CLINICAL FEATURES AND DIAGNOSIS OF THORACIC AORTIC ANEURYSM

An aneurysm is currently defined as a localized dilatation of the aorta, 50 percent over the normal diameter, which includes all three layers of the vessel, intima, media, and adventitia.

CLASSIFICATION —
- Fusiform
- Saccular
- Pseudoaneurysm

Ascending aortic aneurysms arise anywhere from the aortic valve to the innominate artery — 60 percent.

Aortic arch aneurysms include any thoracic aneurysm that involves the brachiocephalic vessels — 10 percent.

Descending aortic aneurysms distal to the left subclavian artery — 40 percent.

Thoracoabdominal aneurysms — 10 percent.

Thoracoabdominal aneurysms are further divided according to the Crawford classification:
I. Proximal descending thoracic to proximal abdominal aorta
II. Proximal descending to infrarenal aorta
III. Distal descending with abdominal aorta
IV. Primarily abdominal aorta

EPIDEMIOLOGY — TAAA (Thoracic aneurysm).
- Common in sixth and seventh decade
- Males are affected approximately two to four times more commonly than females.
- Hypertension present in over 60 percent of patients
- Up to 13 percent of patients have multiple aneurysms; 20 to 25 percent of patients with a large thoracic aortic aneurysm also have an abdominal aortic aneurysm

ETIOLOGY AND PATHOGENESIS —
- Thoracic aortic aneurysms most often result from cystic medial degeneration that leads to weakening of the aortic wall. Cystic medial degeneration occurs normally with aging and is increased with hypertension.
  - Association with atherosclerosis.
  - Aortic dissection.
  - Genetic factors: Marfan or Ehlers-Danlos syndromes.
  - Other: 19 percent of patients with a thoracic aortic aneurysm/dissection have a family history of this disorder independent of those with Marfan or Ehlers-Danlos syndrome.
  - Bicuspid aortic valve and aortic coarctation.
  - Inflammatory/infectious disorders: giant cell arteritis, syphilitic aortitis, mycotic aneurysm often due to bacterial endocarditis, Takayasu arteritis, rheumatoid arthritis, psoriatic arthritis, ankylosing spondylitis, reactive arthritis, Wegener’s granulomatosis, and reactive arthritis.

DIAGNOSIS —
- Chest x-ray — The aneurysm produces a widening of the mediastinal silhouette, enlargement of the aortic knob, or displacement of the trachea from midline.
- Echocardiography — Transthoracic echocardiography, transesophageal echocardiography.
- CT and MRI — preferred tests to detect a thoracic aortic aneurysm, determine its size, and define aortic and branch vessel anatomy. MRI is preferred for aneurysms involving the aortic root.

NATURAL HISTORY — Although natural history data are not widely available, it has been suggested that patients with untreated large ascending or descending thoracic aneurysms are more likely to die of complications associated with their aneurysms than from any other cause. The one, three, and five year survival of unoperated thoracic aneurysms was 65, 36, and 20 percent, respectively.

The most important determinant of rupture is the size of the aneurysm the five year risk of rupture was 0 percent for aneurysms
less than 40 mm compared to 16 and 31 percent for aneurysms 40 to 59 and ≥ 60 mm, respectively. A diameter greater than 60 mm increased the risk of rupture or dissection by 25 percent for an ascending aneurysm, while a diameter greater than 70 mm increased the risk by 37 percent in a descending aneurysm. Aneurysms appear to rupture at smaller sizes in patients with Marfan syndrome or other connective tissue disorders. Among patients with aneurysms ≥ 60 mm, the combined end point of rupture, dissection, or death occurred at a rate of 15.6 percent per year. However, most patients who present with dissection have smaller aneurysms because there are many more individuals in the population with thoracic aortic aneurysm diameters between 40 to 55 mm.

Aneurysm diameter increases by 1 to 10 mm per year. The rate of growth is related to the initial diameter with larger aneurysms growing more quickly. Aneurysms located within the mid portion of the descending aorta showed the most rapid growth, while those in the ascending aorta had the slowest expansion rate, despite having the greatest initial diameter.

