ORIGINAL ARTICLE

Endovascular Aortic Aneurysm Repair in the Octogenarian

Is It Worthwhile?

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Hypothesis: During the past decade, endovascular stent graft repair (EVSG) of abdominal aortic aneurysms has emerged as a less invasive and less morbid alternative to open surgical repair. We hypothesize that EVSG may become the treatment method of choice among patients older than 80 years.

Design: Retrospective case series.

Setting: Major academic medical center with extensive experience in endovascular and open aortic aneurysm surgery.

Patients and Methods: During a 5-year period, EVSG was performed in 595 patients at our institution. One hundred fifty (25.2%) of these patients were older than 80 years. Our prospectively acquired database was reviewed with respect to the demographic, intraoperative, and outcome data of this elderly population.

Main Outcome Measures: Technical and clinical success, aneurysm-related events (aneurysm-related death, type I or type III endoleaks, aneurysm expansion, or aneurysm rupture), and secondary interventions.

Results: There were 119 men (79.3%) and 31 women (20.7%) (mean age, 84.6 years). Mean aneurysm diameter was 6.7 cm. Comorbidities including chronic obstructive pulmonary disease, coronary artery disease, chronic renal insufficiency, peripheral vascular disease, hypertension, and hypercholesterolemia were common in these patients, with an average of 2.9 comorbid conditions per patient. Mean follow-up was 16.9 months (range, 1.0-61.4 months). One hundred forty-six patients (97.3%) received only regional anesthesia, and the average intraoperative blood loss was 369 mL. Average hospital and intensive care unit stays were 2.5 days and 0.1 day, respectively. The procedure was performed emergently in 3 patients, and each recovered uneventfully. There were 5 aborted procedures (3.3%) for technical reasons and 4 conversions to open aortic repair (2.6%). In addition to these aborted procedures, there were 2 additional technical failures resulting in a technical success rate of 95.3%. Endoleaks were common and included 9 type I (6.90%), 35 type II (24.10%), and 1 type III (0.69%). The majority either resolved spontaneously (type IIs) or with minimally invasive secondary intervention, which was performed in 13 patients. Perioperative local/vascular and systemic complications occurred in 16 (10.7%) and 8 (5.3%) patients, respectively. There were 5 perioperative deaths (3.3%)(<30 days postoperatively). Forty late deaths (26.7%)(>30 days postoperatively) occurred, which were unrelated to the EVSG procedure.

Conclusions: Endovascular repair of abdominal aortic aneurysms can be performed safely and successfully in the majority of octogenarians with relatively low complication rates. Improved EVSG devices and operator experience may make this procedure the treatment method of choice for patients in this age group who meet specific anatomical criteria.

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AMERICANS OLDER THAN 75 years are now the most rapidly growing age group.[1] The number of adults older than 85 years is expected to increase from approximately 4 million in 2000 to more than 18 million in 2050 and possibly to more than 37 million by 2100.[2] This represents an increase from 3.4% of the current US population to almost 10% during the next century. As a result, more elderly patients will likely be diagnosed with abdominal aortic aneurysms (AAAs). Considering that an 80-year-old individual in the general US population can be expected to live another 6 to 7 years, the optimum treatment for these elderly patients with AAAs must be determined.

Improvements in surgical and anesthetic techniques have resulted in acceptable mortality rates among octogenar-

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ians undergoing elective open AAA repair (**Table 1**); however, morbidity and mortality rates remain higher than in younger patients.[3,4,6,10] Nonetheless, numerous studies have supported an aggressive approach toward elective aneurysmectomy in octogenarians because of the prohibitive mortality rates of emergency surgery in this age group, which ranges from 32% to 91% in various reports.[3,4,6,10,11-15] Moreover, the majority of octogenarians undergoing elective aneurysmectomy maintain their preoperative quality of life, live longer than those with untreated AAAs, and have life expectancies equal to age- and health-matched control subjects without aneurysmal disease.[3,6,11,13,16]

Despite this support in the literature for surgical treatment of AAAs, many octogenarians are not referred for surgery because they are considered medically unfit for the procedure.[17] Moreover, there appears to be a higher rate of aneurysm rupture among patients in this age group, possibly because they have inappropriately been denied treatment.[18] With the introduction and rapid evolution of endovascular technology, octogenarians and other high-risk patients may now have an alternative to open surgery. Much of the early and mid-term experience with these devices is promising and suggests that endovascular repair is associated with significantly lower morbidity rates. Two other reports in the literature[17,18] have specifically examined the role of endovascular stent graft repair (EVSG) in the octogenarian and have shown promising results. However, each of these studies included relatively small numbers of patients. This current study reexamines this technique in a large number of octogenarians cared for in a single high-volume center.

