Aortic Aneurysm Disease in the Elderly

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7.1 Introduction

Aortic aneurysm disease has remained a challenging clinical pathology for centuries. The primary risk of aortic aneurysmal disease is death from rupture. Currently, there are no medical therapies that effectively prevent rupture, let alone induce regression of the diseased aorta. For decades, surgical repair of the aortic aneurysm has been the mainstay of therapy, at least in patients who were fit enough to tolerate this major operation. In the 1990s, Parodi et al. revolutionized the treatment of abdominal aortic aneurysms (AAA), and ultimately all aneurysm repairs, with the development of endovascular aortic aneurysm repair (EVAR) [1]. The development of this technology has consistently demonstrated decreased short-term mortality when compared to open repair [2]. The decrease in short-term mortality following EVAR, however, is offset by the need for increased rates of reintervention at later time points, which may add to the morbidity and cost of treating aneurysmal disease. With a decrease in perioperative mortality, questions are raised about the futility of treating higher risk patients who may not previously been offered repair – such as the aged population. These questions transcend the endovascular treatment of AAA, and with the evolution of the technology also apply to the endovascular treatment of thoracic aortic aneurysms (TEVAR) and to the use of fenestrated and branched endovascular therapy (F/-B-EVAR) to treat thoracoabdominal aortic aneurysms (TAAA). When considering endovascular or open surgery in the aging population, the untreated

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aneurysm should be considered the major driving factor in late mortality rather than a patient's other comorbidities [3]. With increasing ability to perform endovascular surgery, perhaps it is prudent to rephrase the question from "Will this patient survive the procedure?" to "Will the procedure prolong the patient's life?"

7.1.1 Definition of "Elderly" Men Versus Women

Elderly is typically defined as age >65 years. This definition is being challenged. For the US population, 65-year-old males have a life expectancy of 18 years and females have a life expectancy >20 years. Overall life expectancy at age 75 is 12 years, at 80 is 9 years, and at 85 years of age it is 6.1 years. For males, life expectancy is slightly lower than females: at age 75 is 11 years, at 80 is 8.2 years, and at 85 is 5.8 years. For females, life expectancy at age 75 is 13.6 years, at 80 is 9.7 years, and at 85 is 6.9 years [4]. As a general principle it has been determined that to garner a "benefit" for repair of aortic aneurysmal disease, patients must have a 2-year survival beyond the time of the repair. Based simply upon age at presentation, all patients would be deemed potential candidates for benefiting from aneurysmal repair.

7.1.2 Who Is at Risk?

It is difficult to define "high risk" with respect to patients with aneurysmal disease. Cigarette smoking is the strongest risk factor for aneurysm development. Other risk factors for the development of aneurysms include advanced age, obesity, atherosclerosis, positive family history, hypertension, and hyperlipidemia. In addition to identifying those at risk for developing aneurysmal disease, surgeons must also determine those who are at risk for repair of aneurysmal disease. Many of the risk factors for aneurysm development also make patient at higher risk for aneurysm repair. A recent review of the Vascular Study Group of New England database showed that advanced age, presence of cardiac disease, COPD (on home oxygen), and renal disease (GFR <30) significantly alter the risk benefit profile away from offering repair. Specifically, the presence of COPD on home oxygen had (hazard ratio of 3, CI 2–4.5, $p < 0.001$), unstable angina or recent MI (hazard ratio [HR] 4.2, CI 1.7–10.3, $p < 0.001$), chronic kidney disease with GFR < 30 (HR 3, CI 1.9–4.7, $p < 0.001$) suggested unsuitability for repair. Age 75–79 had a hazard ratio of 2 (confidence interval [CI] 1.4–2.8, $p < 0.001$), age > 80 (CI 2.7, CI 1.8–3.7, $p < 0.001$) [5]. In this study, the authors found that presence of two or more risk factors was associated with a survival of less than 50% at 5 years despite repair. The authors also found that aspirin and statin use were protective factors, associated with improved survival.

Factoring into the "high risk" equation is determining whether a patient is fit for open surgery. Patients considered unfit for open surgery tend to be offered an endovascular repair. Although it seems intuitive that presence of medical comorbidities and degree of anatomic complexity would determine fitness for open surgery, certain studies challenge this assumption [6].

