Endovascular aneurysm repair in nonagenarians is safe and effective

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Objectives: **Advanced age is a significant risk factor that has traditionally steered patients away from open aneurysm repair and toward expectant management. Today, however, the reduced morbidity and mortality of aortic stent grafting has created a new opportunity for aneurysm repair in patients previously considered too high a risk for open surgery. Here we report our experience with endovascular aneurysm repair (EVAR) in nonagenarians.**

Methods: **Retrospective chart review identified all patients >90-years-old undergoing EVAR over a 9-year period at our institution. Collected data included preoperative comorbidities, perioperative complications, endoleaks, reinterventions, and long-term survival.**

Results: **24 patients underwent EVAR. The mean age was 91.5 years (range 90-94) among 15 (63%) males and 9 (37%) females. Mean abdominal aortic aneurysm diameter was 6.3 ± 1.1 cm. Eight patients (33%) were symptomatic (pain or tenderness). There were no ruptures. Fourteen patients (58%) had general anesthesia while 10 (42%) had local or regional anesthesia. Mean postoperative length of stay was 3.2 ± 2.4 days (2.8 ± 1.9 days for asymptomatic vs 4.1 ± 3.2 days for symptomatic, $P = .29$). There was one perioperative mortality (4.2%). There were two local groin seromas (8.3%) and six systemic complications (25%). One patient required reintervention for endoleak (4.2%). There were no aneurysm related deaths beyond the 30-day postoperative period. Mean survival beyond 30 days was 29.7 ± 18.0 months for patients expiring during follow-up. Cumulative estimated 12, 24, and 36-month survival rates were 83%, 64%, and 50%, respectively. Linear regression analysis demonstrated an inverse relationship between the number of preoperative comorbidities and postoperative survival in our cohort ($R^2 = 0.701$), with significantly decreased survival noted for patients presenting with >5 comorbidities. Those still alive in follow-up have a mean survival of 36.1 ± 16.0 months.**

Conclusion: **This is the largest reported EVAR series in nonagenarians. Despite their advanced age, these patients benefit from EVAR with low morbidity, low mortality, and mean survival exceeding 2.4 years. Survival appears best in those patients with ≤5 comorbidities. With or without symptoms, patients over the age of 90 should be considered for EVAR.**
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Improvements in medicine have enabled the elderly to live longer, healthier, more productive lives than ever before.[1] As a result, the elderly are one of the fastest growing segments of the US population. By the year 2050, there will be an estimated 20.9 million Americans over the age of 85, representing 5% of the entire US population, up from just 1.5% in the year 2000.[2] With a current life expectancy of 6.4 years for 85-year-olds, it is projected that many octogenarians will live into their 10th decade.[3]

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Cardiovascular disease is one of the most common causes of morbidity and mortality in this growing elderly population.[3] Treatment of these diseases in elderly patients with the associated comorbidities is a significant challenge with attendant risks. The emergence of endovascular procedures has changed the face of vascular surgery, enabling surgeons to treat elderly patients who previously could not have endured the stresses and risks of open surgery. Specifically, endovascular aneurysm repair (EVAR) offers a treatment modality for patients once thought too frail to undergo traditional open surgical abdominal aneurysmorrhaphy.

While there have been prior analyses of surgical outcomes in the elderly population, until now these efforts have focused on octogenarians.[4-11] Nonagenarians are typically incorporated into these larger categories of elderly or high-risk patients.[11,12] We believe that the nonagenarian population represents a distinct, significant, and growing segment of the elderly population affected with aortic aneurysmal disease. In the 10th decade of life, patients will benefit most from a less invasive approach to repair of a life threatening entity such as abdominal aortic aneurysm. We hypothesized that EVAR offers a safe, durable option for abdominal aortic aneurysm repair in this elderly population. Thus, we sought to examine the outcomes of patients

90 years of age and greater undergoing EVAR at our institution over a 10-year period.