MANAGEMENT AND OUTCOME OF THORACIC AORTIC ANEURYSM: MEDICAL MANAGEMENT OF ASYMPTOMATIC ANEURYSMS —

Asymptomatic aneurysms are detected on routine chest x-ray or during surveillance in a patient at risk from an underlying disorder such as Marfan syndrome or giant cell arteritis. Asymptomatic patients with an aneurysm are initially managed medically, while surgery is indicated for symptomatic patients and for asymptomatic patients with rapid aneurysm expansion or a diameter greater than 50 to 60 mm in diameter, depending on body size, cause of aortic dilation and other clinical factors.

For smaller patients, including many women, we recommend elective repair for aneurysms greater than twice the size of the non-aneurysmal aorta (normal segment) or for those with rapid expansion, defined as growth of more than 0.5 cm during a six month interval.

In the asymptomatic patient, medical management includes:

• Aggressive blood pressure control, with beta blockers being part of the regimen in an attempt to slow aneurysm growth.
• Surveillance for the development of signs and symptoms that may be associated with the aneurysm through patient education
• Serial imaging of the aneurysm to evaluate growth and structure. The preferred imaging technique is CT scanning or MR angiography. Imaging should be repeated at six months after the initial study. Further imaging can be performed at yearly intervals if there is no growth or at three to six months (according to aneurysm size) if there is a significant increase in aneurysm size from one study to another. Ideally, the serial studies should be performed with the same technique in the same center.

In a study in which 70 patients with Marfan syndrome were randomly assigned to propranolol or no beta blocker therapy, the treated group had a 73 percent slower rate of aortic dilatation and a lower mortality after the first four years of follow-up.

SURGICAL THERAPY — Surgical therapy is often recommended prophylactically to prevent the morbidity and mortality associated with aneurysm rupture. However, the optimal timing of surgery for a thoracic aortic aneurysm is uncertain since the natural history is variable, particularly for aneurysms less than 50 mm in size, and the majority of patients have concomitant cardiovascular disease that increases the risks associated with surgery. Thus, many patients die of other cardiovascular causes before the aneurysm ruptures.

Indications —

• The presence of symptoms, although most thoracic aortic aneurysms are asymptomatic.
• An end-diastolic aortic diameter of 50 to 60 mm for an ascending aortic aneurysm and 60 to 70 mm for a descending aortic aneurysm; often ≥ 70 mm in high risk patients.
• Replacement before aortic size index (aortic diameter (cm) divided by body surface area (m2)) for the ascending aorta is 2.75 cm/m2.
• Accelerated growth rate (≥ 10 mm per year) in aneurysms less than 50 mm in diameter.
• Evidence of dissection.
• An aortic aneurysm >45 mm in diameter at the time of aortic valve surgery.
• In patients with aortic regurgitation of any severity and primary disease of the aortic root or ascending aorta (such as Marfan syndrome), the 2006 ACC/AHA valvular disease guidelines recommend aortic valve replacement and aortic root reconstruction when the degree of dilatation is ≥ 50 mm.

Preoperative evaluation —

• Preoperative assessment should include evaluation of left ventricular function and potential concomitant coronary artery disease.
• Patients with ascending aortic and particularly arch disease should undergo carotid artery duplex ultrasound examination.
• Patients with descending thoracic aortic disease require left thoracotomy and should undergo pulmonary function testing if clinical symptoms of pulmonary disease are present.
• Patients with thoracoabdominal aneurysm extension require delineation of any claudication history and a thorough arterial pulse examination. If the history or physical findings suggest peripheral arterial disease (PAD), then noninvasive lower extremity pulse-volume recordings and pressures are
indicated to determine the level and severity of disease.

**Surgical technique** — The location of the surgical incision depends upon the location of the aneurysm. The standard incision for ascending and arch aneurysm repair is a median sternotomy. The standard incision for descending aneurysms is a left thoracotomy. For thoracoabdominal aneurysms, a left thoracotomy incision is extended across the costal margin for a retroperitoneal approach.

Operative repair of thoracic aneurysms resembles standard abdominal aortic aneurysm repair with proximal and distal vascular control, minimal aneurysm manipulation, and prosthetic graft repair. The most common technique of aneurysm repair entails Dacron graft interposition. End-organ revascularization is achieved with the distal anastomosis, native arterial reimplantation with or without endarterectomy, or bypass grafting with saphenous venous or prosthetic conduit.

Aortic root involvement generally necessitates coronary artery reimplantation and may or may not require aortic valve replacement or repair.