Table 1. Perioperative Mortality Rates Following Elective Open Surgical Repair of Abdominal Aortic Aneurysms in Octogenarians

Source	No. of Patients	Mortality Rate, %
Treiman et al,[3] (1982)	35	8.6
Paty et al,[4] (1993)	116	3.0
Akkersdijk et al,[5] (1994)	75	8.3
O'Hara et al,[6] (1995)	94	9.6
Van Damme et al,[7] (1998)	52	4.7
Kazmers et al,[8] (1998)	206	8.3
Dardik et al,[9] (1999)	246	7.3

Figure 1. Stent grafts used to treat infrarenal abdominal aortic aneurysms in 150 octogenarians. From left, Ancure (Guidant Corp, Menlo Park, Calif), AneuRx (Medtronic Inc, Santa Rosa, Calif), Gore Excluder (Gore and Associates, Flagstaff, Ariz), Vanguard (Boston Scientific Corp, Natick, Mass), Talent (Medtronic Inc), Teramed (Teramed Inc, Maple Grove, Minn), and the Parodi-Palmaz custom aorto–uni-iliac device.

METHODS

PATIENTS

All patients aged 80 years and older undergoing endovascular repair of AAAs from January 1997 to August 2002 were included in the study. Patients gave written informed consent and were treated in accordance with the approval of the institutional review board. All patients underwent preoperative contrast-enhanced computed tomography (CT) and arteriography to evaluate AAA anatomy. Patients were prospectively followed up, and data including demographics, aneurysm size, medical comorbidities, operative data, length of intensive care unit and hospital stays, endoleaks, complications, secondary interventions, and mortality rates were reviewed.

ARTERIAL MEASUREMENTS

All AAA diameter measurements were performed manually based on contrast-enhanced CT. The maximal outer vessel diameter was measured for each patient. In cases of torturous aortas with oblong cross-sections, the shortest cross-sectional diameter at that level was chosen.

DEVICES

A total of 145 stent grafts were placed in 150 patients (5 procedures were aborted). These patients were treated with 1 of 7 endovascular systems including 95 Talent (Medtronic Inc, Santa Rosa, Calif), 28 custom-made aorto–uni-iliac devices, 6 AneuRx (Medtronic Inc), 5 Ancure (Guidant Corp, Menlo Park, Calif), 4 Gore Excluder (Gore and Associates, Flagstaff, Ariz), 5 Vanguard (Boston Scientific Corp, Natick, Mass), and 2 Teramed (Teramed Inc, Maple Grove, Minn). Three configurations were used, including bifurcated (n=87), tube (n=16), and aorto–uni-iliac with femorofemoral bypass and contralateral common iliac artery occlusion (n=42) (**Figure 1**). The specific stent graft used, sizing, and configuration were chosen on the basis of preoperative CT and arteriography defining patient arterial anatomy.

OPERATIVE TECHNIQUE

All procedures were performed in the operating room with portable C-arm fluoroscopy. Access to the arterial system was via cutdown across 1 or both femoral arteries. Completion angiograms were obtained in all patients following deployment of the stent graft to confirm aneurysm exclusion.

FOLLOW-UP

Routine follow-up included plain anteroposterior and lateral abdominal radiographs and contrast-enhanced CT angiograms at hospital discharge; 1, 6, and 12 months after hospital discharge; and yearly thereafter (**Figure 2**). Aortography was performed in patients in whom a persistent endoleak or aneurysm sac expansion was detected.