METHODS

We retrospectively reviewed available hospital billing records at New York Presbyterian Hospital (incorporating both the Weill Cornell and Columbia Presbyterian campuses) to obtain records of all patients 90 years of age or older undergoing all vascular surgical procedures over the period between January 1998 and March 2009. Within these patients, we discovered a cohort who had underwent infrarenal abdominal aortic aneurysmorrhaphy between 2001 and 2009. We reviewed hospital charts to collect patient demographics, intraoperative characteristics, and postoperative outcomes. Comorbidities for each patient were analyzed including hypertension, coronary artery disease (CAD), diabetes mellitus (DM), renal disease (chronic renal insufficiency and/or end-stage renal disease), smoking history (any current or past regular use of tobacco), history of myocardial infarction (MI), congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), history of stroke, remote history of transient ischemic attack (TIA) (this included two patients with documented events more than 5 years prior to surgery, and symptoms had resolved with medical therapy), history of cancer (any current or past incidence of malignancy), hypercholesterolemia, previous aortic surgery, previous peripheral vascular surgery, and peripheral vascular disease. Physician clinic notes, telephone inquiries, and the Social Security Death Index were also utilized for postoperative follow-up.

Surgical technique. Surgeries were performed according to generally accepted operating procedures, unless otherwise noted. Patients were anesthetized with general (defined as endotracheal tube, or laryngeal mask), or locoregional anesthesia (defined as local infiltration plus sedation, or spinal or epidural catheters). Open repairs were performed via midline laparotomy in all cases, and tube grafts or bifurcated grafts selected based on anatomy. In endovascular cases, endografts were deployed using open femoral artery exposure, fluoroscopic imaging, and iodinated contrast media. Anesthetic choice and endograft selection were based on patient comorbidities, anatomy, and surgeon preference. A variety of endovascular grafts were used including the Zenith Flex/Renu AAA Endovascular Graft (Cook Medical Inc, Bloomington, Ind), the Talent Abdominal Stent Graft (Medtronic, Inc, Minneapolis, Minn), the AneuRx AAAdvantage Stent Graft (Medtronic, Inc, Minneapolis, Minn), the Gore Excluder AAA Endoprosthesis (W. L. Gore & Associates, Inc, Flagstaff, Ariz), and the Guidant Ancure Endograft System (Guidant Corp, Indianapolis, Ind).

Outcomes. Outcomes were reported according to the 2002 guidelines set forth by the SVS/AAVS (Society for Vascular Surgery/American Association for Vascular Surgery).[13] Postoperative outcomes included perioperative mortality (defined as death within 30 days after surgery), aneurysm rupture, aneurysm-free survival, endoleak, stroke, and MI.

Statistical analysis. Means (±standard deviation) and medians were used to analyze continuous variables. Where applicable, means were compared using the Student two-tailed *t* test and categorical variables were compared using the Fisher's exact test. P values of less than 0.05 were considered to be indicative of statistical significance. Odds ratios with 95% confidence intervals were calculated to compare binary event probabilities occurring between groups. In patients reaching the endpoint of death, linear regression was used to analyze the correlation between postoperative survival and preoperative comorbidity. A Kaplan-Meier curve was constructed, and life table analysis was used to evaluate cumulative estimated long-term postoperative survival following endovascular aneurysm repair.

RESULTS

We identified 28 patients undergoing abdominal aortic aneurysm repair during the study period. Four patients (two male, two female, mean age 91.3 ± 2.0 years) underwent open surgical repair: three patients were repaired emergently for rupture, and one was repaired urgently for a symptomatic aneurysm that did not meet anatomic criteria by imaging for endovascular repair. Three of the four open repairs had imaging performed (one rupture was not imaged prior to repair), and the mean abdominal aortic aneurysm (AAA) size was 6.7 ± 0.6 cm. The patients undergoing open repair had an average of 4.5 comorbidities (3, 5, 6, and 4, for the individual patients). All four patients expired during the postoperative follow-up. One patient expired on postoperative day 6 from multisystem organ failure; the remaining patients survived 3, 8, and 12 months (the nonruptured, symptomatic patient surviving the longest). Causes of death following the perioperative period were respiratory failure, stroke, and myocardial infarction, respectively.

EVAR was successfully performed on the remaining 24 patients, including 15 (63%) males and 9 (37%) females with an overall mean age of 91.5 ± 1.0 years (range 90-94). Twenty-two (92%) patients presented with infrarenal aneurysms. One patient underwent endovascular repair of a hypogastric aneurysm, and one patient underwent repair of an infrarenal penetrating ulcer. Eight (33%) patients presented with symptoms of abdominal pain or tenderness. In the remaining 16 (67%) asymptomatic patients, aneurysms were diagnosed on routine computed tomography (CT) scans. Fourteen (58%) patients had general anesthesia, while 10 (42%) had local or regional anesthesia. Twelve Cook Zenith grafts, 2 Medtronic Talent grafts, 9 Medtronic Aneurx grafts, 1 Gore Excluder graft, and 1 Guidant Ancure graft were used. Grafts were successfully deployed in all patients, and there were no conversions to open repair.

