

7.01.67	Endovascular Stent Grafts for Abdominal Aortic Aneurysms		
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Section:	7.0 Surgery	Page:	Page 1 of 25

Policy Statement

The use of endoprosthesis approved by the U.S. Food and Drug Administration (FDA) as a treatment of abdominal aortic aneurysms (AAAs) may be considered **medically necessary** as a treatment of AAAs in **any** of the following clinical situations:

- A ruptured abdominal aortic aneurysm (see Policy Guidelines section)
- An aneurysmal diameter greater than 5.0 cm
- An aneurysmal diameter of 4 to 5.0 cm that has increased in size by 0.5 cm in the last 6 months
- An aneurysmal diameter that measures twice the size of the normal infrarenal aorta

The use of endoprosthesis approved by the FDA as a treatment of AAAs is considered **investigational** when the above criteria are not met, including but not limited to, **either** of the following clinical situations:

- Treatment of aneurysms that do meet the recommended threshold for surgery in patients who are ineligible for open repair due to physical limitations or other factors
- Treatment of smaller aneurysms that do not meet the current recommended threshold for surgery

Policy Guidelines

For treatment of ruptured abdominal aortic aneurysms with endoprosthesis, several factors must be considered including the following:

- The patient must be sufficiently stable to undergo detailed computed tomography (CT) examination for anatomic measurements
- The aneurysm should be anatomically appropriate for endovascular repair
- Specialized personnel should be available

To monitor for leaking of the graft after implantation, patients will typically undergo routine imaging with CT or ultrasonography every 6 to 12 months, or more frequently if perivascular leaks or aneurysm enlargement are detected.

Coding

The overall procedure involves 4 steps:

- Establishing vascular access
- Introducing catheters and guide wires into the arterial system
- Deploying the endoprosthesis
- Radiologic supervision

Step 1

The following CPT codes describe the establishment of vascular access; either the femoral or iliac arteries are used:

- **34812:** Open femoral artery exposure for delivery of endovascular prosthesis, by groin incision, unilateral (List separately in addition to code for primary procedure)
- **34820:** Open iliac artery exposure for delivery of endovascular prosthesis or iliac occlusion during endovascular therapy, by abdominal or retroperitoneal incision, unilateral (List separately in addition to code for primary procedure)

Step 2

The following CPT codes describe the introduction of catheters and guide wires:

- **36200:** Introduction of catheter, aorta

Sometimes the renal arteries are catheterized to ensure that they are not obstructed by the prosthesis. If this is the case, the following CPT code may be used:

- **36245:** Selective catheter placement, arterial system; each first order abdominal, pelvic, or lower extremity artery branch, within a vascular family

Step 3

Effective January 1, 2018, the following CPT codes describe the deployment of the prosthesis and **will replace CPT codes 34800-34805 and 34825-34826**:

- **34701:** Endovascular repair of infrarenal aorta by deployment of an aorto-aortic tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the aortic bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the aortic bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
- **34702:** Endovascular repair of infrarenal aorta by deployment of an aorto-aortic tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the aortic bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the aortic bifurcation; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
- **34703:** Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-uni-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
- **34704:** Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-uni-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
- **34705:** Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-bi-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
- **34706:** Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-bi-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
- **34707:** Endovascular repair of iliac artery by deployment of an ilio-iliac tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and all endograft extension(s)

proximally to the aortic bifurcation and distally to the iliac bifurcation, and treatment zone angioplasty/stenting, when performed, unilateral; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, arteriovenous malformation)

- **34708:** Endovascular repair of iliac artery by deployment of an ilio-iliac tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and all endograft extension(s) proximally to the aortic bifurcation and distally to the iliac bifurcation, and treatment zone angioplasty/stenting, when performed, unilateral; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, arteriovenous malformation, traumatic disruption)
- **34709:** Placement of extension prosthesis(es) distal to the common iliac artery(ies) or proximal to the renal artery(ies) for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, penetrating ulcer, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed, per vessel treated (List separately in addition to code for primary procedure)
- **34710:** Delayed placement of distal or proximal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, endoleak, or endograft migration, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed; initial vessel treated
- **34711:** Delayed placement of distal or proximal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, endoleak, or endograft migration, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed; each additional vessel treated (List separately in addition to code for primary procedure)

Step 4

Effective January 1, 2018, the following CPT code describes radiologic supervision and **will replace CPT codes 75952-75953**, to report use 34701-34711 and 0254T:

- **0254T:** Endovascular repair of iliac artery bifurcation (e.g., aneurysm, pseudoaneurysm, arteriovenous malformation, trauma, dissection) using bifurcated endograft from the common iliac artery into both the external and internal iliac artery, including all selective and/or nonselective catheterization(s) required for device placement and all associated radiological supervision and interpretation, unilateral

It is estimated that less than 5% of patients will be unsuccessfully treated with endovascular techniques to the extent that the patient must undergo urgent or emergent open surgical aneurysm repair. The following CPT codes describe this situation:

- **34830:** Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; tube prosthesis
- **34831:** Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bi-iliac prosthesis
- **34832:** Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bifemoral prosthesis

There are also category I codes for the use of fenestrated endografts to repair the visceral aorta (34841-34844) and the visceral aorta and infrarenal abdominal aorta (34845-34848):

- **34841:** Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including one visceral artery endoprosthesis (superior mesenteric, celiac or renal artery)

- **34842:** Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including two visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
- **34843:** Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including three visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
- **34844:** Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including four or more visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
- **34845:** Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including one visceral artery endoprosthesis (superior mesenteric, celiac or renal artery)
- **34846:** Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including two visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
- **34847:** Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including three visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
- **34848:** Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including four or more visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])

A code was created for the extra physician work involved in planning a patient-specific fenestrated visceral aortic endograft:

- **34839:** Physician planning of a patient-specific fenestrated visceral aortic endograft requiring a minimum of 90 minutes of physician time

Code 34839 cannot be reported on the day before or the day of the endovascular repair procedure.

Note: As experience with this technology matures, placement of endovascular stents as a treatment of AAAs may be performed by either an interventional radiologist or vascular surgeon in the outpatient setting.

Description

Endovascular stent grafts can be used as minimally invasive alternatives to open surgical repair for treatment of abdominal aortic aneurysms (AAAs). Open surgical repair of AAAs has high morbidity and mortality, and endovascular grafts have the potential to reduce the operative risk associated with AAA repair.

Related Policies

- Endovascular Stent Grafts for Disorders of the Thoracic Aorta

Benefit Application

Benefit determinations should be based in all cases on the applicable contract language. To the extent there are any conflicts between these guidelines and the contract language, the contract language will control. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

Some state or federal mandates [e.g., Federal Employee Program (FEP)] prohibits plans from denying Food and Drug Administration (FDA)-approved technologies as investigational. In these instances, plans may have to consider the coverage eligibility of FDA-approved technologies on the basis of medical necessity alone.

Regulatory Status

A large number of endovascular grafts have been approved by the U.S. Food and Drug Administration (FDA) through the premarket approval (PMA) process for treatment of AAAs (see Table 1). The original PMA dates are shown. Most stents have undergone device modification, name changes, and have approved supplements to the original PMA. FDA product code MIH.