7.1.3 Basic Indications for AAA, DTAA, and TAAA Repair

An aneurysm is defined as a dilation of an artery greater than 50% beyond its normal diameter. A true aneurysm involves the intima, media, and adventitia of the artery. Fusiform aneurysms are characterized by a symmetric, circumferential dilation, while saccular aneurysms develop as an outpouching of a single portion of the arterial wall. The aorta is considered aneurysmal at 3 cm, or greater than 50% increase in maximum transverse diameter. Several large studies have demonstrated a low risk of rupture in AAA smaller than 5 cm. In the ADAM trial, patients aged 50–79 with aneurysms 4−5.4 cm in size were randomized to surveillance or immediate open repair. Even though operative mortality was low (2.7%), there was no survival benefit for open repair of AAA less than 5.5 cm [7–9]. By convention, aneurysms are typically repaired in asymptomatic patients with fusiform aneurysms when the size is greater than or equal to 5.5 cm. Aneurysm growth more than 1 cm/year is also an indication for repair. Symptomatic, mycotic, and saccular aneurysms are indications for repair due to unpredictable propensity for rupture.

The risk of thoracic aortic aneurysms is not only rupture, but aneurysms in this location also carry with them the risk of dissection. Risks of TAA vary depending upon their anatomic location, varying among ascending, arch, descending, and thoracoabdominal classifications. An understanding of the natural history of the disease in these locations is growing. It is interesting to note that aneurysms in the descending and thoracoabdominal regions have higher growth rates than those in the ascending or aortic arch (0.19 cm/year vs. 0.07 cm/year) [10]. Similar elevated growth rates were identified for those that had dissections compared to those without (0.14 cm/year vs. 0.09 cm/year). Patients with an initial TAA size of 6 cm were associated with nearly a four-fold increase in the rate of rupture. The rate of descending TAA rupture approaches 7% per year and death from rupture 12% per year for those with an aneurysm size of 6 cm [11]. Other univariate predictors of rupture include location of the TAA in the descending or thoracoabdominal aorta and history of AAA, while male gender was protective [10]. Other risk factors for rupture include smoking, chronic obstructive pulmonary disease, age, hypertension, and renal failure [12]. Given these data, it is frequently recommended that repair of descending TAA occur when the aneurysm diameter reaches 6 cm – although other patient-related factors must be taken into account. Thoracoabdominal aortic aneurysms have high risk of perioperative morbidity and mortality with elective operations; however, age alone should not be a contraindication for repair because the complication and mortality rates in the elderly population for emergency surgery become exceedingly high. For example, the 1-year mortality is 35% in patients 70–79 years following elective TAAA repair. This increases to 40% in patients 80–89 years of age. The 1 year mortality increases to 69% when an emergency operation is performed [13].

7.1.4 Preoperative Evaluation

The goal of aneurysm repair is to reduce risk of death from rupture. Patient comorbidities factor into estimating the degree in which someone will benefit from prophylactic repair. Patients with a high risk of rupture and minimal comorbidities should be offered repair. The preoperative work up is discussed more thoroughly in another chapter (See Chap. 2 in this book, *Preoperative optimization of the elderly patient prior to vascular surgery*). Briefly, a thorough history and physical will help target specific problems that need to be addressed before surgery. A complete blood count, basic metabolic panel, and PT/INR are typically performed. An ECG helps to identify those at increased cardiac risk. Dipyridamole-thallium imaging or dipyridamole stress echocardiography may be useful in patients with intermediate to high cardiac risk undergoing vascular surgery. A chest x-ray is useful to evaluate for occult malignancy in patients with a history of cigarette smoking. Pulmonary function tests have shown benefit in patients with COPD undergoing cardiac surgery, although the data for AAA repair are less clear [14].

7.1.5 Discussion of How Age Influences Decision-Making

Although advanced age is one of the risk factors for decreased survival after aortic aneurysm repair, it is often linked to other comorbidities. Increased age alone does not necessarily confer decreased survival. EVAR can be performed with acceptable risk even in patients >85 years [15].

EVAR offers a decrease in short-term mortality compared to open repair at the expense of increased secondary interventions [2]. Surveillance after EVAR usually includes serial CT scans with IV contrast, which is a concern in the elderly population whose renal function may already be impaired. Repeated exposure to IV contrast during secondary interventions and CT scans can threaten renal function to the point of needing dialysis. For this reason, some screening protocols use ultrasound for post-EVAR surveillance to detect aneurysm sac enlargement and presence of endoleaks. CT scans are typically performed at 1, 6, and 12 months and yearly thereafter. Because renal function decreases with increasing age, alternative screening and surveillance protocols using duplex ultrasound may be considered [16].

