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1 **Technical eligibility for endovascular treatment of the aortic arch after open type A aortic**  
2 **dissection repair**

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27	<b>Glossary of Abbreviations</b>
28	
29	
30	AAD: Stanford type A aortic dissection
31	
32	AI: Aortic insufficiency
33	
34	AIBS: Arch inner-branched stent
35	
36	BMI: Body mass index
37	
38	CABG: Coronary artery bypass graft
39	
40	CI: Confidence interval
41	
42	COPD: Chronic obstructive pulmonary disease
43	
44	CT: Computed tomography
45	
46	CTD: Connective tissue disease
47	
48	IA: Innominate artery
49	
50	IMH: Intramural hematoma
51	
52	LCC: Left common carotid
53	
54	LSA: Left subclavian artery
55	
56	RCC: Right common carotid
57	
58	TEVAR: Thoracic endovascular aortic repair
59	

60 **Central Picture/Graphical Abstract**

61  
62 Legend: Majority of post aortic dissections are eligible for endovascular arch repair.  
63



64  
65  
66

67 **Central Message**

68

69 The majority of post type A aortic dissection patients are technically eligible for an endovascular  
70 arch-branched stent graft.

71

72 **Perspective Statement**

73

74 Optimal surgery of type A aortic dissections must consider immediate survival, extent of repair, and  
75 the risk for future reoperation. A substantial proportion of patients surviving the initial repair  
76 require reintervention. Given the increased risks of a reoperation, greater awareness of the criteria  
77 and potential eligibility for endovascular treatment of post-dissection aneurysm is needed.

78

79 **Abstract**

80

81 **Objective:** To report on the technical eligibility of patients previously treated for Stanford type A  
82 aorta dissection (AAD) for endovascular aortic arch repair based on contemporary anatomical  
83 criteria for an arch inner-branched stentgraft (AIBS).

84

85 **Methods:** All patients treated for AAD from 2004-2015 at a single aortic centre were identified.  
86 Extent of repair and use of circulatory arrest were reported. Survival and reoperation were assessed  
87 using Kaplan Meier and competing risk models. Anatomic assessment was performed using 3-  
88 dimensional CT-imaging software. Primary outcome was survival  $\geq 1$  year and fulfilment of the  
89 AIBS anatomical criteria.

90

91 **Results:** A total of 198 patients were included (158 Debakey I, 32 Debakey II, and 8 Intramural  
92 hematoma). Mortality was 30-days: 16.2%, 1-year: 19.2%, 10-years: 45.0%. There were 129 patients  
93 with imaging beyond 1 year (mean, 47.8 months), while 89 (69.0%) were AIBS eligible. During  
94 follow-up, 19 (14.7%) patients met the threshold criteria for aortic arch treatment, of which 14  
95 (73.7%) would be considered eligible for AIBS. Patients who underwent AAD repair with circulatory  
96 arrest and no distal clamp were more often eligible for endovascular repair (88.8%) than those  
97 operated with a distal clamp (72.5%),  $p=0.021$ . Among patients who did not meet the AIBS  
98 anatomical criteria, the primary reasons were mechanical valve (40%) and insufficient proximal seal  
99 (30%).

100

101 **Conclusion:** More than two thirds of post AAD patients repair are technically eligible for  
102 endovascular AIBS repair. Development of devices that can accommodate a mechanical aortic  
103 valve and a greater awareness of sufficient graft length would significantly increase availability.

104 **Introduction**

105  
106 Open surgical repair is the gold standard in the treatment of type A aortic dissections. For those  
107 patients successfully treated, approximately 10-15% will require reintervention within the next five  
108 years, including repair of the arch and descending thoracic aorta due to aneurysmal degeneration of  
109 the chronically dissected aorta.<sup>1-4</sup> There is still some debate regarding the optimal initial surgical  
110 technique, balancing more extensive aortic arch surgery with its inherent risks against a potential  
111 reduction of distal dilatation and need for reoperation.<sup>5,6</sup>

112  
113 Endovascular treatment of complex aortic arch and descending aortic pathologies has rapidly  
114 evolved, however, and the landscape of how post-proximal aortic surgery reoperations can be  
115 treated has changed. Verscheure et al recently reported a technical success of 94.3% for the total  
116 endovascular treatment of chronic arch dissections among 70 patients from 13 international centres  
117 of expertise.<sup>7</sup> For endovascular arch repair to be possible, the anatomy of the ascending aorta and  
118 the arch must be technically suitable for an endovascular approach, and Milne et al have reported  
119 that 71.2% of these types of patients were eligible for a subsequent arch inner-branched stent graft  
120 (AIBS) after a median follow-up of 6 months.<sup>8</sup> Notably, however, more than 90% of their patient  
121 cohort did not meet the conventional treatment threshold diameter of 55 mm.