Table 1. Abdominal Aortic Stent Grafts Approved by the FDA

Stent Name	PMA Applicant	Approved	PMA No.
AneuRx® Prosthesis System (AneuRx AAAAdvantage Stent Graft)	Medtronic Vascular	1999	P990020
Ancure® Aortoiliac System	Guidant Endovascular Technologies	2002	P990017
Gore® Excluder®	W.L. Gore & Associates	2002	P020004
Zenith® AAA Endovascular Graft	Cook	2003	P020018
Endologix Powerlink® (Afx Endovascular AAA system)	Endologix	2004	P040002
Talent® Abdominal Stent Graft System	Medtronic	2008	P070027
Endurant® II AAA Stent Graft System	Medtronic	2010	P100021
Valiant Thoracic Stent Graft System	Medtronic	2011	P100040
Relay Thoracic Stent-Graft with Plus Delivery System	Bolton Medical	2012	P110038
Ovation™ Abdominal Stent Graft System	TriVascular	2012	P120006
Aorfix™ AAA Flexible Stent Graft System	Lombard Medical	2013	P110032

FDA: Food and Drug Administration; PMA: premarket approval.

Rationale

Background

Conventional management of a clinically significant abdominal aortic aneurysm (AAA) consists of surgical excision with the placement of a sutured woven graft. Surgical excision is associated with a perioperative mortality rate between 1% and 5%. Perioperative morbidity and mortality are highest in older female patients with cardiac, pulmonary, or kidney disease; the most common cause of death is multisystem organ failure.

Due to the high mortality rate, endovascular prostheses have been developed as a less risky and minimally invasive, catheter-based alternative to open surgical excision of AAAs. These devices are deployed across the aneurysm such that the aneurysm is effectively “excluded” from the circulation, with subsequent restoration of normal blood flow.

The main potential advantage of endovascular grafts for an AAA is that they offer a less invasive and less risky approach to the repair of abdominal aneurysms. While the use of an endovascular approach has the potential to reduce the relatively high perioperative morbidity and mortality associated with open AAA repair, use of endovascular grafts also has potential disadvantages. In particular, there are concerns about the durability of the anchoring system, aneurysm expansion, and other late complications related to the prosthetic graft. Aneurysm expansion may result from perivascular leaks, also known as endoleaks, which are a unique complication of endoprotheses. Perivascular leaks may result from an incompetent seal at one of the graft attachment sites, blood flow in aneurysm tributaries (these tributaries are ligated during open surgery), or perforation of graft fabric.¹⁻⁴

Several types of grafts are currently in use: straight grafts, in which both ends are anchored to the infrarenal aorta, and bifurcated grafts, in which the proximal end is anchored to the infrarenal aorta, and the distal ends are anchored to the iliac arteries. Fenestrated grafts have also been investigated. These grafts are designed with openings in the wall that can be placed across the renal or celiac arteries while still protecting vessel patency through these critical arteries. Also, extensions can be placed from inside the main endograft body into the visceral arteries to create a hemostatic seal.

Literature Review

This review was informed by a Blue Cross Blue Shield Association Technology Evaluation Center (TEC) Assessment (2001) evaluating the use of endovascular stent grafts to repair abdominal aortic aneurysms (AAAs).⁵

Evidence reviews assess the clinical evidence to determine whether the use of a technology improves the net health outcome. Broadly defined, health outcomes are length of life, quality of life, and ability to function—including benefits and harms. Every clinical condition has specific outcomes that are important to patients and to managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance and the quality and credibility. To be relevant, studies must represent one or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse

events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

Endovascular Stent Grafts as an Alternative to Open Repair for Elective Treatment of AAAs

A number of moderate- to large-sized RCTs have compared endovascular aneurysm repair (EVAR) with open surgical repair, and these studies comprise the main body of literature on the comparative efficacy of the 2 procedures.⁶⁻⁸ Early reports of outcomes from these trials have demonstrated that the perioperative morbidity and mortality of an endovascular approach were reduced compared with open surgical repair.^{9,10} These results are consistent with large observational studies.¹¹⁻¹³ However, the mid-term and long-term results of these studies are consistent in finding that the short-term improvements are not associated with a long-term benefit compared with an open approach.

Systematic Reviews

A Cochrane review by Paravastu et al (2014) assessed the evidence on the effectiveness of EVAR compared with open surgery for patients considered fit for surgery.¹⁴ Reviewers identified 4 trials considered high quality that compared EVAR with open repair (OVER, DREAM, EVAR 1, ACE; total N=2790 patients). In a pooled analysis, short-term mortality (30-day or in-hospital mortality) was significantly lower in patients treated with EVAR (1.4% vs 4.2%; odds ratio [OR], 0.33; 95% confidence interval [CI], 0.2 to 0.55; $p < 0.001$). There were no significant differences in mortality between EVAR and open repair groups at intermediate-term follow-up.

Powell et al (2017) published an individual patient data meta-analysis evaluating longer term outcomes from the 4 combined RCTs included in the 2014 Cochrane review (OVER, DREAM, EVAR-1, ACE).¹⁵ The meta-analysis included 2783 patients with a median follow-up of 5.5 years. Mortality within 6 months of randomization was lower in the EVAR group, which was due primarily to a reduction in 30-day mortality (see Table 2). Beyond 3 years, aneurysm-related mortality was significantly higher in the EVAR group, resulting in a loss of survival benefit.

Table 2. Mortality after EVAR or Open Repair in the OVER, DREAM, EVAR 1, and ACE Trials

Morbidity by Time of Follow-Up	EVAR n/N (%)	Open n/N (%)	HR	95% CI	p
Cumulative total deaths					
0-30 days	16/1373 (1.2)	40/1351 (3.0)	0.40	0.22 to 0.74	
0-6 months	46/1393 (3.3)	73/1397 (5.5)	0.61	0.42 to 0.89	<0.05
6 months to 4 years	244/1345 (18.1)	229/1315 (17.4)	1.04	0.87 to 1.25	NS
>4 years	191/987 (19.4)	180/958 (26.4)	1.07	0.88 to 1.32	NS
Aneurysm-related deaths					
0-30 days	16/1373 (1.2)	40/1351 (3.0)	0.41	0.22 to 0.74	<0.05
31 days to 3 years	18/1357 (1.3)	33/1311 (2.5)	1.07	0.49 to 2.36	NS
After 3 years	19/1118 (1.7)	3/1054 (0.3)	5.16	1.49 to 17.89	0.01

Adapted from Powell et al (2017).¹⁵

CI: confidence interval; EVAR: endovascular aneurysm repair; HR: hazard ratio; NS: not significant.

Numerous nonrandomized studies have been performed, including the studies originally used as the basis for U.S. Food and Drug Administration approval. A systematic review of nonrandomized studies that compared EVAR with open surgery in elderly patients, 80 years or older was reported by Biancari et al (2011).¹⁶ This analysis included observational studies of elderly patients who had undergone EVAR and compared results with observational studies of elderly patients who had open repair. Results of the pooled analysis revealed that operative mortality was lower in the EVAR group (2.3%) than in the open surgery group (8.6%) and that EVAR also had lower rates of postoperative cardiac, pulmonary, and renal complications. Survival at 3 years did not differ between patients undergoing EVAR and open repair (relative risk, 1.10; 95% CI, 0.77 to 1.57).

Ulug et al (2017) published a systematic review of 5 studies of men and women who underwent intact AAA repair, either through open repair or EVAR.¹⁷ Three separate meta-analyses were conducted to address 3 issue areas. One meta-analysis included 5 studies and compared morphologic eligibility for EVAR between men and women. There was a greater likelihood that

men were deemed eligible for EVAR, (OR=0.44; 95% CI, 0.32 to 0.63). Another meta-analysis assessed the likelihood of nonintervention in women compared with men. Four studies were included (1365 men, 247 women) and the likelihood of nonintervention in women was 34% vs 19% in men (OR=2.27; 95% CI, 1.21 to 4.23). The third meta-analysis included 9 studies (52,018 men, 11,076 women) and evaluated 30-day mortality rate after EVAR. The 30-day mortality rate for women was 2.3% and 1.4 % for men (OR=1.67; 95% CI, 1.38 to 2.04). Reviewers noted that their analysis was limited by inconsistent reporting of confounders such as age, aneurysm diameter, and comorbidities. Overall, fewer women were offered EVAR than men, and, for both EVAR and open repair, women had a higher incidence of mortality following the procedure.