Open repair of a ruptured aneurysm carries a mortality of 59% and in-hospital mortality of 72% in patients over 80 years of age [17]. Elderly patients are at increased risk for development of delirium. A contemporary study showed decreased delirium following EVAR, compared to open repair [18].

7.1.6 Using Frailty Scores to Risk Stratify and Counsel Patients in Clinic

Because age alone is not a consistent, reliable predictor of outcomes, clinicians have looked at other metrics. In a landmark study, Fried et al. described frailty as a clinical syndrome with three or more of the following criteria: unintentional weight loss (10 pounds in past year), self-reported exhaustion, weakness, slow walking speed, and diminished physical activity. This study, performed in a community setting, showed that presence of frailty was an independent predictor of falls, disability, and death. This study laid the groundwork for future research by showing that presence of comorbidities are risk factors for the development of frailty and that disability is an outcome of frailty, rather than previous notions that frailty, comorbidity, and disability were synonymous [19]. The concept of frailty has moved to the surgical setting, and a recent study found that frailty is an independent risk factor for morbidity and mortality in cardiac surgery patients. The effect of frailty was not dependent on age of the patient [20]. In conclusion, using frailty scores in clinic can help with appropriate patient selection.

7.2 Abdominal Aortic Aneurysm

Abdominal aortic aneurysm is a disease of elderly patients, which begs the question: when is a patient too old for surgery? Although recent publications have stratified according to type of repair and age at time of surgery, the answer remains unclear. What is clear, however, is that 3-year survival in patients with AAA > 5.5 cm turned down for repair is a staggering 17%, with half of all deaths attributable to aneurysm rupture [21]. Current repair strategies continue to offer either open, conventional surgery or endovascular therapy with EVAR. Open surgery requires either a trans-abdominal or retroperitoneal approach with cross-clamping of the aorta in order to halt blood flow thus allowing the aneurysm to be opened and replaced with a graft comprised of artificial material (Fig. 7.1). Alternately, the aneurysm can be repaired in a less-invasive fashion using an endograft (Fig. 7.2). This approach calls for a graft to be inserted through the femoral arteries into the aorta obtaining a seal above the aneurysm in the infrarenal aorta and below the aneurysm, typically in the iliac arteries. This is accomplished either through small incisions over the femoral arteries or in a percutaneous fashion.

Endovascular abdominal aortic aneurysm repair (EVAR) has continued to evolve since it was first described in 1991 [1]. The operative technique and technology has undergone several major advancements, and EVAR is now felt to be a safe and feasible alternative to open repair. Three randomized prospective trials have evaluated EVAR compared to open surgery including EVAR1, the Dutch Randomized Endovascular Aneurysm Management (DREAM) trial, and the Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group [22–24]. All three were randomized, prospective trials that enrolled patients who were deemed fit to undergo open surgical repair of an AAA to either EVAR or open repair. All three studies demonstrated lower 30-day mortality rates that were lower in the EVAR group (0.5–1.7%) compared to the open surgical arm (3–5%). By 2 years, however, these differences resolved and survival after EVAR and open surgery were similar. Patients undergoing EVAR, however, had shorter hospital stays, had shorter operative durations, and required fewer blood transfusions. EVAR patients did have increased exposure to fluoroscopy and contrast. Given its promising initial results, it is not surprising that EVAR has become increasingly popular over the past decade.