The mean infrarenal aneurysm diameter was 6.3 ± 1.1cm for all AAA, and the diameters of the hypogastric aneurysm and infrarenal ulcer were 4 cm and 3.3 cm, respectively. Symptomatic AAAs had a mean diameter of 6.4 ± 1.1 cm vs asymptomatic AAAs, which had a mean diameter of 6.3 ± 1.1 cm ($P = .75$). All procedures were elective, with no suspected or confirmed aneurysm ruptures

Table I. Perioperative systemic complications in nonagenarians undergoing endovascular aneurysm repair (EVAR)

Patient	*Complication*	*Patient history*	*Comorbidities*	*EBL (cc)*	*Procedure length (min)*
4	Myocardial infarction	92F, symptomatic, general anesthesia	HTN, CAD, MI, PVD	500	240 (est)
9	Myocardial infarction, death	91F, symptomatic, general anesthesia,	HTN, CAD, smoking, MI, cancer, cholesterol	200	210 (est)
15	Pulmonary embolism, gastrointestinal bleed	92F, asymptomatic, general anesthesia	HTN, smoking	100	161
16	Myocardial infarction, atrial fibrillation	91M, asymptomatic, local anesthesia	HTN, smoking, previous vascular surgery, PVD, cholesterol	100	300 (est)
18	Atrial fibrillation, altered mental status	91M, asymptomatic, general anesthesia	HTN, CAD, cancer, cholesterol, CHF	500	243
20	Hypotension, troponin leak	93M, asymptomatic, general anesthesia	HTN, CAD, MI, CRI, cancer, PVD	200	169

CAD, Coronary artery disease; *CRI,* chronic renal insufficiency; *EBL,* estimated blood loss; *est,* estimated operative times from records of patient arrival and departure from operating room; *HTN,* hypertension; *MI,* previous myocardial infarction; *PVD,* peripheral vascular disease.

Table II. Preoperative comorbidities and patient demographics in nonagenarians undergoing endovascular aneurysm repair (EVAR)

	All patients (N = 24)	*Symptomatic (N = 8)*	*Asymptomatic (N = 16)*	P *value*
Infrarenal AAA size	6.3 ± 1.1 cm	6.4 ± 1.1 cm	6.3 ± 1.1 cm	.75
Stent graft proximal neck diameter	28.8 ± 3.8 cm	26.2 ± 2.5 cm	30.3 ± 3.7 cm	.006
General anesthesia	14 (58%)	7 (87.5%)	7 (44%)	.05
Hypertension	21 (87.5%)	8 (100.0%)	13 (81.3%)	.52
Coronary artery disease	11 (45.8%)	7 (87.5%)	4 (25.0%)	.007
Diabetes	2 (8.3%)	2 (25%)	0 (0.0%)	.101
Renal disease	3 (12.5%)	1 (12.5%)	2 (12.5%)	1
Smoking history	14 (58.3%)	4 (50.0%)	10 (62.5%)	.67
MI history	7 (29.2%)	5 (62.5%)	2 (12.5%)	.02
COPD	4 (16.7%)	1 (12.5%)	3 (18.8%)	1
Stroke history	3 (12.5%)	1 (12.5%)	2 (12.5%)	1
Remote transient ischemic attack	2 (8.3%)	1 (12.5%)	1 (6.3%)	1
Previous vascular surgery	4 (16.7%)	1 (12.5%)	3 (18.8%)	1
Previous aortic surgery	2 (8.3%)	0 (0.0%)	2 (12.5%)	.53
Cancer	6 (25.0%)	3 (37.5%)	3 (18.8%)	.36
PVD	6 (25.0%)	4 (50.0%)	2 (12.5%)	.13
Cholesterol	8 (33.3%)	3 (37.5%)	5 (31.3%)	1
CHF	4 (16.7%)	2 (25.0%)	2 (12.5%)	.58

AAA, Abdominal aortic aneurysm; *COPD,* chronic obstructive pulmonary disease; *CHF,* congestive heart failure; *MI,* previous myocardial infarction; *PVD,* peripheral vascular disease.

in the EVAR group. Intraoperative adjunct procedures performed included 1 iliac angioplasty to allow passage of the endograft, 3 iliac stent placements within graft limbs, 1 femoral-femoral arterial bypass in a planned aorto-uni-iliac reconstruction, 1 proximal Palmaz aortic stent, 2 femoral patch angioplasties, and 1 proximal aortic cuff placement.