Randomized Controlled Trials

The major RCTs included in the patient-level meta-analyses described above are OVER, DREAM, EVAR 1, and ACE. These trials are discussed below.

Open vs Endovascular Repair Trial

Lederle et al (2012) published long-term results of the Open Versus Endovascular Repair (OVER) trial.¹⁸ In this trial, 881 patients with asymptomatic AAAs from multiple Veterans Administration medical centers were randomized to EVAR or to open repair and followed for a mean of 5.2 years. An early survival advantage (up to 3 years) was reported for EVAR, but at final follow-up, mortality rates were similar between groups (hazard ratio [HR], 0.97; 95% CI, 0.77 to 1.22; p=0.81). On subgroup analysis, differences in mortality rates were noted by age. For patients younger than 70 years, mortality was higher in the EVAR group (HR=1.31; 95% CI, 0.99 to 1.73), while for patients older than 70 years, mortality was lower in the EVAR group (HR=0.65; 95% CI, 0.43 to 0.98).

Dutch Randomized Endovascular Aneurysm Management Trial

The Dutch Randomized Endovascular Aneurysm Management (DREAM) trial enrolled 351 patients who were randomized to endovascular or to open repair.⁷ The incidence of aneurysm-related death (i.e., within 30 days) was 4.6% in the open repair group and 1.2% in the endovascular repair group. However, after 2 years, cumulative survival rates were 89.6% for open repair and 89.7% for endovascular repair, due to a higher incidence of late death in the endovascular group. The trialists suggested that an open approach may precipitate the mortality of frail patients who were most likely to die in the coming year and that the advantage of an endovascular approach may primarily be to delay death. Alternatively, the late mortality of endovascular repair may relate to its inferior ability to prevent rupture or prevent additional complications, compared with an open approach.

Longer term follow-up from this trial was reported by De Bruin et al (2010).¹⁹ After 6 years of follow-up, survival rates were similar between the EVAR (68.9%) and the open repair (69.9%) groups (difference, 1 percentage point, 95% CI, -8.8 to 10.8; p=0.97). Reinterventions were more common in the EVAR group: freedom from reinterventions was 70.4% for EVAR compared with 81.9% for open repair (difference, 11.5%; 95% CI, 2.0 to 21.0; p=0.03).

Endovascular Aneurysm Repair vs Open Repair in Patients with Abdominal Aortic Aneurysm Trial

A larger trial, the Endovascular Aneurysm Repair Versus Open Repair in Patients With Abdominal Aortic Aneurysm (EVAR 1) trial, reported by Greenhalgh et al (2005), enrolled 1082 patients 60 years or older with abdominal aneurysms at least 5.5 cm in diameter and randomized them to elective open or to endovascular repair.⁶ Similar to the DREAM trial, endovascular repair was associated with an improvement in aneurysm-related survival (4.7% open vs 1.7% endovascular at 30 days), but no advantage with respect to all-cause mortality and quality-of-life (QOL) measures. For example, within 4 years of follow-up, the endoscopic repair was associated with a complication rate of 41% compared with only 9% in the surgically treated group.

Longer term follow-up from this trial was also reported by Greenhalgh et al (2010).²⁰ This follow-up included 1252 patients with aneurysms 5.5 cm or larger randomized to EVAR or to open repair. After 8 years of follow-up, there was no difference in survival between the groups (HR=1.03; 95%

CI, 0.86 to 1.23). This evidence would suggest that the early survival advantage of EVAR was lost over time due to late endograft ruptures, some of which were fatal.

Brown et al (2011) reported on follow-up from the EVAR 1 trial, focusing on cardiovascular morbidity and mortality at 5 years posttreatment.²¹ The EVAR group had a lower total cardiovascular event rate at all follow-up time points, but differences during the trial were not statistically significant (HR=0.83; 95% CI, 0.62 to 1.10). During the period of 6 to 24 months postsurgery, the EVAR group had a higher rate of cardiovascular events (HR=1.44; 95% CI, 0.79 to 2.62), which attenuated the early benefit of EVAR and led to a convergence of events between the 2 procedures. Cardiovascular mortality during the trial was similar between groups (HR=1.06; 95% CI, 0.83 to 1.36).

Anevrysme de l'aorte abdominale: Chirurgie versus Endoprothese Trial

The Anevrysme de l'aorte abdominale: Chirurgie versus Endoprothese (ACE) trial compared EVAR with open surgical repair in patients at low-to-moderate surgical risk.²² A total of 306 patients were randomized from 25 clinical centers in France. Selection criteria included a Society of Vascular Surgery comorbidity score of 0 to 2 and suitable anatomy for EVAR without high-risk features. There were 17 (11%) crossovers from open surgery to EVAR and 4 (3%) crossovers from EVAR to open surgery. Median follow-up was 3 years.

The perioperative mortality rate was 1.3% for the EVAR group and 0.6% for the open surgery group ($p=0.12$). The survival rate at 1 year was 95.2% for EVAR and 96.5% for open surgery ($p=0.24$). At 3 years, survival remained similar at 86.3% for EVAR and 86.7% for open surgery. Major adverse cardiovascular events were present in 6.7% of EVAR patients compared with 4.0% of open surgery, a difference that was also not statistically significant. Reinterventions were more common with EVAR (16%) than with open surgery (2.7%; $p<0.001$). Endoleaks were identified on follow-up computed tomography (CT) scanning in 27% of EVAR patients (41/150). There was a total of 10 type I endoleaks; 5 were treated by endoluminal procedures, 2 were treated with open surgery, and 3 were treated by observation. There was a total of 31 type II endoleaks; 8 of these were treated with coil embolization, and 23 were left untreated.

Nonrandomized Comparative Studies

Schermerhorn et al (2015) published a propensity-matched study comparing EVAR with open repair in 79,932 Medicare patients.²³ Matching was based on demographic and clinical variables available for the 2 years before the index procedure. Analysis of Medicare data showed that patients treated using EVAR had a lower perioperative mortality rate (1.6% vs 5.2% $p<0.001$) and improved survival through the first 3 years of follow-up compared with patients treated using open repair. Survival rates between 3 and 8 years of follow-up did not differ between groups. Reasons for interventions through 8 years of follow-up differed and were related to the management of the aneurysm after EVAR vs laparotomy after open repair. Aneurysm rupture occurred in a significantly greater proportion of patients after endovascular repair (5.4%) than in patients who had open repair (1.4%) through the 8-year follow-up ($p<0.001$). Interpretation of these data is limited by the potential for selection bias. While this study used propensity matching to reduce selection bias, the potential for bias in selecting patients for EVAR remains.