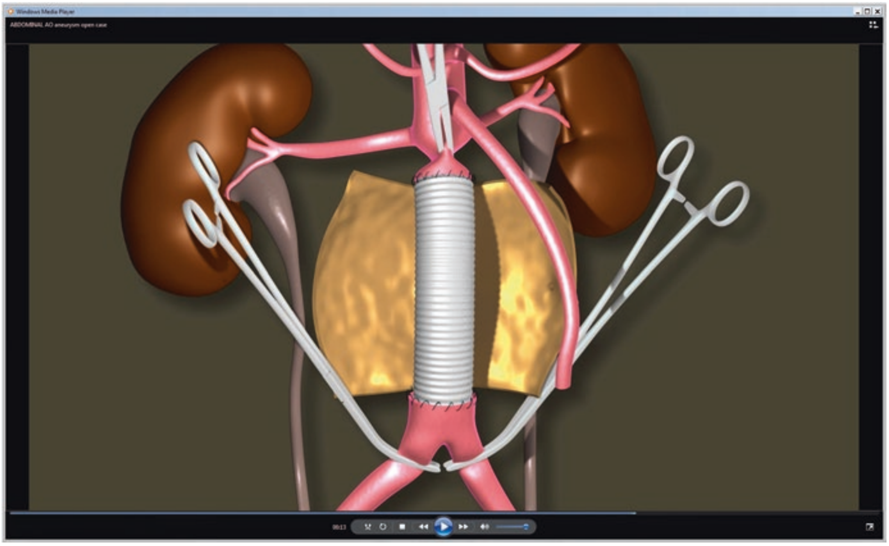

Fig. 7.1 Illustration of an open repair of an abdominal aortic aneurysm. This is accomplished through either a transabdominal or retroperitoneal approach. The aneurysm is exposed and the nonaneurysmal aorta above the aneurysm and iliac arteries below the aneurysm are occluded with vascular clamps. The aneurysm is opened longitudinally and an artificial graft is sutured in place. The aneurysmal segment is not typically resected, but the tissue can be wrapped around the graft material providing an additional layer of biologic material (not pictured)

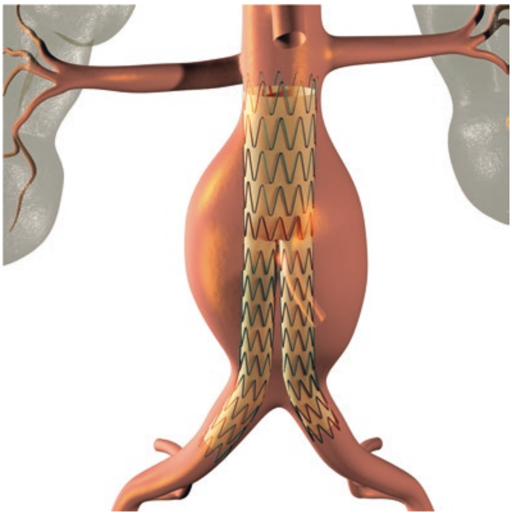

Fig. 7.2 An illustration of an abdominal aortic aneurysm that was repaired with an endograft. The endograft is inserted, in pieces, either through small incisions over the femoral arteries or in a percutaneous fashion. The main body is deployed in the neck of the aorta, below the level of the renal arteries, above the level of the aneurysm. The metal framework of the stent graft provides a radial force that helps it achieve a durable seal and fixation in this location. Extension limbs are then placed that extend into the iliac arteries for a distal seal and fixation

One of the most controversial aspects of AAA repair, however, is when to perform EVAR and when to perform conventional open surgery. Open surgical repair of AAA has long been considered the gold standard, and there is evidence that this option provides good long-term durability [25, 26]. EVAR, however, relative to open surgery, does not have similar time-tested outcomes data. Recently, longer-term outcomes from both EVAR1 and DREAM have been reported [27, 28]. For EVAR1 [27], the median follow-up was 6 years (5–10 year range), and at follow-up the overall aneurysm-related mortality was 1.0 deaths per 100 person-years in the EVAR group and 1.2 deaths per 100 person-years in the open repair group ($p = 0.73$). All-cause mortality was 7.2 deaths per 100 person-years (EVAR) and 7.1 deaths per 100 person-years (open surgery). Graft-related complication rates were higher in the EVAR group (12.6 per 100-person-years) compared to the open surgical arm (2.5 per 100 person-years, $p < 0.001$), and significantly more patients in the EVAR group required re-intervention (5.1 per 100 person-years vs. 1.7 per 100 person-years, $p < 0.001$). In fact, new graft-related complications and re-interventions were reported for as long as 8 years following EVAR. For DREAM [8], at a median follow-up of 6.4 years (5.1–8.2 years), cumulative survival rates were 69.9% for open repair and 68.9% for EVAR. The cumulative rates of freedom from secondary interventions were 81.9% for the open repair group and 70.4% for EVAR ($p = 0.03$). Based on this data, it is clear that EVAR is not without its drawbacks. These factors may change as the technology improves and as we gain a better understanding of the long-term implications of placing an endovascular graft in the aorta. Given this, there is debate over whether repair with endovascular therapy is as durable as conventional repair, and it is not entirely clear when one approach should be used over another. This is especially true for the aged population in which there may be potentially higher risks associated with major surgery.