**Vascular control** —

- In ascending aneurysm repair, protection against end-organ damage is accomplished with cardiopulmonary bypass and antegrade aortic perfusion distal to the aneurysm.

- In arch aneurysm repair, the need for open vascular access to the brachiocephalic orifices mandates interruption of cerebral blood flow and the need for cerebral protection.

- In descending aortic aneurysm repair, the utility of adjunctive end-organ protective measures is unclear. The degree of risk for this patient was illustrated in a series of over 1500 patients: paraparesis or paraplegia developed in 16 percent, while acute renal failure severe enough to require dialysis occurred in 7 percent.

**Cerebral protection** —

- With selective cerebral perfusion (SCP).

- Hypothermic circulatory arrest (HCA) involves the use of cardiopulmonary bypass with the establishment of profound systemic hypothermia.

- Retrograde cerebral perfusion (RCP) in which hypothermic circulatory arrest is used in conjunction with retrograde jugular venous perfusion with cold oxygenated blood.

**Surgical outcome** — Morbidity and mortality in thoracic aneurysm repair are higher than most elective surgical procedures given the anatomic constraints and operative complexity. The subsets of aortic arch and Crawford type II (proximal descending to infrarenal aorta) aneurysms have the highest morbidity and mortality rates.

In studies documenting outcomes in procedures performed through the mid-1990s, it was not unusual to see overall thirty day postoperative mortality rates exceeding 10 percent, stroke rates of 20 percent with ascending and arch aneurysm repair, and spinal and renal injury rates of 15 percent with repair of a descending aneurysm. In one series of 1509 patients who underwent descending aneurysm repair, the overall mortality was 8 percent at 30 days and paraparesis or paraplegia developed in 16 percent. In another report from the same group, the incidence of postoperative acute renal failure severe enough to require dialysis was 7 percent. The long-term mortality and morbidity were related to other cardiovascular events, such as aneurysm in other areas, MI, and stroke.

The risk of morbidity and mortality has decreased significantly in more recent series, perhaps attributable to improving technology and increased use of the end-organ protective adjuncts described above.

**Predictors of outcome with thoracoabdominal aneurysm** — In order to establish factors associated with an adverse 30 day outcome (death, paraplegia, paraparesis, stroke, or acute renal failure requiring dialysis) after surgery for a thoracoabdominal aneurysm, one study retrospectively reviewed data on 1108 patients undergoing elective surgery. The main adverse predictors included preoperative renal insufficiency, increasing age, symptomatic aneurysms, and Crawford type II aneurysms (proximal descending to infrarenal aorta).

**Emergency surgery** — Emergency surgery for thoracoabdominal aneurysm that has ruptured or dissected is associated with a substantial morbidity and mortality. In one series of 19 patients, for example, the 30 day mortality was 42 percent; there were serious postoperative complications in the surviving patients, including renal failure (36 percent of surviving patients), respiratory failure (36 percent), and paraplegia or paraparesis (27 percent).

**THORACIC ENDOVASCULAR AORTIC REPAIR.**

Thoracic endovascular aortic repair (TEVAR) refers to the percutaneous placement of a stent graft in the descending thoracic or thoracoabdominal aorta to improve long-term survival in patients with aortic aneurysms.

Potential benefits of TEVAR relative to OS include avoidance of long incisions in the thorax or abdomen, no cross-clamping of the aorta, less blood loss, lower incidence of visceral, renal, and spinal chord ischemia (SCI), fewer episodes of respiratory dependency, and quicker recovery.

**INDICATIONS FOR TEVAR** — The indications for TEVAR of the descending aorta are similar to those for surgical repair and include width >6 cm, rapidly enlarging diameter (>5 mm of growth over six months), symptoms such as chest pain, and diagnosis of aortic rupture or dissection.

**PREOPERATIVE PLANNING** — Computed tomography angiography (CTA) of the chest, abdomen and pelvis with 3-D reformating is performed preoperatively.

**CONDUCT OF THE OPERATION** — The procedure is typically done under general endotracheal anesthesia. A lumbar
Management of Aortic Aneurysms

A drain is placed in the L3-L4 disc space for drainage of cerebrospinal fluid (CSF) in cases where extensive coverage of the thoracic aorta is anticipated, where interruption of contributing blood supply to the artery of Adamkiewicz (T8-L1) is high, and in cases where the patient has had prior abdominal aortic aneurysm (AAA) repair.