Liang et al (2018) analyzed data from 2641 patients who were 65 years or younger being treated for AAA with EVAR or open repair; patients were drawn from the Vascular Quality Initiative, a national registry.²⁴ Most patients were treated with EVAR (73%), and 13% ($n=337$) of patients were female. The primary outcomes included perioperative, short-term mortality, and complications in younger patients with few comorbidities. Exclusions included patients with open para-renal or thoracoabdominal repair, patients unfit for open repair, and patients with EVAR for isolated iliac aneurysms. Unadjusted reintervention rates were 5 (open repair) and 7 (EVAR) reinterventions per 100 person-years ($p<0.8$). Unadjusted 1-year survival rates did not differ significantly between the interventions (both open repair and EVAR, 3.0%; $p<0.98$). Neither propensity weighted survival (HR=0.88; 95% CI, 0.56 to 1.38; $p<0.6$) nor reintervention rates (incidence rate ratio, 1.35;

95% CI, 0.57 to 3.21; $p < 0.5$) differed between the methods of repair. This study was at risk of selection bias because participation in the Vascular Quality Initiative registry is voluntary. The data were self-reported with incomplete 1-year follow-up results. The short-term survival advantage of EVAR was not demonstrated in the younger age cohort.

Section Summary: Endovascular Stent Grafts as an Alternative to Open Repair for Treatment of AAAs

Evidence from several RCTs and meta-analyses of the RCTs has supported EVAR as a reasonable alternative to open surgical repair for aneurysms greater than 5.5 cm, and for aneurysms that have high-risk features such as rapid growth. In unselected patients with AAAs who are appropriate candidates for surgery, EVAR is associated with lower perioperative morbidity and mortality. However, EVAR is associated with a higher rate of longer term complications, including endoleaks and the need for reinterventions. Longer term mortality is similar for EVAR and open surgery at 5 to 8 years of follow-up. For patients at low risk for open surgery, 1 RCT has reported low perioperative morbidity and mortality rates for both EVAR and open surgery, with no differences between the 2 procedures. Thus, the advantage for EVAR in reduced perioperative morbidity and mortality may not be present for patients who are low risk for surgery.

EVAR as an Alternative to Open Repair for Ruptured AAAs

Emergency EVAR for ruptured AAAs is being studied as a treatment option to decrease the high mortality rate associated with open surgical repair. Conducting RCTs has been difficult in this patient population due to the emergent or semi-emergent nature of treatment for ruptured aneurysms. As a result, until 2013, the most relevant evidence on this question derived from nonrandomized studies comparing EVAR with open surgery. However, there is a high risk for selection bias in uncontrolled studies. Aneurysms that meet the anatomic criteria for EVAR tend to be smaller and less complex than aneurysms that do not, resulting in the highest risk patients being preferentially treated with open surgery. Some studies have attempted to identify the degree to which selection bias may contribute to apparent favorable outcomes in endovascular EVAR repair by comparing outcomes for patients who underwent open repair who met eligibility for EVAR with those who did not. In a study by Krenzien et al (2013), those suitable for EVAR had a significantly lower prevalence of in-hospital deaths (25%) than those unsuitable for EVAR (53%; $p = 0.02$).²⁵ In contrast, as reported by van Beek et al (2014) in an observational cohort of 279 patients who underwent open repair of suspected ruptured AAAs who were enrolled in parallel to the Amsterdam Acute Aneurysm Trial (described below), 30-day morbidity was not lower among the 71 patients who met criteria for EVAR (38%) compared with the 208 patients who did not (30%; $p = 0.23$).²⁶ Because of the possibility of selection bias, several nonrandomized studies have used patient matching or other methods to reduce potential for selection bias.

Systematic Reviews

Sweeting et al (2015) published a patient-level meta-analysis of 3 RCTs (total $N = 836$ patients) that compared EVAR with open repair for ruptured AAAs.²⁷ To have a more uniform comparison, 90-day data from only the patients who were anatomically suitable for EVAR who participated in the IMPROVE trial were analyzed along with patient-level data from the AJAX and ECAR trials (described below). There was no survival benefit from EVAR in pooled analysis at 90 days ($OR = 0.85$; 95% CI, 0.64 to 1.13). However, pooled analysis confirmed findings from IMPROVE that women benefited more than men from an endovascular strategy (ratio of $OR = 0.49$; 95% CI, 0.24 to 0.99). Pooled analysis also confirmed the individual findings of the 3 trials that hospital length of stay was shorter after EVAR than after open repair ($HR = 1.24$; 95% CI, 1.04 to 1.47).

The most recent relevant Cochrane review, by Badger et al (2017), reported on 4 RCTs (AJAX, ECAR, Hinchliffe et al [2006], and IMPROVE) which evaluated short- and mid-term outcomes of 868 patients with ruptured AAA treated with emergency EVAR or open repair.²⁸ For the primary outcome, short-term mortality (defined as 30-day or in-hospital mortality), there was no significant difference between EVAR and open repair ($OR = 0.88$; 95% CI, 0.66 to 1.16; $p = 0.36$). Secondary outcomes (endoleak events, 30-day complication rates, 6-month mortality) were not assessed in all studies. Reductions in bowel ischemia (a secondary outcome) were more

significant in the EVAR group than in the open repair group (OR=0.37; 95% CI, 0.14 to 0.94; p=0.04). Using data from the AJAX trial (n=116), reviewers found no 6-month survival advantage for patients treated with emergency EVAR (OR=0.89; 95% CI, 0.40 to 1.98).

Randomized Controlled Trials

Immediate Management of Patients with Rupture: Open vs Endovascular Repair Trial

The Immediate Management of Patients With Rupture: Open vs Endovascular Repair Trial (IMPROVE) trial randomized 623 patients at 30 centers (29 in the U.K., 1 in Canada) with a clinical diagnosis of a ruptured AAA to an endovascular strategy of immediate CT and emergency EVAR, with open repair for patients anatomically unsuitable for EVAR (endovascular strategy group), or to the standard treatment of emergency open repair (open repair group).²⁹ Patients were excluded if they had had an aneurysm repair, rupture of an isolated internal iliac aneurysm, aorto-caval or aorto-enteric fistulae, recent anatomic assessment of the aorta (e.g., awaiting elective EVAR), a diagnosis of connective tissue disorder, or if the intervention was considered futile. The trial protocol permitted inclusion of hemodynamically unstable patients. Ten randomized patients were excluded from data analysis due to a breach of inclusion criteria. Three hundred sixteen patients were randomized to EVAR, 275 (87%) of whom had a confirmed diagnosis of ruptured AAA and 174 (64%) were considered anatomically suitable for EVAR. EVAR was attempted in 154 patients, 4 of whom were converted to open repair. Open repair was attempted in 112 other patients (84 anatomically unsuitable for EVAR, 28 crossovers). Sixteen patients died before repair, and 1 patient refused to repair and was discharged. Two hundred seventy-nine patients were randomized to open repair, 261 (88%) of whom had a confirmed diagnosis of ruptured AAA. In the open repair randomization group, open repair was attempted in 220 (80%) patients, EVAR was attempted in 36 (13%) patients, and 19 patients died before repair.

For the trial's primary outcome, overall 30-day mortality was 35.4% (112/316) in the EVAR group and 37.4% (111/297) in the open repair group (unadjusted OR=0.92; 95% CI, 0.66 to 1.28; p=0.62). After adjusting for age, sex, and Hardman index (a prognostic score for mortality after ruptured AAA), there were no significant differences between groups for overall 30-day mortality (adjusted odds ratio, 0.94; 95% CI, 0.67 to 1.33; p=0.73). Compared with men (adjusted odds ratio, 0.44), women demonstrated a greater benefit from EVAR (adjusted odds ratio, 1.18; p=0.019 for interaction). There was a trend for lower mortality in the EVAR group for patients with higher Hardman index and age. Patients in the EVAR group (94%) were more likely to be discharged directly to home than those in the open repair group (77%; p<0.001).