OUTCOME REPORTING

Technical and clinical success were identified according to the 2002 Society for Vascular Surgery/American Association for Vascular Surgery (SVS/AAVS) reporting standards.[19] Technical success included periprocedural events occurring from the initia-

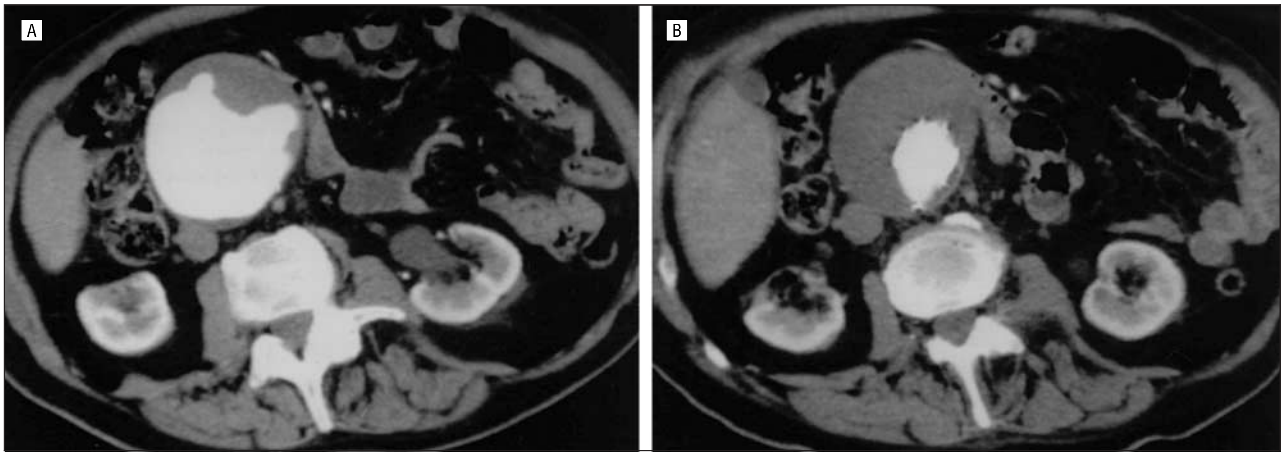

Figure 2. A, Preoperative computed tomography results from an 86-year-old patient with a 9-cm infrarenal abdominal aortic aneurysm. B, Computed tomography results from the same patient, 1 month following successful endovascular repair.

Table 2. Comorbid Illnesses

Risk Factor	No. (%) of Patients
Coronary artery disease	112 (74.7)
Chronic obstructive pulmonary disease	29 (19.3)
Hypertension	111 (74.0)
Diabetes mellitus, type I and type II	24 (16.0)
Renal insufficiency*	37 (24.7)
Tobacco use	45 (30.0)
Hypercholesterolemia	63 (42.0)
Cerebral vascular disease	10 (6.7)
Cirrhosis	1 (0.67)

*Defined as preoperative serum creatinine level higher than 1.6 mg/dL (>122 μmol/L).

tion of the procedure through the first 24 hours postoperatively and required the following: successful access to the arterial system using a remote site, successful deployment of the endoluminal graft with secure proximal and distal fixation, and no evidence for type I or type III endoleaks. In contrast to prior reporting standards, a type II endoleak was not considered a technical failure.[20] Clinical success required successful deployment of the endovascular device without death as a result of aneurysm-related treatment, no evidence of type I or type III endoleaks, and no aneurysm expansion (>5 mm), rupture, graft failure, graft migration, or conversion to open repair. Aneurysm-related death included any death resulting from aneurysm rupture, a primary or secondary endovascular procedure, or surgical conversion.

ENDOLEAKS

Endoleaks, defined as persistent blood flow outside the lumen of the stent graft but within the aneurysm sac, were also defined according to the most recent SVS/AAVS reporting standards.[19] Type I endoleaks result from ineffective seal at either the proximal or distal attachment zones. Type II endoleaks result from retrograde flow from lumbar arteries, a patent inferior mesenteric artery, or other collateral vessels. Type III endoleaks are caused by a tear in the graft fabric or disconnection of the modular components of the graft. Endoleaks were further classified according to their time of occurrence. Any endoleak discovered within the perioperative period (≤30 days) was defined as primary and initial detection thereafter, secondary.

STATISTICAL METHODS

Comparisons of preoperative and postoperative AAA sizes were made using the Wilcoxon signed rank test. A P value <.05 was considered significant. Survival curves were generated by the Kaplan-Meier method.

RESULTS

PATIENT DEMOGRAPHICS

A total of 595 AAAs were treated with endovascular grafts at our institution between January 1997 and August 2002. One hundred fifty patients (25.2%) were older than 80 years (mean ± SD age, 84.6 ± 3 years; range, 80-95 years). There were 119 men (79.3%) and 31 women (20.7%). These patients had multiple medical comorbidities with an average of 2.9 comorbidities per patient (range, 1-7) Preoperative medical risk factors are presented in **Table 2**.