Perioperative local complications (groin seroma) occurred in two (8.3%) patients. Perioperative systemic complications occurred in six (25%) patients (patient demographics, comorbidities, and operative information detailed in Table I). There was one (4.2%) perioperative death. This patient suffered a myocardial infarction and expired on postoperative day 26 following elective EVAR for a 5.3 cm symptomatic aneurysm and discharge on postoperative day 2. Mean postoperative length of stay was 3.2 ± 2.4 days (2.8 ± 1.9 days for asymptomatic vs 4.1 ± 3.2 days for symptomatic, *P* = .29).

Patients presented with a mean of 4.0 (± 2.2) comorbidities (Table II). Asymptomatic patients had a larger mean proximal stent graft neck size than symptomatic patients (30.3 ± 3.7cm vs 26.2 ± 2.5 cm, *P* = .006). Compared with the asymptomatic group, those patients with symptomatic aneurysms had a significantly higher incidence of coronary artery disease (87.5% vs 25.0%, *P* = .007) and prior myocardial infarction (62.5% vs 12.5%, *P* = .02). The group of patients receiving general anesthesia had a higher incidence of coronary artery disease as well (64% vs 20% for those receiving a loco-regional anesthetic, *P* = .04). Finally, symptomatic patients were also more likely than asymptomatic patients to receive a general anesthetic

Table III. Life table analysis of long-term survival following endovascular aneurysm repair (EVAR) in nonagenarians

Time (months)	*Number at risk*	*Number withdrawing during interval*	*Number of terminal events*	*Cumulative proportion surviving at end of interval*	*Standard error*
0	24	0	2	.92	.06
6	22	1	1	.87	.07
12	20	0	1	.83	.08
18	19	1	2	.74	.09
24	16	2	2	.64	.10
30	12	3	1	.58	.11
36	8	1	1	.50	.12
42	6	1	0	.50	.12
48	5	1	2	.28	.14
54	2	0	0	.28	.14
60	2	1	1	.09	.12

for their procedure (87.5% vs 44%, $P = .05$). Of the 6 systemic complications occurring (Table I), 5 occurred in patients receiving a general anesthetic (2 symptomatic patients and 3 asymptomatic patients), and 1 occurred in a patient receiving local infiltration and intravenous sedation, (odds ratio [OR] 5.0, 95% confidence interval [CI] 0.5-51.8).

One type I endoleak (4.2%), and three type II endoleaks (12.5%) were identified in three patients during the postoperative period. One patient had both type I and type II endoleaks and underwent reinterventions including a proximal cuff placement and Palmaz aortic stent at 20 months for a type 1 endoleak. She subsequently had unsuccessful coil embolizations performed 9 months later for a recurrent type 1 endoleak, but was believed too frail to undergo open conversion. The two remaining patients had type II endoleaks detected without increase in aneurysm size and are followed serially.

Among the 23 patients that survived beyond the perioperative period, 12 expired during follow-up. There were no aneurysm related deaths beyond the 30-day postoperative period. The mean and median postoperative survival among those patients that expired was 29.7 ± 18.0 months and 25.2 months, respectively. At the time of this report, the mean and median postoperative survival among the remaining 11 patients was 36.1 ± 16.0 and 33.6 months respectively, (range 9.9-59.9 months). Life table analysis demonstrated cumulative estimated 12, 24, and 36-month survival rates of 83%, 64%, and 50%, respectively (Table III, Fig 1).

In the 12 patients who expired during follow-up, linear regression analysis was performed to examine the correlation between preoperative comorbidity and postoperative survival (Fig 2). An inverse relationship was demonstrated between the number of preoperative comorbidities and the long-term postoperative survival ($R^2 = 0.701$). Significantly decreased survival was noted for patients presenting with >5 comorbidities (range 3.7-13 months), whereas patients with five or less comorbidities all survived beyond 20 months (range 22.3-63.0).