One-year outcomes were reported by IMPROVE investigators (2015).³⁰ For the trial's primary 1-year outcome, survival data were available for 611 of 613 patients randomized. All-cause mortality did not differ significantly between the EVAR (41.1%) and the open repair groups (45.1%) groups (OR=0.85; 95% CI, 0.62 to 1.17; p=0.325), with similar reintervention rates in both groups.³⁰ The EVAR group (17 days) had shorter hospital stays than the open repair group (26 days; p<0.001). QOL, measured with the EuroQol questionnaire, was higher in the EVAR group than in the open group, with a mean difference of 0.087 (95% CI, 0.017 to 0.158) at 3 months and 0.068 (95% CI, -0.004 to 0.140) at 12 months. The EuroQol outcome difference exceeded the minimally clinically important difference of 0.03.

Amsterdam Acute Aneurysm Trial

Reimerink et al (2013) reported on results from the Amsterdam Acute Aneurysm (AJAX) trial, a regional multicenter randomized trial that compared EVAR with open repair in the treatment of ruptured AAA.³¹ In this trial, patients were recruited from the set of all patients who presented with suspected ruptured AAA at 1 of 3 trial centers. The other 7 regional hospitals agreed to transfer patients with suspected ruptured AAA to one of the trial centers, if possible. After initial resuscitation, the diagnosis of a ruptured aneurysm was confirmed or rejected based on abdominal ultrasound and/or computed tomography angiography. Patients considered suitable for both EVAR and open repair by the treating vascular surgeon were randomized to EVAR or to open repair. Five hundred twenty patients were diagnosed with ruptured AAA in the

trial region; of those, 365 patients were excluded (240 for unfavorable anatomy, 71 for lack of evaluation by computed tomography angiography, 54 who were not referred to a trial center). One hundred fifty-five patients were considered to have favorable anatomy; 39 of them were excluded (16 were considered unfit for open repair, 11 for "logistics," 7 with severe hemodynamic instability after computed tomography angiography, 5 refused surgery). One hundred sixteen patients were randomized, 57 of whom were allocated to the EVAR group and 59 to the open repair group. Ten patients in the EVAR group underwent open repair, and there was 1 perioperative death. In the open repair group, there were 3 diagnoses other than ruptured AAA during surgery and 4 perioperative deaths.

For the trial's primary outcome, rates of a composite end point (death and severe complications at 30 days) were 42% (24/57) in the EVAR group compared with 47% (28/59) in the open repair group (absolute risk reduction, 5.4%; 95% CI, -13% to 23%). The 30-day mortality rate was 21% (12/57) in the EVAR group compared with 25% (15/59) in the open repair group (ARR=4.4%; 95% CI, -11% to 20%). The 2 groups had similar median hospital stay and likelihood of intensive care unit admission. The trialists noted that patients in the open repair group had a much lower 30-day mortality rate than was anticipated in the trial's design (25% vs results from a prior meta-analysis demonstrating a mortality rate of 48.5% in subjects undergoing open repair of ruptured AAA). As such, the trial may have been underpowered to detect a difference between groups. Also, the trial had a high rate of exclusion of patients with ruptured aortic aneurysm, most commonly because of unfavorable infrarenal aortic neck anatomy with absent or very short necks and very wide necks.

Endovasculaire ou Chirurgie dans les Anevrysmes aorto-iliaques Rompus

Desgranges et al (2015) reported on the 30-day and 1-year results of the multicenter Endovasculaire ou Chirurgie dans les Anevrysmes aorto-iliaques Rompus (ECAR) pseudo-randomized trial.³² A total of 107 patients were assigned by alternating weeks to EVAR (n=56) or open repair (n=51). Power analysis indicated that 80 patients per group would be required to detect a 20% reduction in mortality. However, trial enrollment was terminated after 5 years. Patients were included if they had a ruptured aortic, aorto-iliac, or iliac aneurysm met clinical and anatomic criteria for both EVAR and open repair and were hemodynamically stable. The assignment also included the availability of a qualified surgeon (≥ 15 EVAR procedures) and facilities. During the study period, 417 patients were treated for ruptured aorto-iliac aneurysms, of which 32% qualified for EVAR (56 included, 116 not included). Baseline characteristics were similar between the EVAR and open repair study groups. There were no significant differences between the EVAR and open repair group for the primary outcome of mortality at 30 days (18% vs 24%, $p=0.239$) or 1 year (30% vs 35%, $p=0.296$), although the trial was underpowered to detect a difference of this magnitude. The lower than expected mortality rate in the open repair group might have been due to the exclusion of patients with hemodynamic instability or unfavorable anatomic criteria. Despite a longer delay to repair with EVAR compared with open surgery (2.9 hours vs 1.3 hours, $p<0.005$), EVAR reduced respiratory support time (59.3 hours vs 180.3 hours, $p=0.007$), pulmonary complications (15.4% vs 41.5%, $p=0.05$), total blood transfusion (6.8 units vs 10.9 units, $p=0.020$), and duration of intensive care unit stay (7 days vs 11.9 days, $p=0.010$).

Nonrandomized Comparative Studies

Edwards et al (2014) evaluated outcomes after EVAR and open repair for ruptured AAAs among traditional Medicare beneficiaries discharged from a U.S. hospital from 2001 to 2008.³³ Overall, 10,998 patients underwent ruptured AAA repair, 1126 by EVAR and 9872 by open repair. The population analyzed included 1099 patient pairs who were propensity-score matched based on baseline demographics, comorbid conditions, admission source, and hospital volume of ruptured AAA repair. Short-term mortality was significantly lower in the EVAR group (33.8% vs 47.7%, $p<0.001$). The survival benefit persisted until 4 years postsurgery. However, at 36 months after surgery, EVAR patients (10.9%) were more likely to have had AAA-related reinterventions than open repair patients (1.5%; $p<0.001$). Strengths of this trial included its large sample size, the availability of longer term follow-up data, and the use of propensity-score matching to reduce

bias based on observed variables. However, the trial was subject to bias because unobserved variables might have been associated with the decision to perform open repair.

Section Summary: EVAR as an Alternative to Open Repair for Ruptured AAAs

For patients with ruptured AAAs to be candidates for endovascular repair, the lesions need to be suitable for the endovascular devices, and patients need to be sufficiently stable to undergo CT evaluation. Three RCTs have published outcomes comparing EVAR with open surgery for patients with ruptured AAA; they reported that the 30-day and 1-year mortality rates for EVAR did not differ significantly from those for open surgery. Longer term outcomes comparing EVAR with open surgery for ruptured aneurysms have not been reported.

EVAR as an Alternative for Treating Smaller Aneurysms Not Meeting Current Size Criteria for Surgery or for Patients Ineligible for Open Surgery

Few randomized trials have addressed patients with aneurysms who are not recommended for surgery. This population includes patients with smaller aneurysms that do not meet the size threshold for open surgery and patients who cannot undergo open surgery due to prohibitive operative risk.

EVAR for Smaller Aneurysms

Systematic Reviews

A Cochrane Review by Filardo et al (2012) summarized the evidence on interventions for small aneurysms (4.0-5.5 cm), either by open surgery or EVAR.³⁴ Four RCTs were identified, including 2 RCTs on EVAR (discussed below)^{35,36} and 2 others on open surgical repair. Combined analysis of the 2 EVAR trials revealed no difference in mortality at 1 year (OR=1.15; 95% CI, 0.59 to 2.25). There was also no survival benefit for the trials of open surgery.