7.2.1 Open Repair Versus EVAR in Octogenarians

A recent retrospective study from France looked at patients 85–93 years of age undergoing both EVAR and open AAA repair [15]. This population comprised 6% of all AAA repairs at the authors' institution during the study period. Fifty-six percent of patients underwent EVAR, 44% underwent an open repair. Thirty-day mortality was 6.7% (6% with EVAR, 7.6% open repair). Although the mortality was similar, perioperative morbidity in the open repair (OR) group was much higher (42% vs. 15%) than in the EVAR group. Complications in the OR group included MI, respiratory insufficiency, renal failure, stroke, and multiple organ failure. The EVAR group had a higher incidence of midterm complications, which was mostly related to appearance of type II endoleak. Overall survival was 53% at 5 years [15]. Perioperative mortality is higher but considered acceptable in octogenarians when looking at both open and endovascular AAA repair when compared to patients <80 years [29]. EVAR is safe in octogenarians, with a 30-day mortality of 1.5% in a large database. Not surprisingly, octogenarians do experience a significantly longer hospital stay [30]. EVAR can be performed with low perioperative mortality leading some to prefer an endovascular approach [31]. Another study showed no significant difference in operative mortality or long-term survival comparing open repair with EVAR, however, which suggests that either approach may be effective in appropriately selected patients [32].

7.2.2 Open Repair Versus EVAR in Nonagenarians

A review of the Nationwide Inpatient Sample Database evaluated mortality in patients >90 years compared to patients 18–89 undergoing AAA repair. Mortality in patients >90 undergoing open AAA repair was 18.3% compared to 4.6% in patients <90. EVAR in nonagenarians carried a 3.1% mortality compared to 1.2% mortality in patients <90. The authors concluded that EVAR in nonagenarians is preferable to open repair. EVAR in nonagenarians was associated with a higher complication rate compared to younger patients in a recent systematic review [33]. Thirty-day mortality was 4%, considerably higher than the 1.8% mortality in the pivotal EVAR trial and 5-year mortality was 17% [27]. Although complications are higher in the >90 group compared to younger patients, EVAR carries substantially lower mortality compared to open repair and should be offered selectively to appropriate surgical candidates.

7.3 Thoracic Aortic and Thoracoabdominal Aortic Aneurysms

Thoracic aortic aneurysms and their relative the thoracoabdominal aortic aneurysms provide an even greater clinical challenge. Conventional open repair remains a major invasive surgical operation with significant inherent risk. This is frequently related to the requirement of a thoracotomy and the subsequent pulmonary morbidity associated with this in those undergoing TAA repair. TAAA repair has the added morbidity of requiring revascularization of the visceral vessels leading to increased rates of post-operative renal failure and spinal cord ischemia. Similar to AAA, endovascular approaches to these pathologies may significantly alter the short-term outcomes and allow for treatment of those patients at high risk for conventional surgery. Pivotal trials analyzing the outcomes of TEVAR for TAA have demonstrated that endovascular approaches demonstrate a marked reduction in 30-day mortality rates [34–36]. This may translate into reduced long-term aneurysm-related mortality, but not all-cause mortality. Whether these results translate to improved outcomes for the elderly will be discussed in more detail below.