DISCUSSION

Abdominal aortic aneurysms remain a significant cause of morbidity and mortality among the general population. The risk of rupture and its sequelae necessitates repair in patients with both asymptomatic and symptomatic aneurysms.[14] Over the past decade, technological advancements have resulted in a shift towards EVAR as a safe and effective alternative to open aneurysm repair. Among the general population, EVAR has been shown to result in decreased perioperative mortality compared with open repair, without compromising short-term and mid-term survival.[15-17]

Bush et al found high-risk patients (which included patients age ≥60) to have a significantly decreased 30-day and 1-year all cause mortality following EVAR vs open repair.[18] Other studies have confirmed EVAR to be safe and effective in octogenarians, reporting low rates of perioperative mortality (0.5%-3.3%) and high rates of technical success.[4,5,9] Yet despite the promising data regarding EVAR in high-risk and octogenarian patients, the nonagenarian population specifically has not been widely addressed in the literature.

Here we report the largest series of nonagenarians undergoing EVAR. A total of 24 patients, both men and women, underwent EVAR for symptomatic and asymptomatic AAAs. Operative technical success was 100%, with one (4.2%) perioperative death. While this perioperative mortality rate is higher than the 1.2% reported in the DREAM trial among the general population, it is comparable to rates reported in studies of EVAR in octogenarians, and lower than the 5.6% to 11% rate reported in the other published reports on EVAR in nonagenarians.[5,9,15,19,20] Moreover, the local and systemic complication rates (8.3% and 25%, respectively) among our nonagenarian patients is lower than those reported in octogenarians by Lobato et al (26% and 18%, respectively), and comparable to those reported in nonagenarians by Baril et al (22% and 17%, respectively) and Jim et al (17% systemic complication rate).[8,19,20] The incidence of endoleak in our series was also in line with published reports: 4.2% incidence of type I endoleak and 12.5% incidence of type II endoleak in our series compared with 6.9% to 10% and 2% to 24.1% (respec-

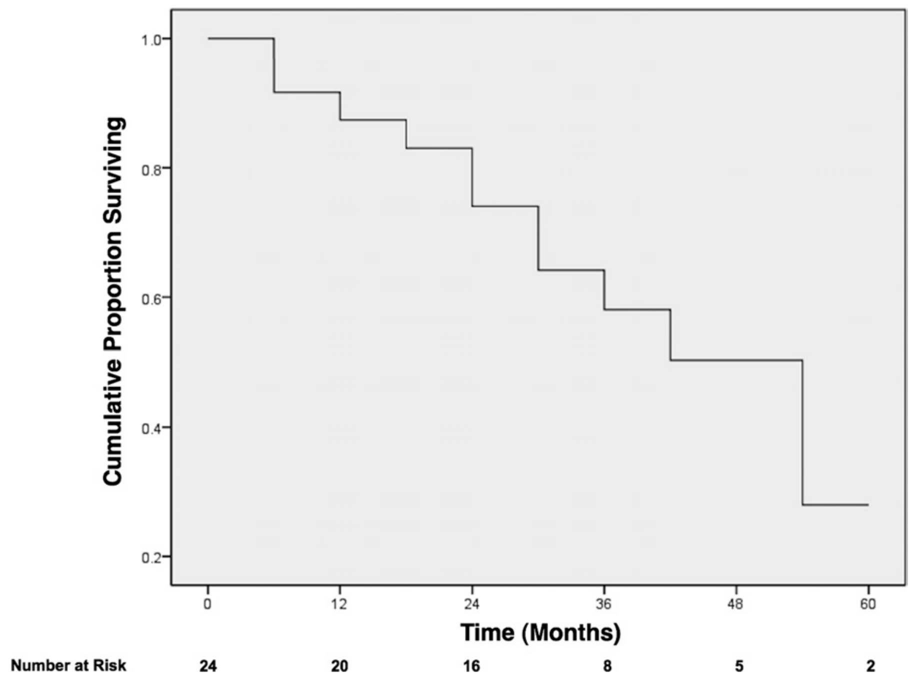

Fig 1. Kaplan-Meier curve for estimated long-term postoperative survival following endovascular aneurysm repair (EVAR) in nonagenarians.