Randomized Controlled Trials

The Comparison of surveillance versus Aortic Endografting for Small Aneurysm Repair (CAESAR) trial compared the use of EVAR for small AAAs not meeting the current thresholds recommended for intervention with active surveillance.³⁵ The study enrolled 360 patients, 50-to-79 years old, with aneurysms of 4.1 to 5.4 cm. Patients were randomized to early EVAR or surveillance by ultrasound and/or CT. In the surveillance group, surgery was performed only after the AAA met current recommendations for intervention (≥ 5.5 cm, growth 1 cm/y, or symptomatic). If the repair was indicated, EVAR was performed unless the anatomy of the AAA was unsuitable for EVAR, in which case open repair was performed. Patients were followed for a median of 32.4 months for the primary outcome of all-cause mortality.

The primary outcome occurred at a lower rate than anticipated, thus limiting the power to detect a difference. At final follow-up, there was no significant difference in the main end point. Kaplan-Meier estimates of all-cause mortality were 10.1% for the surveillance group and 14.5% for the EVAR group (HR=0.76; 95% CI, 0.30 to 1.93). Aneurysm-related mortality, aneurysm rupture, and major morbidity rates were also similar between groups. For patients in the surveillance group, the Kaplan-Meier estimate of undergoing aneurysm repair was 59.7% at 36 months and 84.5% at 54 months.

In a follow-up publication from the CAESAR trial, De Rango et al (2011) reported on QOL outcomes.³⁷ Patients were assessed with the 36-Item Short-Form Health Survey at baseline, 6 months, 12 months, and yearly after that (mean follow-up, 31.8 months). Following EVAR, QOL scores in the EVAR arm improved while those in the observation arm worsened. At 6-month follow-up, QOL scores in the EVAR group were significantly higher than in the observation group, with significant differences found for 36-Item Short-Form Health Survey overall score (mean difference, 5.4, $p=0.002$), physical domain score (mean difference, 3.8; $p=0.02$), and mental domain score (mean difference, 6.0; $p=0.001$). Over longer follow-up, scores in both the EVAR and observation group declined, and scores did not differ significantly at 1 year and beyond. The PIVOTAL (Positive Impact of Endovascular Options for Treating Aneurysms Early) trial randomized 728 patients with AAAs of 4 to 5 cm to early EVAR or ultrasound surveillance.³⁶

Patients were followed for a mean 20 months for the primary outcomes (aneurysm rupture, aneurysm-related death, overall mortality). At the final follow-up, overall mortality was the same in both groups (4.1%). Aneurysm rupture or aneurysm-related death occurred at a low rate and was also the same for both groups (0.6%). The HR for the primary outcome measures was 0.99 (95% CI, 0.14 to 7.06).

EVAR for Patients at Prohibitive Surgical Risk

Greenhalgh et al (2005) reported on EVAR trial 2, which compared endovascular repair for AAAs with no surgical intervention in patients unsuitable for open surgery.⁸ Patients (338 of 404 eligible) who had been excluded from EVAR trial 1 were randomized to endovascular repair or medical management. Endovascular repair had a 9% 30-day operative mortality and did not improve survival over no intervention. However, the results of this trial were limited, because 20% of patients assigned to medical management underwent elective aneurysm repair in violation of the protocol. Also, endovascular repair was not performed until a median of 57 days after randomization; during this period, 9 aneurysms ruptured, contributing to the endovascular mortality calculation, and biasing results against endovascular repair.

A longer term follow-up for this trial was reported by Greenhalgh et al (2010); they evaluated 404 patients randomized to EVAR or no treatment.³⁸ The perioperative mortality rate in the EVAR group was 7.3%. At the 8-year follow-up, aneurysm-related mortality was lower in the EVAR group, but overall mortality did not differ (HR=0.99; 95% CI, 0.78 to 1.27). There was a high rate of long-term complications in the EVAR group, with 48% of patients having a graft-related complication, and 27% of patients required reintervention for complications.

Based solely on EVAR trial 2, an Agency for Healthcare Research and Quality (2006) technology assessment, comparing endovascular with open surgical repair for AAA, concluded that endovascular repair did not improve survival in patients who are medically unfit for open surgery.³⁹ As previously discussed, the EVAR trial 2, and thus this technology assessment, was compromised by the high proportion of patients who crossed over from nonoperative to endovascular repair, and by the number of patients who died in the interval between randomization and treatment with EVAR.

Sweeting et al (2017) reported on very long-term follow-up of patients (mean follow-up, 12 years) for the EVAR trial 2 and found that life expectancy was 4.2 years and was the same independent of treatment.⁴⁰ At 12 years, an estimated 5.3% (95% CI, 2.6% to 9.2%) of patients in the EVAR group were still living, compared with 8.5% (95% CI, 5.2% to 12.9%) of patients who received no intervention. There was no statistically significant difference between groups in total mortality (EVAR, 22.6 deaths per 100 person-years vs no intervention, 22.1 deaths per 100 person-years; adjusted HR=1.07; 95% CI, 0.86 to 1.34; p=0.52). For aneurysm-related mortality, patients who received EVAR had a survival advantage at long-term follow-up (3.3 deaths per 100 person-years) compared with those who received no intervention (6.5 deaths per 100 person-years; adjusted HR=0.55; 95% CI, 0.34 to 0.91). As previously discussed, substantial crossover and the small sample size at 8 years and beyond are limitations of this long-term follow-up to the EVAR trial 2. While there appears to be no overall survival advantage for the patients ineligible for open repair who receive EVAR compared with those who did not receive intervention for AAA, there is an apparent reduction in aneurysm-related mortality for EVAR patients.

Section Summary: EVAR as an Alternative for Treating Smaller Aneurysms Not Meeting Current Size Criteria for Surgery or for Patients Ineligible for Open Surgery

The evidence does not indicate that EVAR improves outcomes for patients who are not suitable for open surgery, as judged by aneurysm size and or clinical factors that indicate prohibitive risk for open surgery. For small aneurysms, RCT evidence has suggested that morbidity and mortality outcomes from surveillance are as good as those from early intervention with EVAR. For patients at prohibitive operative risk, 1 RCT has reported that EVAR is associated with lower aneurysm mortality but no difference in overall mortality and that there is a high rate of long-term complications and reinterventions with EVAR. This RCT evidence is biased by a high rate of

crossovers, primarily from open surgery to EVAR, which would limit the ability to detect a difference between the 2 treatments.

Summary of Evidence

For individuals who have AAAs eligible for open repair who receive endovascular stent grafts, the evidence includes RCTs and systematic reviews of RCTs. Relevant outcomes are overall survival, morbid events, and treatment-related mortality and morbidity. Evidence from a patient-level meta-analysis of 4 RCTs comparing EVAR with open repair for elective treatment of AAAs has indicated that neither approach is clearly superior to the other. While EVAR is associated with an early reduction in mortality, outcomes at 5 years or longer have shown greater reintervention rates and endovascular mortality and comparable overall survival rates for EVAR and open repair. Thus, the early advantage of EVAR is offset by a higher rate of late complications over the long term. Based on these data, EVAR may be considered as an alternative to open surgery in patients who are candidates for both procedures. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have ruptured AAAs who receive endovascular stent grafts, the evidence includes RCTs and systematic reviews of RCTs. Relevant outcomes are overall survival, morbid events, and treatment-related mortality and morbidity. For patients with ruptured AAAs, evidence from 4 RCTs and a patient-level meta-analysis has indicated that short- and intermediate-term survival following EVAR is comparable with open repair. Evidence from RCTs and nonrandomized matched comparisons has shown that EVAR is associated with lower perioperative morbidity. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have AAAs ineligible for open repair who receive endovascular stent grafts, the evidence includes RCTs. Relevant outcomes are overall survival, morbid events, and treatment-related mortality and morbidity. At least 2 RCTs have compared EVAR with no surgical intervention for patients ineligible for open repair, either because of aneurysm size or prohibitive surgical risk. These trials did not report superior outcomes with EVAR and thus do not support the use of EVAR in this population. The evidence is sufficient to determine that the technology is unlikely to improve the net health outcome.