Performance of the procedure requires the delivery of a large-bore sheath into the aorta as well as angiographic access, transfemorally or via an iliac conduit.

**Anatomic considerations** — At least 20 mm proximal and distal landing zones, maximum diameter of 40 mm with minimal or no thrombus. The curve of the thoracic aorta at the arch presents special challenges in attempting to achieve adequate proximal fixation and seal. Placement of the proximal or distal end of the device may require covering important side branches. “Hybrid” procedures which combine open vascular bypass to important vessels followed by thoracic stent grafting have been developed.

**Endoleak**

- **Type I endoleak** — Involves the proximal or distal seal zones. Further ballooning or placement of another graft may be necessary to achieve seal. Vigorous proximal ballooning may be hazardous; retrograde proximal aortic dissection has been reported.

- **Type II endoleak** — Unusual in the thoracic aorta but due to retrograde flow from intercostal arteries into the sac. Typically resolves with observation.

- **Type III endoleak** — Occurs with inadequate overlap and seal between modular components. Usually responds with further ballooning or additional graft or stent placement.

- **Type IV endoleak** — Occurs due to porosity of the graft, which is a rare occurrence with current generation devices.

- **Type V endoleak** — Otherwise known as “endotension,” occurs in the setting of continued sac expansion despite absence of an identifiable endoleak on subsequent imaging studies.

**Devices** — The Gore-TAG, Medtronic Talent thoracic stent graft system, Cook TX2 stent graft.

**OUTCOMES** — While little comparative data exists between TEVAR and medical management, it is reasonable to assume that outcomes will also be better with TEVAR in those patients with indications for OS, since TEVAR compares favorably with OS.

Combined perioperative outcomes — TEVAR group compared to the OS arm, 9 percent versus 33 percent.

Stroke — TEVAR- 4%-8%.

Spinal cord ischemia — reported to be between 3 to 11 percent, comparable to the rate of OS.

Visceral ischemia — Visceral ischemia can occur with coverage of the celiac axis.

Access complications — iliac artery disruption, need for iliac artery conduit in 9 to 20 percent.

**Postimplantation syndrome** — This syndrome occurs during the early postoperative period and is characterized by leukocytosis, fever, and elevation of inflammatory mediators such as C-reactive protein, IL-6, and TNF-alpha.

**Thirty day mortality** — Perioperative mortality with second generation stent grafts is low, ranging from 1.9 percent to 2.1 percent.

**Short-term** — One year all cause mortality among patients treated for aortic aneurysm and aortic dissection were 20 and 10 percent respectively.

**Device migration and endoleak** — Migration of the graft (>10 mm) caudally can occur, with a published incidence of 1 percent to 2.8 percent over a 6-12 month period. The incidence of endoleak at five-year follow up with the Gore TAG device was 4.3 percent with Type I attachment site leaks being the most common type. Ongoing surveillance for endoleak is necessary and discussed in the next section.

**TEVAR versus open surgery** — The best available evidence comes from a 2008 meta-analysis of 17 observational studies (1109 patients) which compared TEVAR to OS [41]. There was a significant reduction in perioperative mortality (OR 0.36; 95% CI 0.23-0.58) and in major neurological injury (OR 0.39; 95% CI 0.25-0.62). There was no difference in major reintervention rates, but a significant reduction in hospital and critical care stay. The evidence cited above argues for the use of TEVAR as opposed to OS in those patients who are candidates for both approaches. However there are patients who not candidate for TEVAR while others are not candidates for open surgery(OS).

**OTHER POTENTIAL USES OF TEVAR**

Traumatic aortic transection, Type B uncomplicated dissection, Type B complicated dissection, Penetrating aortic ulcer/Intramural hematoma, Thoracoabdominal aneurysms.

**SUMMARY**

TEVAR, in patients with or without involvement of the abdominal aorta, has gained acceptance as a reasonable alternative to OS. While no randomized trial data is available to compare the two strategies, observational data suggests equivalent or better patient important outcomes with TEVAR.

Despite the significant rate of secondary intervention required following stent grafting (3.6 percent to 4.4 percent), the decreased morbidity of this approach makes it preferable to open repair in the majority of cases.
MANAGEMENT OF ABDOMINAL AORTIC ANEURYSM

Approximately 15,000 deaths annually in the United States are attributed to abdominal aortic aneurysms (AAA).