7.3.1 Open Descending TAA and TAAA Repair

Conventional surgery for descending TAA (DTAA) and TAAA has not been limited due to patients' advanced age, but there are limited analyses of outcomes in the markedly aged population. Di Luozzo and colleagues have reported on the outcomes of septuagenarians and octogenarians undergoing repair of DTAA and TAAA [37]. In this series of 93 patients over a 6-year period of time, 22 (24%) had open repair of DTAA, while 71 (76%) underwent TAAA repair. Perioperative mortality was 13.6% for the DTAA group, while those undergoing more extensive repair had a higher rate of 15.5%. Interestingly, the in-hospital mortality was greater in the septuagenarians (16%) compared to the octogenarians (11%). Factors associated with mortality included pneumonia, tracheostomy, and acute respiratory distress syndrome. Long-term survival was equivalent to that of a normal age- and gender-matched population, and male gender provided a survival benefit. Similarly, Huynh and colleagues evaluated the outcomes of patients over the age of 79 years undergoing DTAR and TAAA repair [38]. A total of 56 patients between the ages of 79 and 88 years of age underwent open repair of the descending thoracic aorta ($N = 16$, 29%) or thoracoabdominal aortic aneurysms ($N = 40$, 71%). This represented only 6.6% of the patients undergoing these procedures during that time. Overall 30-day mortality was a striking 25% but was higher in those considered high risk (emergent presentation, diabetes, or congestive heart failure) at 50% compared to those lacking any of these risk factors at 17%. This mortality rate, however, is higher than previously reported for all consecutive patients from this institution (14%) [38]. The mean 5-year actuarial survival rate for this group was 48%. Similar results, however, with a 30-day mortality rate of 21% and a mean survival rate of 61% in patients over 70 years of age, have been reported [39].

7.3.2 Thoracic Endovascular Aneurysm Repair

There are few analyses comparing open repair of DTAA and TEVAR in the markedly aged population. The University of Michigan evaluated outcomes in 93 patients aged 75 years and older undergoing either open ($N = 41$) or endovascular ($N = 52$) descending aortic repair between 1993 and 2008 [40]. Selection criteria for entry into this study were indications for operations were identical in both groups, the extent of pathology was confined to the left chest distal to the left carotid artery, and all patients were initially evaluated for open repair by a thoracic surgeon. The option for TEVAR was offered to patients who were deemed high risk for conventional surgery, who had localized pathology, or who specifically requested endovascular repair. Final suitability for TEVAR was determined by a collaborative multidisciplinary team. While the mean age of the whole group was nearly 79 years, the group undergoing TEVAR were older, had smaller thoracic aortic aneurysms, and had a higher incidence of COPD and prior infrarenal AAA repair. The procedure was observed to be elective in only 63% of patients, and contained rupture was more frequently seen in the TEVAR group (26.9% vs. 4.9%, $p = 0.005$), but a larger proportion of patients undergoing open repaired had an aneurysm involving the distal aortic arch. Technical success was observed in 96% of patients undergoing TEVAR. There was a trend to reduced perioperative mortality in those undergoing TEVAR (5.8% vs. 17.1%, $p = 0.1$), and the incidence of stroke was the same for both groups (14.6% vs. 9.6%, $p = 0.53$). Spinal cord ischemia and renal failure were rare events overall. Crude mortality at last follow-up was 45%, and Kaplan-Meier estimates demonstrate no difference between the open and endovascular cohorts. Endoleaks were observed in 23% of the TEVAR group, and five patients had indications for conversion to open surgery but were considered non-operative candidates. The authors concluded that TEVAR may be a more suitable therapeutic option in this complex elderly group.

7.3.3 F/B-EVAR for Juxtarenal and TAAA

Fenestrated and branched endograft repair began in 1999 in patients with infrarenal aortic necks that were too short for traditional EVAR. The technology has evolved to allow for the treatment of juxtarenal AAA to more complex thoracoabdominal aortic aneurysms. These endovascular surgeries allow for a less-invasive approach to complex AAA and TAAA treatment, but add a complexity of requiring preservation of flow to the renal and/or visceral vessels depending upon the extent of the aneurysm undergoing repair. The preservation of flow is accomplished by incorporating fenestrations or branches on a conventional stent graft (Fig. 7.3). These are connected to their target vessels using a self-expanding or balloon-expandable bridging stent graft. While still fairly early in its development, these procedures have been used to treat patients considered high risk for conventional surgery [3].