Supplemental Information Practice Guidelines and Position Statements

American College of Cardiology Foundation and American Heart Association

Updated guidelines on the management of abdominal aortic aneurysms (AAAs) were released by the American College of Cardiology Foundation and the American Heart Association in 2011 as a focused update to the 2005 guidelines on the management of patients with peripheral artery disease.⁴¹ These guidelines made the following recommendations (see Table 3).

Table 3. Guidelines on Management of Patients with Peripheral Artery Disease

Recommendation	COR	LOE
Open or endovascular repair of infrarenal AAAs and/or common iliac aneurysms is indicated in patients who are good surgical candidates	I	A
Periodic long-term surveillance imaging should be performed to monitor for endoleak, confirm graft position, document shrinkage or stability of the excluded aneurysm sac, and determine the need for further intervention in patients who have undergone endovascular repair of infrarenal aortic and/or iliac aneurysms	I	A
Open aneurysm repair is reasonable to perform in patients who are good surgical candidates but who cannot comply with the periodic long-term surveillance required after endovascular repair	IIa	C

Recommendation	COR	LOE
Endovascular repair of infrarenal aortic aneurysms in patients who are at high surgical or anesthetic risk as determined by the presence of coexisting severe cardiac, pulmonary, and/or renal disease is of uncertain effectiveness	IIb	C

AAA: abdominal aortic aneurysm; COR: class of recommendation; LOE: level of evidence.

Professional guidelines from the American College of Cardiology and American Heart Association (2006), based on both randomized and nonrandomized trials, have suggested that endovascular repair of infrarenal aortic and/or common iliac aneurysms is reasonable in patients at high risk of complication from open surgeries.⁴²

Society of Interventional Radiology

Guidelines on the use of endovascular aneurysm repair (EVAR) were developed by the Society of Interventional Radiology in 2010 and endorsed by the Cardiovascular and Interventional Radiological Society of Europe and the Canadian Interventional Radiology Association.⁴³ These guidelines indicated that:

“Indications for EVAR are currently the same as open repair....”

“Patient preference for EVAR versus open repair should be considered when appropriate....”

“Endovascular abdominal aortic aneurysm repair should be considered as having an intermediate to high cardiac risk that ranges from 3% to 7%.”

There has been increasing use of EVAR for ruptured aneurysms. “Achieving optimal EVAR results for ruptured AAA requires establishment of a treatment protocol involving the emergency department, the endovascular team, anesthesiology, and the operating room personnel.”

“Lifelong imaging surveillance of patients after EVAR is critical for (i) the detection and, if possible, the characterization of endoleaks; (ii) evidence of expansion or shrinkage of the residual AAA sac through measurement of aneurysm size, volume calculation, and identification of substantial changes in aneurysm dimensions; (iii) detection of mechanical changes in the stent-graft, such as migration, kinking, or fracture; and (iv) evaluation of the long-term performance of the endoprosthesis.”

Society for Vascular Surgery

The Society for Vascular Surgery published guidelines for the treatment of AAAs in 2018.⁴⁴ As in previous publications, these guidelines indicated that open surgery and EVAR are options for patients with aneurysms that meet the current treatment threshold. These guidelines also made the following recommendations (see Table 4).

Table 4. Guidelines on Management of Patients with Aneurysms

Recommendation	QOE	LOR
EVAR is progressively replacing open surgery as the treatment of choice, and accounts for more than half of all elective AAA repairs in the United States		
Emergent EVAR should be considered for treatment of a ruptured AAA, if anatomically feasible	Moderate	Strong
EVAR may be considered for high-risk patients unfit for surgical repair	Low	Weak
For patients with ruptured aneurysm, immediate repair is recommended	High	Strong

AAA: abdominal aortic aneurysm; EVAR: endovascular aneurysm repair; LOR: level of recommendation; QOE: quality of evidence.

U.S. Preventive Services Task Force Recommendations

Not applicable.

Medicare National Coverage

There is no national coverage determination. In the absence of a national coverage determination, coverage decisions are left to the discretion of local Medicare carriers.

Ongoing and Unpublished Clinical Trials

Some currently unpublished trials that might influence this review are listed in Table 5.

Table 5. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
Ongoing			
NCT01878240	Prevention of Type II Endoleaks During Endovascular Treatment of Abdominal Aortic Aneurysm: Endovascular Treatment Versus Combination With Coil Embolisation of the Aneurysmal Sac	100	May 2019
NCT00583050	Endovascular Exclusion of Thoracoabdominal Aortic Aneurysms or Abdominal Aneurysms Utilizing Fenestrated/Branched Stent-Grafts	1440	Dec 2020
NCT01937949 ^a	Clinical Outcomes and Quality of Life Measures in Patients Treated for Complex Abdominal Aortic Aneurysms With Fenestrated Stent Grafts	200	Dec 2020
NCT03446287	Clinical Outcomes and Quality of Life Measures in Patients Treated With Open Surgical Repair for Complex Aortic Aneurysms	150	Dec 2020
NCT01726257 ^a	Prospective, Multicenter, Single Arm Safety and Effectiveness Study of Endovascular Abdominal Aortic Aneurysm Repair Using the Nellix [®] System: A Pivotal and Continued Access Study	429	Jun 2021
NCT02485496 ^a	SECURE – A post-market Registry in Patients With infraRenal aortic Aneurysm Undergoing endovascular Stenting With the New E-tegra Stent Graft System	100	Oct 2021
NCT02996396 ^a	Multicenter, Observational, Registry to Assess Outcomes of Patients Treated With the CE Nellix [™] System for Endovascular Abdominal Aortic Aneurysm Repair	300	Oct 2023
NCT03298477 ^a	Prospective, Multicenter, Single Arm Safety and Effectiveness Confirmatory Study of Endovascular Abdominal Aortic Aneurysm Repair Using the Nellix System IDE Study (EVAS 2 Confirmatory IDE Study)	90	May 2024
NCT02489539 ^a	Assessment of the GORE [®] EXCLUDER [®] Confromable AAA Endoprosthesis in the Treatment of Abdominal Aortic Aneurysms	190	Dec 2024
NCT03180996 ^a	A Prospective, Global, Multicentre, Real World Outcome Study of Fenestrated Endovascular Aneurysm Repair Using the Fenestrated Anaconda [™] Device	160	Sep 2029
Unpublished			
NCT00583414	Endovascular Exclusion of Abdominal Aortic Aneurysms in High Risk Patients	400	Oct 2017 (completed)

NCT: national clinical trial.

^a Denotes an industry-sponsored or cosponsored trial.

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Documentation for Clinical Review

Please provide the following documentation (if/when requested):

- History and physical and/or consultation notes including:
 - Imaging report(s) of abdominal aortic aneurysm(s), including measurements
 - Name of endovascular stent graft used
 - Reason for endovascular stent graft (e.g., disorder of abdominal aorta)
- Procedure report(s)

Post Service

- Procedure report(s)

Coding

This Policy relates only to the services or supplies described herein. Benefits may vary according to product design; therefore, contract language should be reviewed before applying the terms of the Policy. Inclusion or exclusion of codes does not constitute or imply member coverage or provider reimbursement.