ANEURYSM SIZE

Preoperative aneurysm diameter ranged from 4.8 to 12.5 cm with a mean ± SD aneurysm diameter of 6.7 ± 1 cm. Three patients (2%) were seen emergently with evidence of contained aortic rupture, and all underwent uncomplicated endoluminal repair. The remainder of the aneurysms were discovered incidentally and repaired electively.

PERIOPERATIVE RESULTS

The majority of procedures were performed under regional (spinal or epidural) anesthesia (n = 146; 97.3%). Mean ± SD intraoperative blood loss was 369 ± 327 mL (range, 40-2000 mL). Mean ± SD operative time was 216.5 ± 78 minutes (range, 80-475 minutes). Postoperative intensive care unit stay was necessary in 2 patients in whom an endovascular graft was successfully placed. Mean ± SD intensive care unit and hospital length of stay were 0.1 ±1.0 and 2.5 ± 4.0 days, respectively.

Technical success (as defined earlier) was achieved in 143 patients (95.3%). Technical failures included the inability to deliver the endovascular device into the aorta (n=2), deployment-related arterial injury (n=2), inadvertent renal artery compromise (n=1), immediate proximal type I endoleak (n=1), and postoperative graft limb thrombosis requiring thrombectomy (n=1) (**Table 3**). Other complications occurring within 30 days postoperatively were predominantly local/vascular in nature and included primary type I endoleaks (n=3), early graft limb occlusions (n=2), and minor wound complications including nonoperative hematomas (n=5) and lymphoceles (n=2). None of the 3 primary type I endoleaks were seen on the intraoperative completion arteriography results but became evident later in the follow-up CT scan results within 30 days. Two patients underwent successful endovascular reintervention to seal these leaks. The third died from pneumonia prior to undergoing secondary treatment.

Systemic complications occurred in 11 patients and were primarily cardiac, including myocardial infarction (4 fatal) and arrhythmia. Renal failure requiring dialysis occurred in 2 patients. In the first (mentioned earlier), a poorly positioned endovascular graft compromised perfusion to the renal arteries necessitating hepatorenal bypass, and the patient was discharged from the hospital 29 days later. The second patient with preoperative chronic renal insufficiency (serum creatinine level, 2 mg/dL [153 µmol/L]; normal range, 0.6-1.2 mg/dL [53-106 µmol/L]) developed worsening of his renal function postprocedure, followed by multisystem organ failure and death in the postoperative period. The remainder of systemic complications included urinary retention (n=1) and deep venous thrombosis (n=1), both of which prolonged the patients' hospital stay. Five patients (3.3%) died within the perioperative period.

LATE OUTCOME

Follow-up ranged from 1 to 61.4 months (mean±SD, 16.9±15 months). During this period, 6 secondary type I endoleaks occurred (**Table 4**). Four were successfully treated endovascularly (2 aorto–uni-iliac graft placements, 1 iliac limb extension graft, and 1 proximal extension cuff). A fifth patient who had undergone endoluminal placement of a tube graft 4 years previously developed a distal type I endoleak from dilation of the distal attachment site. A subsequent attempt at endoluminal repair failed because of the presence of severely diseased, tortuous iliac arteries. No further attempt at repair was undertaken given the patient's extremely poor health, and she died 3 months later from causes related to underlying heart failure. The sixth patient had been lost to follow-up and eventually was seen at an outside hospital with abdominal pain presumed to be related to his aneurysm. He underwent open repair and fully recovered. There was no evidence for aneurysm rupture. A single type III endoleak occurred during follow-up, 2 years postoperatively. Endovascular repair of this leak is currently planned. The 36-month rate of freedom from type I or type III endoleaks was 92% (**Figure 3**).

Thirty-five type II endoleaks (24.1%) were identified after endograft insertion. These consisted of 30 primary (20.7%) (occurring <30 days postoperatively) and 5 secondary (3.4%) (occurring >30 days postoperatively) type II endoleaks. Four patients (2.8%) received minimally invasive treatment of these type II endoleaks for evidence of aneurysm expansion (3 coil embolizations and 1 laparoscopic clipping of a patent inferior mesenteric artery). Twenty (57%) resolved spontaneously; 18 (90%) of those within 6 months. The remaining 11 patients with persistent type II endoleaks (7.8%) have been followed up closely with serial CT scans, which have not shown evidence for aneurysm expansion.

