination, the blood pressure is 125/78 mm Hg, and the pulse rate is 70/min and regular. The lungs are clear; cardiac examination shows an S4, and abdominal examination shows a nontender abdomen with a pulsatile mass. A follow-up ultrasonography shows a 5.1-cm aneurysm with thrombus. The patient is again encouraged to stop smoking.

   What is the most appropriate next step in this patient's management?

   A. Repeat ultrasonography in 6 months
   B. Increase atenolol, repeat ultrasonography in 6 months
   C. Elective aneurysm repair
   D. Start warfarin (international normalized ration, 2–3), repeat ultrasonography in 6 months

3. A 67-year-old woman comes to your office because of intermittent lower back pain of 4 days' duration. The pain is dull, nonradiating, and nonpositional, and is unrelated to meals or exertion. She has no dyspnea, chest pain, or dysuria, and no history of trauma. She has a history of hypercholesterolemia and underwent a cholecystectomy at age 45 years. She also has a history of recurrent urinary tract infections. She stopped smoking 10 years ago. Her only medication is simvastatin, 20 mg every night orally.

   On physical examination, blood pressure is 145/85 mm Hg and heart rate is 86 beats/min and regular. The patient is afebrile. Jugular venous pressure is normal. Carotid pulses are 2+ bilaterally, without bruits. Cardiac examination shows S4; the findings are otherwise normal. The lungs are clear to auscultation. Abdominal examination shows a midline pulsatile mass. No spinal or costovertebral angle tenderness is noted. Distal pulses are normal.

   Laboratory findings include hematocrit of 36%, leukocyte count of 9.5×10^9 cells/L, platelet count of 290×10^9 cells/L, and serum creatinine level of 1.5 mg/dL (114.38 μmol/L). Results of urinalysis are normal. The LDL cholesterol level is 115 mg/dL (2.98 mmol/L). Abdominal ultrasound shows a 4.8-cm abdominal aortic aneurysm that originates from the celiac trunk and extends below the renal arteries.

   Which of the following is the most appropriate next step?

   A. Initiate treatment with metoprolol, 25 mg twice a day orally, and schedule a follow-up visit with ultrasonography in 6 months.
   B. Increase the dose of simvastatin to 40 mg/d and schedule a follow-up visit with ultrasonography in 3 months.
   C. Hospitalize the patient, order a high-resolution computed tomography scan, and obtain a vascular surgery consultation.
   D. Hospitalize the patient; initiate treatment with metoprolol, 25 mg twice a day; and refer the patient to a vascular surgeon.
   E. Initiate treatment with metoprolol, 25 mg twice a day orally, and order magnetic resonance imaging of the spine.

4. A 72-year-old man is evaluated during a routine examination. He has a 45-pack-year history of smoking but quit smoking 10 years ago. He is fit and exercises aggressively. He has no known coronary artery disease and no medical problems.

   On physical examination, BMI is 26.4 kg/m^2. Pulse rate is 62/min, and blood pressure is 118/64 mm Hg. Serum total cholesterol level is 175 mg/dL (4.53 mmol/L), serum high-density lipoprotein cholesterol level is 52 mg/dL (1.34 mmol/L), serum low-density lipoprotein cholesterol level is 102 mg/dL (2.64 mmol/L), serum triglyceride level is 105 mg/dL (1.19 mmol/L).

   Which of the following is most appropriate next step in the management of this patient?

   A. Electron-beam computed tomography for calcium score
   B. Carotid artery ultrasonography
   C. Ultrasound to evaluate for abdominal aortic aneurysm
   D. Statin therapy

Questions are largely from the ACP's Medical Knowledge Self-Assessment Program (MKSAP). Go to www.annals.org/intheclinic/ to obtain up to 1.5 CME credits, to view explanations for correct answers, or to purchase the complete MKSAP program.