MN/IE

The following services may be considered medically necessary in certain instances and investigational in others. Services may be considered medically necessary when policy criteria are met. Services may be considered investigational when the policy criteria are not met or when the code describes application of a product in the position statement that is investigational.

Type	Code	Description
CPT®	0254T	Endovascular repair of iliac artery bifurcation (e.g., aneurysm, pseudoaneurysm, arteriovenous malformation, trauma, dissection) using bifurcated endograft from the common iliac artery into both the external and internal iliac artery, including all selective and/or

Type	Code	Description
		nonselective catheterization(s) required for device placement and all associated radiological supervision and interpretation, unilateral
	34701	Endovascular repair of infrarenal aorta by deployment of an aorto-aortic tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the aortic bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the aortic bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
	34702	Endovascular repair of infrarenal aorta by deployment of an aorto-aortic tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the aortic bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the aortic bifurcation; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
	34703	Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-uni-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
	34704	Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-uni-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
	34705	Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-bi-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer)
	34706	Endovascular repair of infrarenal aorta and/or iliac artery(ies) by deployment of an aorto-bi-iliac endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, all endograft extension(s) placed in the aorta from the level of the renal arteries to the iliac bifurcation, and all angioplasty/stenting performed from the level of the renal arteries to the iliac bifurcation; for rupture including

Type	Code	Description
		temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, penetrating ulcer, traumatic disruption)
	34707	Endovascular repair of iliac artery by deployment of an ilio-iliac tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and all endograft extension(s) proximally to the aortic bifurcation and distally to the iliac bifurcation, and treatment zone angioplasty/stenting, when performed, unilateral; for other than rupture (e.g., for aneurysm, pseudoaneurysm, dissection, arteriovenous malformation)
	34708	Endovascular repair of iliac artery by deployment of an ilio-iliac tube endograft including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and all endograft extension(s) proximally to the aortic bifurcation and distally to the iliac bifurcation, and treatment zone angioplasty/stenting, when performed, unilateral; for rupture including temporary aortic and/or iliac balloon occlusion, when performed (e.g., for aneurysm, pseudoaneurysm, dissection, arteriovenous malformation, traumatic disruption)
	34709	Placement of extension prosthesis(es) distal to the common iliac artery(ies) or proximal to the renal artery(ies) for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, penetrating ulcer, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed, per vessel treated (List separately in addition to code for primary procedure)
	34710	Delayed placement of distal or proximal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, endoleak, or endograft migration, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed; initial vessel treated
	34711	Delayed placement of distal or proximal extension prosthesis for endovascular repair of infrarenal abdominal aortic or iliac aneurysm, false aneurysm, dissection, endoleak, or endograft migration, including pre-procedure sizing and device selection, all nonselective catheterization(s), all associated radiological supervision and interpretation, and treatment zone angioplasty/stenting, when performed; each additional vessel treated (List separately in addition to code for primary procedure)
	34812	Open femoral artery exposure for delivery of endovascular prosthesis, by groin incision, unilateral (List separately in addition to code for primary procedure)
	34820	Open iliac artery exposure for delivery of endovascular prosthesis or iliac occlusion during endovascular therapy, by abdominal or retroperitoneal incision, unilateral (List separately in addition to code for primary procedure)
	34830	Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; tube prosthesis

Type	Code	Description
	34831	Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bi-iliac prosthesis
	34832	Open repair of infrarenal aortic aneurysm or dissection, plus repair of associated arterial trauma, following unsuccessful endovascular repair; aorto-bifemoral prosthesis
	34839	Physician planning of a patient-specific fenestrated visceral aortic endograft requiring a minimum of 90 minutes of physician time
	34841	Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including one visceral artery endoprosthesis (superior mesenteric, celiac or renal artery)
	34842	Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including two visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
	34843	Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including three visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
	34844	Endovascular repair of visceral aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) by deployment of a fenestrated visceral aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including four or more visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
	34845	Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including one visceral artery endoprosthesis (superior mesenteric, celiac or renal artery)
	34846	Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including two visceral artery endoprostheses (superior mesenteric, celiac and/or renal artery[s])
	34847	Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated

Type	Code	Description
		visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including three visceral artery endoprosthesis (superior mesenteric, celiac and/or renal artery[s])
	34848	Endovascular repair of visceral aorta and infrarenal abdominal aorta (e.g., aneurysm, pseudoaneurysm, dissection, penetrating ulcer, intramural hematoma, or traumatic disruption) with a fenestrated visceral aortic endograft and concomitant unibody or modular infrarenal aortic endograft and all associated radiological supervision and interpretation, including target zone angioplasty, when performed; including four or more visceral artery endoprosthesis (superior mesenteric, celiac and/or renal artery[s])
	36200	Introduction of catheter, aorta
	36245	Selective catheter placement, arterial system; each first order abdominal, pelvic, or lower extremity artery branch, within a vascular family
HCPCS	None	
ICD-10 Procedure	04V00DZ	Restriction of Abdominal Aorta with Intraluminal Device, Open Approach
	04V03DZ	Restriction of Abdominal Aorta with Intraluminal Device, Percutaneous Approach
	04V04DZ	Restriction of Abdominal Aorta with Intraluminal Device, Percutaneous Endoscopic Approach

Policy History

This section provides a chronological history of the activities, updates and changes that have occurred with this Medical Policy.

Effective Date	Action	Reason
08/31/2015	BCBSA Medical Policy adoption	Medical Policy Committee
07/01/2016	Policy title change from "Endovascular Grafts for Abdominal Aortic Aneurysms"	Medical Policy Committee
07/01/2017	Policy revision without position change	Medical Policy Committee
01/01/2018	Coding update	Administrative Review
07/01/2018	Policy revision without position change	Medical Policy Committee

Definitions of Decision Determinations

Medically Necessary: A treatment, procedure, or drug is medically necessary only when it has been established as safe and effective for the particular symptoms or diagnosis, is not investigational or experimental, is not being provided primarily for the convenience of the patient or the provider, and is provided at the most appropriate level to treat the condition.

Investigational/Experimental: A treatment, procedure, or drug is investigational when it has not been recognized as safe and effective for use in treating the particular condition in accordance with generally accepted professional medical standards. This includes services where approval by the federal or state governmental is required prior to use, but has not yet been granted.

Split Evaluation: Blue Shield of California/Blue Shield of California Life & Health Insurance Company (Blue Shield) policy review can result in a split evaluation, where a treatment, procedure, or drug will be considered to be investigational for certain indications or conditions,

but will be deemed safe and effective for other indications or conditions, and therefore potentially medically necessary in those instances.

Prior Authorization Requirements (as applicable to your plan)

Within five days before the actual date of service, the provider must confirm with Blue Shield that the member's health plan coverage is still in effect. Blue Shield reserves the right to revoke an authorization prior to services being rendered based on cancellation of the member's eligibility. Final determination of benefits will be made after review of the claim for limitations or exclusions.

Questions regarding the applicability of this policy should be directed to the Prior Authorization Department. Please call (800) 541-6652 or visit the provider portal at www.blueshieldca.com/provider.

Disclaimer: This medical policy is a guide in evaluating the medical necessity of a particular service or treatment. Blue Shield of California may consider published peer-reviewed scientific literature, national guidelines, and local standards of practice in developing its medical policy. Federal and state law, as well as contract language, including definitions and specific contract provisions/exclusions, take precedence over medical policy and must be considered first in determining covered services. Member contracts may differ in their benefits. Blue Shield reserves the right to review and update policies as appropriate.