There was no increase in the aneurysm sac diameter in 139 patients (95.9%) in whom a stent graft was

Table 3. Perioperative Results*

Mean operative time, min†	217 ± 78
Estimated blood loss, mL†	369 ± 327
Anesthesia	
Regional‡	146 (97.3)
General	4 (2.7)
Mean intensive care unit stay, d†	0.1 ± 1
Mean hospital stay, d†	2.5 ± 4
Primary open conversions	3 (2.0)
Aborted procedures	5 (3.3)
Technical success	143 (95.3)
Initial clinical success	136 (90.7)
Perioperative mortality	5 (3.3)

*Values expressed as number (percentage) of patients unless otherwise indicated.
†Values expressed as mean ± SD.
‡Spinal or epidural.

Table 4. Late Outcomes (Occurring >30 Days Postoperatively)*

Secondary type I and type III endoleaks	7 (4.8)
Type II endoleaks	
Primary	30 (20.1)
Secondary	5 (3.4)
Persistent	11 (7.6)
Late open conversions	1 (0.67)
Aneurysm expansion†	6 (4.1)
Secondary interventions	21 (14.5)

*Values expressed as number (percentage) of occurrences.
†Growth of maximal aneurysm diameter greater than 5 mm.

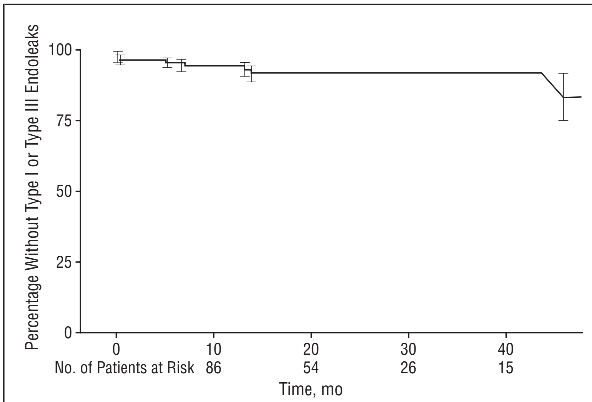

Figure 3. Rates of freedom from type I or type III endoleaks.

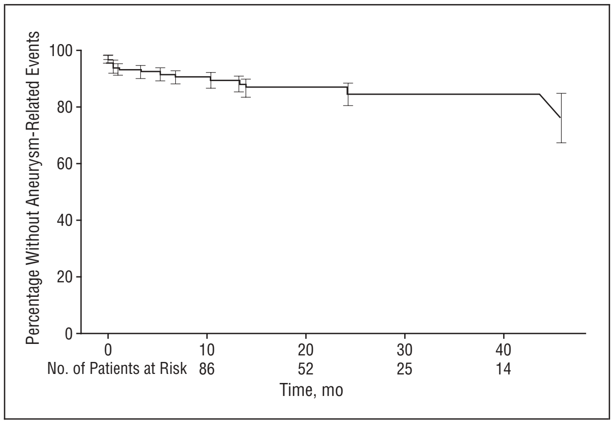

Figure 4. Rates of freedom from aneurysm-related events (ie, aneurysm-related death, aneurysm rupture, type I or type III endoleaks, or aneurysm expansion >5 mm).

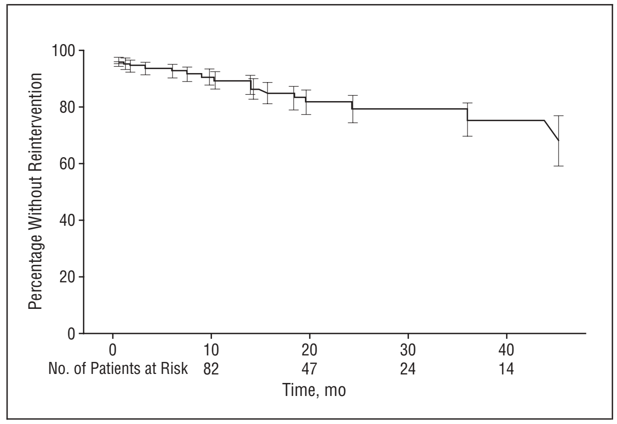

Figure 5. Rates of freedom from secondary interventions.