122  
123 The objective of the present analysis is to update the current data of eligibility for an endovascular  
124 AIBS with a larger patient cohort and longer follow-up, as well as to identify factors that play a role  
125 in this process.

126  
127 **Materials and methods**

128  
129 *Patients*

130

131 Prospectively registered data from all patients admitted and operated acutely for either a Stanford  
132 type A aortic dissection or ascending aortic intramural hematoma (IMH) from October 1, 2004 to  
133 January 1, 2015 from Uppsala University Hospital were collected. Data included age, sex, height,  
134 weight, smoking status, medical comorbidities, and post-operative living status of all patients.  
135 Known connective disease was also reported, as was the presence or absence of a bovine aortic arch  
136 or bicuspid aortic valve.

137  
138 *Procedures*

139 The initial open surgical procedure and results for aortic dissection and IMH are previously  
140 described.<sup>9-11</sup> The data reported here include: the DeBakey aortic dissection classification, the  
141 diameter of the implanted aortic graft, the use of a clamp for the distal ascending aortic  
142 anastomosis, whether concomitant coronary artery bypass grafting or reimplantation was carried  
143 out, whether or not the aortic valve was preserved or replaced (mechanical, biological, or composite  
144 graft), and whether any bypass to one of the supraaortic vessels or immediate aortic arch repair was  
145 carried out at the primary operation.

146  
147 *Endovascular Arch Inner-Branched Stentgraft*

148  
149 The endovascular aortic arch inner-branched stentgraft is designed and manufactured by Cook  
150 Medical (Bloomington, IN, USA). It is available with either one or two proximal sealing stents with  
151 options for up to three internal branches to the supraaortic vessels. To date, reports have focused on  
152 the stentgraft with two branches, thus often necessitating a left common carotid (LCC)-left subclavian  
153 artery (LSA) bypass.

154  
155 The required anatomy includes: a uniform ascending aorta with a length  $\geq 40$  mm and diameter  $\leq 38$   
156 mm, an innominate artery (IA)  $\leq 18$  mm. Kinking of a previous implanted aortic graft, albeit

157 subjective, is also a contraindication. In questionable cases, i.e., sealing lengths close to 40 mm or  
158 considerable angulation, minimum outer and inner curve lengths of 45 mm and 24 mm, respectively,  
159 are required by the stentgraft manufacturers. Furthermore, the presence of a mechanical aortic valve  
160 is a contraindication. See Table 1 for the detailed criteria.

161  
162

### 163 *Imaging evaluation and measurements*

164 The most recent post-operative computed tomography (CT) images were assessed for each patient.  
165 For those patients who underwent subsequent aortic arch repair, either open, hybrid, or total  
166 endovascular reintervention, the most recent CT imaging prior to this procedure was used. All CT  
167 images were analyzed using the post-processing software 3mensio Vascular (3mensio Medical  
168 Imaging Bilthoven, The Netherlands), in which adequate centre-, outer-, and inner-line  
169 measurements were obtained. Measurements included the maximum diameter and length of the  
170 ascending aorta, from the IA to either the most proximal edge of prosthetic material or the most  
171 distal coronary artery to avoid coverage. Maximum diameters of the aortic arch and proximal  
172 descending aorta were also recorded. The IA, LCC and LSA were measured for their length and  
173 diameter, noting the presence of disease in these vessels. If either the IA or LCC were burdened  
174 with dissection, calcification, or tortuosity, more distal measurements were obtained for potential  
175 adjunct procedures, which were defined as either interposition-graft placement to ensure  
176 appropriate landing zone or supraaortic deviation, i.e., carotid-subclavian bypass, with endovascular  
177 bridging stentgraft extension. In the presence of a bovine aortic arch variant, diameters and  
178 angulation of the two vessels were obtained for this common origin of the LCC and IA in order to  
179 assess accommodation of two bridging stentgrafts for these particular vessels.