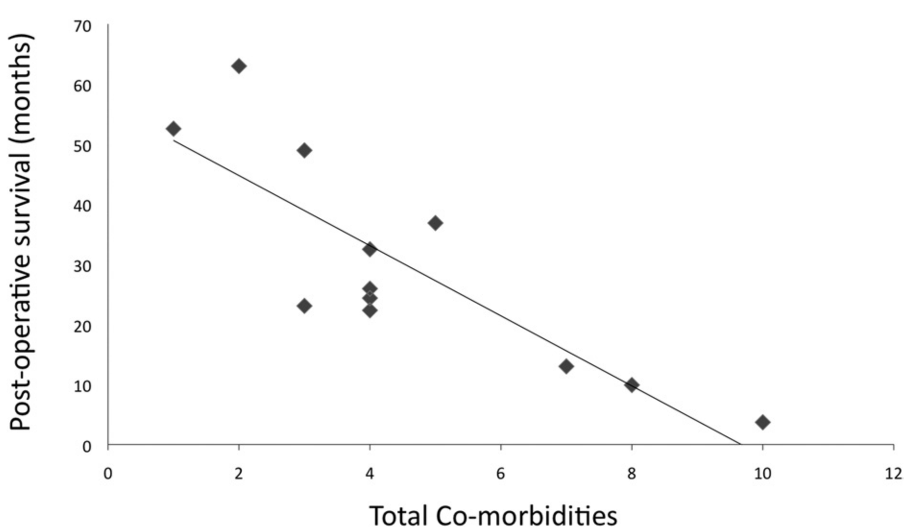

Fig 2. Postoperative survival vs comorbidities in nonagenarians following endovascular aneurysm repair (EVAR). Linear regression of preoperative comorbidities vs postoperative survival (*months*) in patients reaching endpoint of death, R2 = 0.701.

tively) reported in octogenarians, and 6% to 11% incidence of type I endoleak and 11% to 33% incidence of type II endoleak reported in nonagenarians.[8,9,19,20]

Baril et al and Jim et al are the only reports to date of EVAR specifically in nonagenarians. Baril describes an all-male series exclusively performed with spinal anesthesia with a perioperative mortality of 11%, and a technical success rate of 100%, concluding that EVAR was potentially beneficial for "suitable" nonagenarian patients.[19] Jim et al references our study, demonstrating a 5.6% perioperative mortality, and includes a slightly more heterogeneous population.[20] Our study expands on the results of both of these smaller analyses by including the largest sample of patients, both genders, a comparative experience with both loco-regional and general anesthesia, a correlation between preoperative comorbidities and long-term survival, and life-table analysis with the longest follow-up to date of this elderly population. Taken together, these studies strengthen the argument in favor of treating this elderly, high-risk population, and guide the clinician as to the best candidates for intervention.

In high-risk patients undergoing EVAR, Timaran et al reported a higher in-hospital mortality rate among patients with "the most severe comorbidities" compared with those with lower comorbidity (1.7% vs 0.4%).[21] In our series as well, among patients that survived beyond the perioperative period, there was a negative correlation ($R^2 = 0.701$) between the number of comorbidities and postoperative survival (Fig 2). Patients with greater than five comorbidities in our cohort exhibited a sharply decreased long-term survival, and similar patients in the future may be treated more conservatively. However, one could be cautioned against extrapolating this finding to clinical practice as our study was limited by a small sample size.

Patients with symptomatic aneurysms in our cohort had a significantly higher incidence of coronary artery disease and prior myocardial infarction. They were also more likely than asymptomatic patients to receive a general anesthetic. In our study, there was a trend towards systemic complications (of which five out of six were cardiac in nature) being associated with general anesthesia (OR 5.0, 95% CI 0.5-51.8). Careful consideration must be given to the use of general anesthetics in the nonagenarian with a significant history of coronary artery occlusive disease or previous myocardial infarction.

As a retrospective study, this report suffers from the limitation of a sample selection bias, in that the number of patients over the age of 90 in our treatment area who were not treated (ie, "the denominator") is unknown. We unsuccessfully attempted to obtain records of those patients triaged at our hospital in this age group with the diagnosis of abdominal aneurysm who remained untreated, but were unable to procure this data. Thus, our cohort may represent a preselected group healthier and more suitable for EVAR than the overall group of nonagenarians presenting with AAA. Additionally, without knowing the outcomes of those nonagenarians left untreated, it remains unknown if AAA in the 10th decade may represent a distinct, potentially more indolent natural history that that seen in younger patients. Having a cohort of nonagenarians with untreated AAA would allow a comparison of survival between these groups, and an assessment of the benefit of intervention, which we were unable to perform. The three nonagenarian patients who presented to our institution over the study period with rupture (treated emergently with open aneurysmorrhaphy), however, reinforce the deadly potential of this disease even in the 10th decade. The decreased morbidity of EVAR could have an even more substantial impact on those nonagenarians presenting with a ruptured AAA if implemented for this entity.