Table 5. Reinterventions

Type	No. (%) of Patients
Open surgery	8 (5.3)
Hepatorenal bypass	1
Exploratory laparotomy	1
Late open conversion for type I endoleak	1
Femoro-femoral bypass for isolated limb occlusion	3
Axillo-femoral bypass for isolated limb occlusion	2
Endovascular surgery	12 (8.0)
Extension cuff/graft	5
Coil embolization of type II endoleak	3
Coil embolization of type I endoleak	1
Iliac limb balloon angioplasty	2
Other	1
Other interventions	1 (0.67)
Laparoscopic inferior mesenteric artery clipping for type II endoleak	1

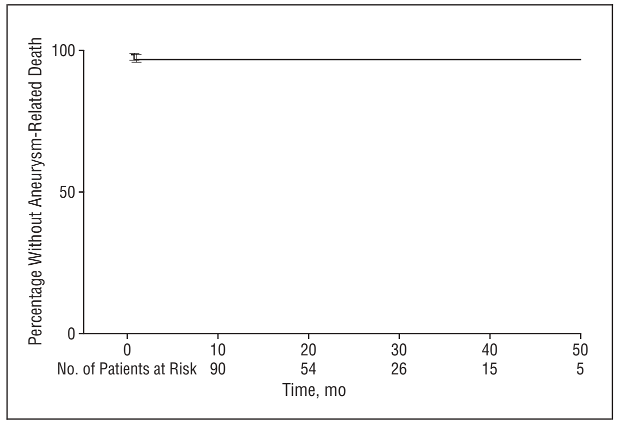

Figure 6. Rates of freedom from aneurysm-related death.

successfully placed. Mean aneurysm diameter decreased in all patients from 6.7 cm preoperatively to 6.1 cm at last follow-up ($P<.001$). Five of the 6 patients who experienced aneurysm growth had type I endoleaks, which were treated endovascularly. In the sixth patient, arteriography failed to identify an endoleak. Freedom from aneurysm expansion and aneurysm-related events (type I and type III endoleaks, aneurysm expansion, and aneurysm-related death) at 36 months postoperatively was 93% and 85%, respectively (**Figure 4**).

Secondary interventions were required in 21 patients (14.5%) and are listed in **Table 5**. The majority (13 of 21) were either minimally invasive or endovascular, with only 3 patients requiring laparotomy. The 36-month freedom from secondary intervention and need for surgical conversion were 75% and 96%, respectively (**Figure 5**).

Late deaths (>30 days postoperatively) occurred in 40 patients (26.7%). These late deaths were secondary to progression of the patient's medical comorbidities. Causes of late mortality included cardiac events (n=14), respiratory failure (n=5), malignancy (n=7), pneumonia (n=3), stroke (n=3), trauma (n=2), perforated viscus (n=2), sepsis (n=3), and pulmonary embolus (n=1). Overall freedom from aneurysm-related death at 36 months was 97% (**Figure 6**).

COMMENT

Since the first description by Dubost et al[21] in 1952, open surgical repair has been the gold standard treatment of AAAs. Through advancements in the surgical technique, anesthesia, and postoperative care, conventional aneurysmorrhaphy is now performed safely, durably, and with acceptable mortality rates in the majority of patients. Perioperative mortality rates for open AAA repair in the general population ranges from 1.4% to 8.0% in single-center and population-based reports.[6,22-24]

Although many authors have supported the conventional repair of AAAs in octogenarians, perioperative morbidity and mortality rates in this age group remain higher than in younger patients.[3,4,6,8,10,13-15,25] In fact, in one large series of 2335 elective AAA repairs, Dardik et al[29] demonstrated significantly higher mortality rates with advancing age ranging from 2.2% in patients in the sixth decade of life to more than 7.0% in octogenarians. Others have reported perioperative mortality rates as high as 9.6% in elderly patients[6] (Table 1). As the population ages and as diagnostic imaging improves, many more octogenarians will be diagnosed with AAAs and fewer invasive treatments with reduced morbidity and mortality rates will be needed.