180  
181

182

183 *Outcomes*

184 The primary outcome was fulfillment of the above-detailed technical criteria for endovascular inner  
185 branched aortic arch stentgraft for patients with  $\geq$  one-year survival. The authors agreed in advance  
186 on the applied criteria, as given above. One experienced surgeon (JBL) then reviewed all imaging  
187 regarding anatomic suitability. In case of borderline conditions or uncertainties, two other surgeons  
188 (AW and KM) also evaluated the image material and consensus was reached on how to classify it.  
189 Rejection was then noted for one or more of the following issues: ascending aorta diameter,  
190 ascending aorta length, ascending aorta kinking, supraaortic landing zone suitability, presence of a  
191 mechanical valve, or severe aortic valve insufficiency and/or root dilatation, indicating a need for  
192 valve/root surgery.

193

194

195 *Statistics*

196 Data were assessed for normality with quantile-quantile plots. Continuous data are presented with  
197 mean values and 95% confidence intervals, and compared using t-tests. Categorical variables are  
198 reported as absolute numbers (%) and compared using the Chi-squared test. Data on survival were  
199 analyzed using Kaplan-Meier curve estimates, truncated at 10 years. A competing risks model, with  
200 subdistribution dependent only on the specific cause, was used to calculate the cumulative  
201 incidence of aortic reoperation with death as the competing risk.<sup>12</sup> A p-value less than 0.05 was  
202 considered statistically significant.

203

204 All data analysis was carried out using Stata, version 14.2 (StatCorp. 2015. Stata Statistical  
205 Software: Release 14. College Station, TX, USA: StataCorp LP.)

206

207 *Ethical Considerations*

208 The study complies with the Declaration of Helsinki. The regional ethical review board waived the  
209 need for individual informed patient consent.

210

211

## 212 **Results**

213 A total of 198 patients were identified, 124 (62.6%) men and 74 (37.4%) women. The mean age at  
214 the time of operation was 61.4 years (95% CI, 59.8-62.9). Six patients (3.0%) were identified with  
215 connective tissue disease, all of which were Marfan syndrome. Thirty-day mortality was 16.2% (n =  
216 32), all of which were in-hospital, while mortality at one year was 19.2% (n=38). The maximum  
217 follow-up was 14.3 years, while Kaplan-Meier analysis revealed an estimated 10-year survival of  
218 55.0% (95% CI, 45.6% - 63.5%), Figure 2a.

219

220 A total of 129 patients were available with follow-up CT imaging after one year (See Flowchart,  
221 Figure 1, for exclusion process). The mean duration to the most recent scanning was 47.8 months  
222 (95% CI, 40.3-55.3 months). There were 108 (83.7%) patients who fulfilled anatomical criteria for  
223 AIBS in terms of adequate ascending aortic sealing zone without kink, and adequate branch vessels  
224 sealing zone, Table 3. Of these patients, 16 had mechanical aortic valves precluding AIBS repair with  
225 the current standard device, and an additional three patients had severe aortic insufficiency with aortic  
226 root dilatation which cannot be treated with endovascular technique, rendering 89 (69.0%) patients  
227 as eligible candidates for endovascular arch repair as an alternative to open surgery, if indicated. No  
228 patients were ineligible due to supraaortic vessel pathology, although 18 (20.2%) of the 89 patients  
229 would require an adjunct procedure, six of which were bilateral and 12 unilateral. Thus, the most  
230 common cause of ineligibility was the presence of a mechanical valve (40.0%), followed by  
231 inadequate seal length (30.0%) and a combination thereof (17.5%), e.g., mechanical valve plus

232 inadequate seal length. It should be noted that 11 of the 12 patients who underwent coronary artery  
233 bypass grafting (CABG) or reimplantation also received a mechanical valve, thus entailing  
234 ineligibility. Of these 12 patients, only three had insufficient sealing length (Fig. 3).

235

236 For the evaluated cohort of 129 patients, those ineligible for AIBS were younger, had shorter  
237 ascending aortic seal length, and more often underwent primary ascending repair with a distal aortic  
238 clamp in place, Table 3. Circulatory arrest with no clamping of the distal ascending aorta was  
239 employed in 108 (83.7%) patients. The difference in the use of this technique among patients deemed  
240 technical candidates (88.8%) against those who were not (72.5%) was statistically significant  
241 ( $p=0.021$ ). The mean length of the ascending graft sealing zone was 46.3 mm (95% CI, 44.2-48.3) in  
242 patients who underwent ascending repair with total circulatory arrest, versus 39.5 mm (95% CI, 33.6-  
243 45.3),  $p=0.01$ , in patients with distal clamp during repair.