Risk of rupture — The likelihood that an aneurysm will rupture is influenced by number of factors, including aneurysm diameter, rate of expansion, and gender.

Aneurysm size — Rupture per annum
- Zero in aneurysms less than 4.0 cm in diameter.
- 0.5 to 5 percent for those 4.0 to 4.9 cm in diameter.
- 3 to 15 percent for those 5.0 to 5.9 cm in diameter.
- 10 to 20 percent for those 6.0 to 6.9 cm in diameter.
- 20 to 40 percent for those 7.0 to 7.9 cm in diameter.
- 30 to 50 percent for those 8.0 cm in diameter.

Rate of expansion — One study, found the mean expansion rate of ruptured versus nonruptured aneurysms was 0.82 and 0.42 cm/year, respectively.

Growth tends to be more rapid in smokers, and less rapid in patients with diabetes mellitus or peripheral vascular disease. Some aneurysms, for unclear reasons, remain relatively fixed in size for a period of time and then undergo rapid expansion.

Gender — female more than males.

SURGERY VERSUS WATCHFUL WAITING — Appropriate patient selection and timing for aneurysm repair is based upon identifying individuals at the greatest risk of aneurysm rupture. Once rupture occurs, emergency repair is indicated, but mortality is extremely high due to rapid exsanguination.

For asymptomatic patients with aneurysms between 3.0 and 5.5 cm in diameter, determining the intensity of monitoring and the timing of repair can be challenging. The choice between surgery and surveillance should take into account patient preferences and consider the following:
- Patients with small aneurysms will often die from associated illnesses before rupture occurs.
- For aneurysms between 4 and 5.5 cm, the likelihood of eventually requiring surgery is 60 to 65 percent at five years and 70 to 75 percent at eight years.
- The potential benefits of early surgery must be weighed against the perioperative mortality risk. Estimation of risk from various risk scores may be helpful.

MEDICAL THERAPY — Cessation of smoking, treating cardiovascular risk factors, such as hypertension and dyslipidemia. Beta blockers.

SURGICAL THERAPY — The options for surgical repair include the traditional transabdominal route or the more recently popularized retroperitoneal approach.

Preoperative evaluation — Patients with AAA are more likely to have underlying cardiovascular disease and more likely to experience a cardiovascular event whether or not they undergo surgical repair. Need careful preoperative cardiac assessment.

Short-term mortality — Thirty-day mortality after elective aneurysm repair was 5.8 and 2.7 percent in the UK Small Aneurysm trial and the ADAM trial, respectively. The risk is also related to surgeon expertise. In a nationwide review of 3912 patients in the United States, the in-hospital mortality after abdominal aortic aneurysm repair was 2.2 percent with vascular surgeons, 4.0 percent with cardiac surgeons, and 5.5 percent with general surgeons. The overall mortality rate was 4.2 percent.

RECOMMENDATIONS — Recommendations are in broad agreement with the 2005 ACC/AHA guidelines.

Indications for aneurysm repair — The indications for aneurysm repair are largely based upon the presence of symptoms, aneurysm size, and the rate of expansion.
- Patients with symptomatic aneurysms should undergo repair, regardless of aneurysm diameter.
- Patients with asymptomatic aneurysms that are more than twice the size of the normal segment should be considered for repair.
- Early repair may be beneficial in patients whose aneurysm increases ≥ 0.5 cm in diameter in six months.
- Repair of suprarenal and/or thoracoabdominal aneurysms involves more extensive surgery and greater operative risk. Repair of such aneurysms may be beneficial at diameters >5.5 to 6.0 cm in diameter.
- AAA repair may be reasonable in patients with medium-size aneurysms who also have iliac or femoral artery aneurysms requiring treatment, and in patients with severe coexistent occlusive disease or thrombotic or embolic complications.

Watchful waiting —
- Aneurysms 4.0 to 5.4 cm in diameter should be monitored by ultrasound or CT every 6 to 12 months.
- Aneurysms 3.0 to 4.0 cm in diameter should be monitored by ultrasound every 2 to 3 years.

STENT GRAFTS FOR ABDOMINAL AORTIC ANEURYSMS (EVAR)

— Endovascular repair consists of insertion of an endograft into the lumen of the aneurysm that effectively excludes the aneurysm from flow through the aorta, thereby minimizing the risk of rupture.