Comparisons of conventional and endovascular repair of AAAs in the general population have shown that EVSG is associated with lower intraoperative blood loss and transfusion requirements as well as shorter hospital and intensive care unit stays.[26,27] Likewise, hospital and intensive care unit stays are often longer in octogenarians when compared with younger patients undergoing open repair. Falk et al[28] reported a mean intensive care unit stay of 1.8 days in octogenarians following elective conventional AAA repair. In our series, only 2 patients, in whom an endoluminal graft was successfully placed, required an intensive care unit stay (mean stay, 0.1 days). Moreover, mean hospital stay and estimated blood loss (2.5 days and 369 mL, respectively) in our series are both significantly less than that reported for open AAA repair in octogenarians.[27,28]

Two other published series have examined the role of EVSG in octogenarian patients. Sicard et al[18] examined 90 octogenarian patients, 38 of whom underwent conventional open repair and 52, endovascular repair. Technical success was achieved in 43 patients (83%) in the endovascular group compared with 85 (94.7%) in the conventional group. Much of this difference was accounted for by endoleaks. Estimated blood loss, mean intensive care unit stay, and overall hospital stay were all significantly lower in the endovascular group. Moreover, the perioperative complication rate was decreased by more than 70% in the endovascular group compared with the open repair group with much of this decreased morbidity as a result of fewer cardiac complications. Cardiac events represented half of all morbidity in the conventional open group and only 30% in the endoluminal group. In contrast, the majority of complications in the endovascular group were local/vascular problems, with endoleaks, graft thrombosis, lymphocele, and minor groin wound infections being the most common. These were treated with local surgical interventions or secondary endovascular procedures. Interestingly, mortality rates were equal in the 2 groups.

In another series, Lobato et al[17] examined the effect of endovascular AAA repair in 50 consecutive octogenarian patients and found similar results. Technical success for the series was 82%. Moreover, intraoperative blood loss, perioperative transfusion requirements, and intensive care unit and overall hospital stays were all significantly reduced compared with historical open repair control subjects—most likely because of the much less invasive nature of the procedure.

Our results support the conclusions reached by these other authors. Despite the high-risk nature of this group of patients, AAAs were successfully excluded in the majority of our patients for a technical success rate of 95.3%. This higher rate of technical success compared with the 2 earlier series may represent, in part, the use of a more recently adopted reporting standard than that used by the authors referenced earlier as well as more recent advancements in endovascular device technology. (Earlier standards considered type II endoleaks a technical failure.[19,20]) In addition, many of the device-related events occurred with the use of early-generation technology, much of which is no longer widely used. Importantly, the majority of deployment and graft-related complications were not life threatening, and major surgical reintervention was avoided in most patients. Systemic complication rates were low (5.3%), representing the much less invasive nature of the procedure compared with open repair. The perioperative mortality rate in our series was 3.3%, comparable to that of the other 2 endovascular series and similar to that of elective open surgery in the general population.

Late-mortality rates in our patients were high (n=40; 26.7%) with a mean 4-year survival rate of 43% by life-table analysis. All the late deaths were secondary to preexisting medical conditions, and none were related to aneurysm rupture or aneurysm-related treatment. This relatively high late-mortality rate reflects the overall poor medical condition of octogenarians with AAAs in this study. Nonetheless, treatment of AAAs in these patients appears justifiable based on reports of the natural history of untreated AAAs in the elderly population and the prohibitively high mortality rate of surgery for AAA rupture in this subset of patients. Conway et al[29] described a series of 106 patients turned down for conventional aneurysmorrhaphy. Eighteen of these patients were octogenarians, and their 3-year survival rate was only 17%, with more than 50% of these deaths occurring as a result of aneurysm rupture. Moreover, as aneurysm size increased, so did the risk of rupture-related death, which increased from 36% in patients with aneurysms less than 6.0 cm in diameter to 50% for aneurysms 6.0 to 7.0 cm and 55% for aneurysms greater than 7.0 cm in diameter. Therefore, the mean aneurysm diameter in our series of 6.7 cm may have predicted a high rate of rupture-related death if these patients had not been treated.

CONCLUSIONS

Because of considerable advancements in operative technique, anesthesia delivery, and perioperative management, conventional repair of AAAs is now commonly performed in elderly patients with acceptable mortality rates. Morbidity rates, however, remain significant, with cardiac events composing the major risk. With the introduction and rapid advancement of EVSG during the 1990s, elderly patients can now benefit from a significantly less invasive and better tolerated procedure to effectively exclude their aneurysm and prevent rupture with considerably less physiologic stress. Mortality rates remain similar to that of open surgery, but major complication rates are lower, allowing these patients to leave the hospital sooner and preserve their quality of life. This study, along with those of Sicard et al[18] and Lobato et al,[17] show that endovascular aneurysm repair is a safe and effective alternative to open surgery in the octogenarian and may become the preferred method of AAA repair in this rapidly growing and important group of patients. Advancements in device design and operator experience may be expected to further improve the results from EVSG procedures.

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