With the current senescence of the baby boomer generation, record numbers of Americans are living well into their 10th decade of life. As such, we believe nonagenarians to be a growing and distinct population within the US healthcare system; one whose healthcare needs and concerns must be uniquely addressed. While this study has demonstrated that EVAR can be safely performed in the nonagenarian population, there are many unresolved issues in this group including postoperative surveillance in elderly patients, the socio-economic constraints of elderly patients requiring increased medical care and surveillance, and finally quality of life and cost considerations. Though careful consideration must be given to each patient individually, there may also be merit to considering a higher aortic diameter threshold for intervention in this fragile elderly population. The symptomatic population treated in our study had a significantly smaller proximal neck size compared with the asymptomatic group, which may suggest that the virulence of this entity relates to aneurysm size relative to the native proximal aorta. These are all topics requiring further study.

We have presented the largest series to date of endovascular aortic aneurysm repair in nonagenarians with low morbidity, low mortality, and prolonged aneurysm-free survival. Clinicians should consider loco-regional anesthetics when suitable, and be cautious in treating elective patients with greater than five comorbidities. In suitable patients over 90 years of age, without significant numbers of comorbidities, EVAR is safe and effective.

AUTHOR CONTRIBUTIONS

Conception and design: LG, JH
Analysis and interpretation: LG, JH, CR, ES, JK
Data collection: LG, JH, CR, KG, HB, ES
Writing the article: LG, JH, CR, JK
Critical revision of the article: ES, KG, HB, JK
Final approval of the article: LG, JH, CR, KG, ES, HB, JK
Statistical analysis: LG, JH
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REFERENCES

1. Manton KG. Recent declines in chronic disability in the elderly U.S. population: risk factors and future dynamics. Annu Rev Public Health. 2008;29:91-113.
2. United States Census Bureau Population Estimates. [cited]; Available at: http://www.census.gov/popest/estimates.html. Accessed October 4, 2010.
3. Services USDoHH. Deaths: final data for 2006. National Vital Statistics Reports 2009;57:1-135.
4. Biebl M, Lau LL, Hakaim AG, Oldenburg WA, Klocker J, Neuhauser B, et al. Midterm outcome of endovascular abdominal aortic aneurysm repair in octogenarians: a single institution's experience. J Vasc Surg 2004;40:435-42.
5. Brinkman WT, Terramani TT, Najibi S, Weiss VJ, Salam AA, Dodson TF, et al. Endovascular abdominal aortic aneurysm repair in the octogenarian. Ann Vasc Surg 2004;18:401-7.
6. Haug ES, Romundstad P, Aune S, Hayes TBJ, Myhre HO. Elective open operation for abdominal aortic aneurysm in octogenarians–survival analysis of 105 patients. Eur J Vasc Endovasc 2005;29:489-95.
7. Henebiens M, Vahl A, Koelemay MJW. Elective surgery of abdominal aortic aneurysms in octogenarians: a systematic review. J Vasc Surg 2008;47:676-81.
8. Lobato AC, Rodriguez-Lopez J, Malik A, Vranic M, Vaughn PL, Douglas M, et al. Impact of endovascular repair for abdominal aortic aneurysms in octogenarians. Ann Vasc Surg 2001;15:525-32.