244

245 In the follow-up period, 19 (14.7%) patients developed aortic arch dilatation to  $>55$  mm, thus  
246 meeting the threshold criteria for aortic arch repair, of which 14 (73.7%) would be considered  
247 eligible for an endovascular inner branch graft. A total of 13 arch repairs (68.4%) were carried out,  
248 of which two, in the most recent time period, used an endovascular AIBS. In addition to the 13  
249 aortic arch repairs, there were 11 patients who underwent open aortic repair for indications other  
250 than aortic arch or descending aorta dilatation (5 aortic insufficiency, 4 endocarditis, 2  
251 pseudoaneurysm), rendering a total reoperation rate of 18.6% at a mean duration of 7.1 years (95%  
252 CI, 6.6 - 7.7). Accounting for the competing risk of death in Figure 2b, the total risk for aortic  
253 reoperation at 10 years was 14.3% (95% CI, 9.1-20.5). The risk of reoperation was 20.0% (95% CI,  
254 12.4-29.0) for patients younger than the mean age of 61.4 and 5.1% (95% CI, 1.7-11.6) for the older  
255 patients.

256

257 **Discussion**

258

259 It is evident that patients treated for an aortic dissection sustain a considerable risk of need for  
260 future aortic reintervention.<sup>1,2,13</sup> The present study reiterates this risk, with almost 20% of the  
261 surviving patients undergoing some form of aortic reoperation. Moreover, it confirms that a  
262 substantial number of patients (14.7%) ultimately meet the conventional threshold diameter for  
263 aortic arch repair of 55 mm.<sup>14</sup> Considering the progressive nature of the disease, the proportion of  
264 patients developing critical arch dilatation is expected to increase with longer follow-up in this  
265 patient cohort with a mean age of 61 years at the time of primary type A aortic pathology.

266

267 Conventional treatment has consisted of a second sternotomy and open arch repair, which  
268 inherently limits patient selection due to greater technical complexity, in addition to the increased  
269 morbidity of the patients. Hybrid options, with supraaortic vessel debranching and thoracic  
270 endovascular aortic repair (TEVAR) stent placement, are available alternatives for some  
271 patients.<sup>15,16</sup> More recently, a total endovascular approach for treating the aortic arch has also been  
272 advocated, in large part due to its less invasive nature. Moreover, previously implanted prosthetic  
273 material in the ascending aorta offers a profitable proximal landing zone for a stentgraft. Spear et al  
274 reported on their experience of 43 post-dissection endovascular procedures, 19 of which were  
275 performed in the aortic arch with three technical failures.<sup>17</sup> The largest report to date, by Verscheure  
276 et al, noted a technical success of 94.3% and a low combined mortality and stroke rate of 4.3% in  
277 the treatment of chronic arch dissections among 70 patients, suggesting that this treatment has  
278 “come of age”.<sup>7</sup>

279

280 Of course, much of the success and improvement of a total endovascular treatment will be  
281 predicated on patient selection. Milne et al identified approximately 70% of their post-dissection  
282 patients as technical candidates for endovascular arch repair, although the majority (90%) did not  
283 meet the threshold aortic arch diameter of 55 mm during a median follow-up of six months.<sup>8</sup> It is  
284 therefore unknown how longer follow-up would impact the potential proportion of patients who  
285 could be offered this treatment.

286

287 Although the almost 70% technical eligibility reported in the present study appears unchanged,  
288 there are several key differences. First, the above data represent a larger cohort with longer follow-  
289 up, with a mean follow-up to re-imaging of almost four years. On the surface, this may suggest that  
290 patients rarely alter their anatomical suitability over time. Second, patients with mechanical valves  
291 were excluded in the present analysis. The reason a mechanical aortic valve is regarded as a  
292 contraindication for AIBS is related to the fact that the top cap of the stent graft delivery system  
293 needs to go through the aortic valve during deployment of the stent graft. This would result in  
294 malfunctioning of the mechanical valve, thus making mechanical valve a contraindication to the  
295 current AIBS technique. A modified delivery system could potentially allow for stent graft  
296 implantation without need to cross the aortic valve. Based on a single case with a modified short  
297 bullet nose, Spear et al have suggested that mechanical valves are no longer an absolute  
298 contraindication.<sup>18</sup> However, the modified bullet nose delivery system requires an additional 3 cm  
299 of sealing zone to allow for stent graft implantation. Additionally, although custom made bullet  
300 nose delivery systems have at times been produced by Cook, it is not readily available, and  
301 regulatory constraints may limit their availability in the future. It was in this light, and as per advice  
302 from the manufacturer, that the more conservative exclusion criterion was applied.