A U.S. multicenter trial evaluated fenestrated endograft repair of juxtarenal AAA. Mean age at the time of repair was 74 years and mean aneurysm diameter was 6 cm. Thirty-day mortality was 1.5%. Freedom from all-cause mortality at 5 years was 91%. This multicenter prospective trial showed that fenestrated endograft repair for short-necked AAA can be done with low mortality in experienced hands [41]. Other analyses have analyzed extensive aneurysm repair involving juxtarenal aneurysms as well as TAAA. The French multicenter experience represented a medium-term outcome assessment of prospectively collected data on 134 patients deemed high risk for conventional repair from 16 French academic centers treated between 2004 and 2009 who underwent fenestrated aortic endografting [42]. Unlike the U.S. trial, while the majority of patients were treated for juxtarenal AAA (74%), inclusion of more extensive aneurysms including suprarenal (20%) and type IV TAAA (6%) were included. Median age for this cohort was 73 years (range 48–91 years). Completion angiography confirmed 99% of the target vessels were patent with occlusion of four renal arteries and one celiac artery. Two patients required permanent hemodialysis post-operatively, one related to thrombosis of a renal artery. There was one conversion to open surgery secondary to aortic bifurcation occlusion. The 30-day mortality rate was 2%. Two patients died secondary to multisystem organ failure as a consequence of ruptured iliac artery ($N = 1$) and conversion to open surgery ($N = 1$), while one patient suffered a suspected myocardial infarction after discharge. Twelve- and 24-month survival was 93% and 86%, respectively, with no aneurysm-related mortalities.

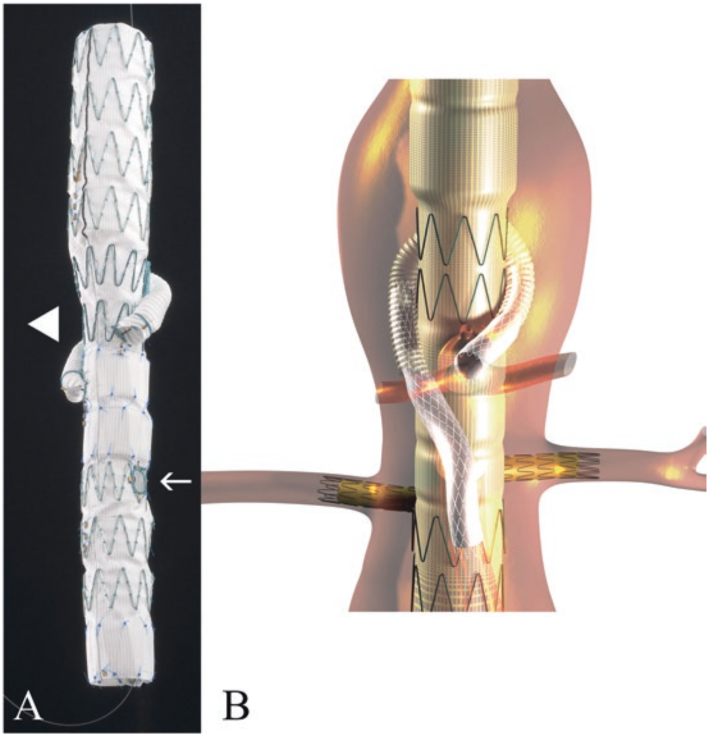

Fig. 7.3 For more complex, extensive abdominal aortic aneurysms, or for thoracoabdominal aortic aneurysms, in which the disease involves the renal or visceral vessels, fenestrated/branched endograft are used. (**a**) Typically these are custom-made grafts that incorporate fenestrations (*arrow*) or directional branches (*triangles*) to allow for preservation of flow to the renal and visceral arteries. (**b**) An illustration of a device with two directional branches and two fenestrations used to treat a thoracoabdominal aortic aneurysm. The branches and fenestrations are mated with their corresponding renal or visceral vessels using balloon-expandable or self-expanding bridging stent grafts

The WINDOWS trial represents the early outcomes of patients treated with fenestrated/branched endografts for complex AAA and TAAA aneurysms in France [43]. This was a multicenter, prospective, single-arm trial of F/B-EVAR for complex aneurysms performed on 268 patients from eight centers between 2009 and 2012. The mean age of those undergoing repair was 72 ± 8.5 years. The population was divided into one of three groups depending on the extent of aneurysm treated: Group 1 ($N = 184$) juxtarenal (51%) and pararenal (18%); Group 2 ($N = 42$) suprarenal (6%) and type IV TAAA (10%); and Group 3 ($N = 42$) type III TAAA (9%), type II TAAA (6%), and type I TAAA (1%). The 30-day mortality rate was 6.7%, and the in-hospital mortality rate was 10.1%. Severe complications occurred in 5.6% of patients and were associated with a 93% mortality rate. Acute renal insufficiency occurred in 18% of patients. Thirty-one (11.6%) patients required aneurysm-related re-intervention due to lower limb ischemia, hemorrhages, infection, and lymphocele. The 30-day combined mortality and severe complications was 22%. The presence of a more extensive aneurysm was predictive of in-hospital mortality, as was the duration of surgery and post-operative events.