9. Minor ME, Ellozy S, Carroccio A, Oak J, Chae K, Agarwal G, et al. Endovascular aortic aneurysm repair in the octogenarian: is it worthwhile? Arch Surg 2004;139:308-14.
10. Paolini D, Chahwan S, Wojnarowski D, Pigott JP, LaPorte F, Comerota AJ. Elective endovascular and open repair of abdominal aortic aneurysms in octogenarians. J Vasc Surg 2008;47:924-7.
11. Sicard GA, Rubin BG, Sanchez LA, Keller CA, Flye MW, Picus D, et al. Endoluminal graft repair for abdominal aortic aneurysms in high-risk patients and octogenarians: is it better than open repair? Ann Surg 2001;234:427-35; discussion 35-7.
12. Jordan WD, Alcocer F, Wirthlin DJ, Westfall AO, Whitley D. Abdominal aortic aneurysms in "high-risk" surgical patients: comparison of open and endovascular repair. Ann Surg 2003;237:623-9; discussion 9-30.
13. Chaikof EL, Blankensteijn JD, Harris PL, White GH, Zarins CK, Bernhard VM, et al. Reporting standards for endovascular aortic aneurysm repair. J Vasc Surg 2002;35:1048-60.
14. Lederle FA, Johnson GR, Wilson SE, Ballard DJ, Jordan WD, Blebea J, et al. Rupture rate of large abdominal aortic aneurysms in patients refusing or unfit for elective repair. JAMA 2002;287:2968-72.
15. Prinssen M, Verhoeven ELG, Buth J, Cuypers PWM, van Sambeek MRHM, Balm R, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004;351:1607-18.
16. Gouëffic Y, Becquemin J-P, Desgranges P, Kobeiter H. Midterm survival after endovascular vs open repair of infrarenal aortic aneurysms. J Endovasc Ther 2005;12:47-57.
17. Greenhalgh RM, Brown LC, Kwong GPS, Powell JT, Thompson SG, participants Et. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomised controlled trial. Lancet 2004;364:843-8.
18. Bush RL, Johnson ML, Hedayati N, Henderson WG, Lin PH, Lumsden AB. Performance of endovascular aortic aneurysm repair in high-risk patients: results from the Veterans Affairs National Surgical Quality Improvement Program. J Vasc Surg 2007;45:227-33; discussion 33-5.
19. Baril DT, Palchik E, Carroccio A, Olin JW, Ellozy SH, Jacobs TS, et al. Experience with endovascular abdominal aortic aneurysm repair in nonagenarians. J Endovasc Ther 2006;13:330-7.
20. Jim J, Sanchez LA, Sicard GA, Curci JA, Choi ET, Geraghty PJ, et al. Acceptable risk but small benefit of endovascular aneurysm repair in nonagenarians. Ann Vasc Surg 2010;24:441-6.
21. Timaran CH, Veith FJ, Rosero EB, Modrall JG, Arko FR, Clagett GP, et al. Endovascular aortic aneurysm repair in patients with the highest risk and in-hospital mortality in the United States. Arch Surg 2007;142: 520-4; discussion 4-5.

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INVITED COMMENTARY

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The manuscript by Dr Goldstein and colleagues explores the issue of repairing abdominal aortic aneurysms in a very special group of patients, the oldest of old, nonagenarians. They report their outcomes of endovascular repair (EVAR) in this small and unique cohort. Given the advanced age of the patients, the authors show very acceptable morbidity and mortality rates. They do temper their conclusions with caveats about intervening on patients with multiple medical comorbidities. It is not unexpected that the authors found an inverse relationship between the number of comorbidities and long-term survival. With the largest series to date in 90+ year olds with long-term follow-up, a few distinct observations should be made.

I believe this article raises the most important concern – the importance of individual patient selection. The surgeon must establish a quality patient relationship and exercise excellent patient and family communication. The nonagenarian and his or her family must be attuned to the realistic outcomes associated with this disease process, especially in elderly patients with numerous comorbidities. We must remind ourselves that in such challenging situations, just because we can technically perform the procedure, surgical intervention may not be the right decision for the patient? This conversation is much easier to approach in the asymptomatic patient in whom the risk of rupture may be much less than the true mortality rate of a nonagenarian. National Vital Statistics state that the general life expectancy for 90-year-olds is 5 years and 3.6 years for 95-year-olds.[1] Sometimes the strongest and most valiant decision may be to not intervene, a decision that is generally difficult for many, both physicians and families alike.

In the Hippocratic Oath, physicians pledge to consider more than a patient's pathology but also to realize that "illness may affect the person's family and economic stability". The independent elderly may end up dependent upon family members or in a skilled facility following repair, Alternatively, older persons may have a very fixed and limited income. The expenses associated with EVAR and the mandatory future follow-up imaging (and associated transportation costs) needs to be considered when intervention is being discussed. Undue stress on a person and/or their family may represent a worse situation than that of living with the risk of aneurysm rupture. Due to advances in medical science, nonagenarians, while a small proportion of the population, are increasing in numbers. These conversations between the patient, families, and physician will become more commonplace in all medical specialties. I fully agree with the authors in their conclusion that perhaps we must "consider a higher aortic diameter threshold in this fragile elderly population". Above all, exercise caution and moderation. In this special circumstance, posing the question to yourself, "What would I want done to my parent?" is very appropriate.

REFERENCE

1. Centers for Disease Control and Prevention, National Center for Health Statistics. Available at: http://www.cdc.gov/nchs/data/nvsr/nvsr56/nvsr56_09.pdf. Accessed June 4, 2010.