Although the vast majority of abdominal aortic aneurysms are infrarenal, less than 50 percent are amenable to endovascular repair due to anatomic considerations [3]. Angiography and computed tomography (CT) are commonly obtained as initial radiographic
studies to determine both the feasibility of an endograft and the appropriate size and configuration of the endograft.

ANATOMIC CONSIDERATIONS

Proximal neck length — length of normal aorta measured from the lowest renal artery to the most superior extent of the aneurysm. The minimum length needed varies from device to device but may be as long as 15 mm. Newer designs allow suprarenal fixation and require a shorter proximal neck length.

Angulation — An angle of 60° or more leads to difficulties in implantation, kinking, leakage, and the possibility of downward migration of the device.

Femoral artery diameter — To accommodate the delivery system of most devices, a minimal femoral artery diameter of 8 mm is usually required.

PATIENT FOLLOW-UP

Follow-up protocols vary but a typical schedule after uncomplicated endograft placement consists of abdominal plain films before discharge and at one, six, and 12 months, and then every year thereafter. Abdominal plain films are an economical and quick way to evaluate the integrity of the graft and the stability of graft appearance, alignment, and position.

CT scans, which are obtained on a similar schedule, are used to evaluate the diameter and volume of the aneurysm and to look for signs of endoleak or of endograft migration.

COMPLICATIONS

Endoleaks — A type I endoleak, which occurs in 0 to 10 percent of endovascular aortic aneurysm repairs, is due to an incompetent seal at either the proximal or distal attachment site. Type I endoleaks must be repaired as soon as they are discovered because the aneurysm sac remains exposed to systemic pressure, predisposing to aneurysmal rupture, and spontaneous closure of the leak is rare.

Type II — Type II endoleaks are the most prevalent type, occurring in 10 to 25 percent of endovascular aortic aneurysm repairs [22], and describe flow into and out of the aneurysm sac from patent branch vessels. A “wait and see” approach is preferable, while carefully following aneurysm volume and morphology on CT imaging.

Type III/IV — Type III and type IV endoleaks are much less common. Type III endoleaks represent flow into the aneurysm sac from separation between components of a modular system, or tears in the endograft fabric.

Type IV endoleaks are due to egress of blood through the pores in the fabric. Type IV leaks heal spontaneously, while type III leaks are repaired with an additional endograft to eliminate systemic flow and pressure in the aneurysm.

Postimplantation syndrome — often experience an acute inflammatory syndrome characterized by fever, leukocytosis, elevation of serum C-reactive protein (CRP) concentration, and perigraft air during the first week to 10 days after implantation.

Device migration — With the AneuRx device, the rate of freedom from device migration (≥ 10 mm or a clinical event) was 96, 90, 78, and 72 percent at one, two, three, and four years, respectively. Twelve of the fourteen patients underwent 14 secondary procedures (13 endovascular, one open conversion). Initial neck length was shorter in patients with migration (22 versus 31 mm).

CLINICAL OUTCOME

Short term — The EVAR 1 trial included 1082 patients who were at least 60 years of age, with aneurysms at least 5.5 cm in diameter [34]. At 30 days, mortality was significantly lower with endovascular than with open repair (1.6 versus 4.6 percent, adjusted odds ratio 0.34, 95% CI 0.15-0.74). Endovascular repair was also associated with a significantly shorter hospital stay (7 versus 12 days), although more secondary interventions (additional surgical procedures) were required with endovascular repair (9.8 versus 5.8 percent).

Long term — Survival compared to open repair — The early survival benefit seen with endovascular repair compared to open repair described above is lost between one and four years, after which survival appears equivalent. This observation was seen in the 2007 systematic review, which included follow-up of 1473 patients from the DREAM (two years) and EVAR 1 randomized trials (four years) [33], as well as from a report using data from the United State Medicare program. Majority of the late deaths in the EVAR group were not related to rupture but more so to cardiovascular events.

Surgical versus endovascular repair — ACC/AHA guidelines recommend surgical repair for most patients, although the use of endovascular stent grafts is an area of active investigation and improvement.

• Open surgical repair is recommended for patients at low or average risk of operative complications.
• Endovascular repair is suggested in patients at high risk of complications from open operations.
• Endovascular repair may be considered in patients who are not at high surgical risk, but evidence of benefit is less well established in this setting.