In a recent review of 610 patients (349 patients with type IV repair, 258 patients with juxtarenal AAA repair, 3 unclassified) long-term outcomes of fenestrated/branched endograft repair was assessed. At 8 years of follow-up, survival was 20% and aneurysm-related mortality was 2%. The authors concluded that endovascular repair of juxtarenal and type IV TAAA using fenestrated and branched endografts is safe and durable [44]. Another article stressed the importance of selecting patients with appropriate anatomy. Sealing the proximal landing zone in unhealthy aorta or in the juxtarenal aorta was associated with increased risk for type 1a endoleak development. Although the incidence was low, patients with type 1a endoleak (2.8%) had significantly higher aortic-related mortality than those without endoleak (26.9% vs. 6.2%, $p = 0.001$) [45].

There is only one analysis specifically evaluating fenestrated/branched endograft repair in the elderly. In a review of 288 patients undergoing fenestrated branched endovascular aneurysm repair, 11% of the patients were greater than 80 years of age. There were no statistically significant differences in comorbidities between the two groups. The 30-day mortality was higher in the octogenarian group (9% vs. 1.6%, $p = 0.04$). All of the patients who died within 30 days in the octogenarian group had undergone a secondary procedure [46]. The authors conclude that F/B- EVAR is a satisfactory choice of treatment in patients expected to live >2 years. They cautioned that octogenarians with challenging anatomy (who are at higher risk for needing secondary procedures) should be treated with discretion.

7.3.4 Functional Recovery and Quality of Life

The physiologic consequences of open DTAA and TAAA repair are poorly tolerated in the aged population. As the perioperative care of patients improves, in-hospital mortality will continue to decline, and thus more patients will survive in the short-term. The success of these surgeries, however, is not just based on the acute outcomes, but also on the ability to return the elderly patient to the preoperative functional status. Given that, the long-term quality of life improvement is called into question. Quality of life after DTAA and TAAA repair in patients in their 70s and 80s has recently been evaluated by Di Luozzo and colleagues [37]. In a cohort of 48 patients that underwent open repair, 43 patients were living in their homes with family, four were living outside the United States, and one patient was in a nursing home. At a median of 4.1 years from the date of surgery (range 1.1–7.1 years), patients scored slightly lower on quality of life assessment compared to matched United States population, although these did not meet statistical significance. The area of greatest difference was in overall vitality.

7.3.5 Surveillance Protocols

EVAR surveillance typically includes yearly surveillance with CT scans using IV contrast, which can exacerbate underlying renal insufficiency in the aging population. Surveillance using ultrasound has been proposed as a reasonable alternative [15]. The ideal surveillance protocol should be inexpensive, non-invasive, highly sensitive and specific to detect endoleaks, aneurysm growth, and other complications of endovascular repair and should be safe for the patients. Contrast enhanced computed tomography (CTA) is considered the gold standard for surveillance following EVAR. The drawbacks include radiation exposure, contrast nephropathy, and cost. Although Doppler ultrasound (DUS) is less sensitive, it is less expensive and avoids nephrotoxic agents. These qualities make it especially appealing in the elderly population. One institution has modified their protocol using abdominal x-ray and DUS for octogenarians, an approach which has been validated in the general population as well [47, 48]. At our institution, we use color Doppler US + non-contrast CT scan for patients with decreased renal function, which may be an appropriate protocol for elderly patients in general.

Key Points

- Candidacy for aneurysm repair cannot be determined based strictly on age.
- In addition to advanced age, "high risk" factors include cardiac disease, COPD, renal disease, obesity, and unstable angina or recent MI.
- The goal of aneurysm repair is to reduce the risk of death from aneurysm rupture.
- EVAR offers a decrease in short-term mortality, which may be beneficial to patients at "high-risk" for conventional surgery.
- Long-term EVAR is associated with higher rates of re-intervention.
- Open surgical repair of AAA is safe in physically fit elderly patients but is associated with higher perioperative morbidity and mortality.
- While open repair of thoracic aortic aneurysms is possible in the elderly, overall TEVAR appears to be associated with improved perioperative survival.
- Fenestrated and branched aortic endografting is a durable option for patients who present with juxtarenal and thoracoabdominal aortic aneurysms, and it may be particularly beneficial in elderly and high-risk patients.

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