303

304 Another important finding is the difference in eligibility between those patients in whom a clamp  
305 for the distal anastomosis was used. Notwithstanding other important consequences of surgical  
306 techniques, such as operative time and neurological complications, it could be argued that an open  
307 anastomosis with circulatory arrest may lead to a longer and therefore technically suitable landing  
308 zone for future endovascular options.<sup>19,20</sup> Although Table 3 suggests that coronary artery  
309 revascularization may hamper eligibility, these results were confounded by the concomitant  
310 placement of a mechanical aortic valve.

311

312 Having noted this, provided a satisfactory remedy for mechanical valves together with a greater  
313 awareness of the anatomical requirements of ensuring a graft of sufficient length and without  
314 kinking, the technical eligibility for a total endovascular solution could potentially reach more than  
315 90%. Increasing trends in the use of bioprosthetic valves, coupled with the potential for future  
316 transcatheter valve-in-valve procedures, may also impact future eligibility.<sup>21-24</sup>

317

318 Finally, it is interesting to note the significant difference in age between the technically eligible and  
319 ineligible groups. A type I error might be at play, but one could speculate whether more complex  
320 dissections, or at least more complex surgery, among younger patients has impacted their technical  
321 suitability. At any rate, older patients do not appear to be less suitable for AIBS candidacy, although  
322 the often-accompanying comorbidities of age are not taken into account in this study regarding  
323 candidacy. This is somewhat underscored in Figure 2, where the competing risk of death is  
324 substantial. While the less invasiveness of an endovascular approach maintains its appeal, these  
325 procedures are extremely complex, and clinical evaluation of potential candidates is compulsory.  
326 The reported eligibility of 70% is promising, and future long-term studies and focus on patient  
327 selection are anticipated.

328

329 *Limitations*

330 By its nature, a retrospective analysis has its limitations, particularly regarding the bias of patient  
331 selection. The patients included were only those who underwent surgery for their primary  
332 dissection. The external and internal validity of the Swedish patient data registries are otherwise  
333 robust, and unique personal identity numbers for all Swedish patients allow for complete follow-up  
334 on survival data. Follow-up imaging, however, was lacking for 26 patients. The reasons for no  
335 imaging were often because of poor patient clinical status. Although data from these images would  
336 have been useful, this again reflects common clinical practice. Even for those patients who  
337 underwent follow-up imaging, as indicated above, only 68.4% of those meeting the threshold for  
338 repair were indeed treated.

339

340 The definition of technical eligibility presents itself as somewhat of a moving target. Improved  
341 devices should be anticipated, but this vouches for the current analysis, in that the conservative  
342 criteria yields an already high proportion of patients who are currently technically eligible for a  
343 potential endovascular reoperation. The majority of the patients included in this study underwent  
344 repair at the era prior to the availability of the total endovascular arch repair technique. With  
345 increasing knowledge among cardiac surgeons performing type A dissection repair regarding the  
346 anatomical requirements for future endovascular arch repair, specifically the need for a long and  
347 straight ascending aortic graft as a landing zone, the proportion of eligible patients may increase  
348 over time.

349

350 **Conclusion**

351 This large patient cohort with long follow-up confirms that a substantial number of patients require  
352 further aortic repair following acute AAD or IMH open surgery. The majority of these patients,  
353 including those who meet the threshold indication for treatment, are technically eligible for the  
354 contemporary endovascular arch inner-branched stentgraft. Accommodation of a mechanical aortic  
355 valve would significantly increase this availability. Increasing age is not associated with a loss of  
356 eligibility, in contrast to the use of a clamp for the distal ascending aorta anastomosis at the primary  
357 surgery. These findings should help guide clinicians in their considerations of surgical approach and  
358 post-operative surveillance.

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360

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432

433 **Tables**

434 Table 1: Technical anatomic criteria for the custom made Cook aortic arch branched stent graft. \*

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- Ascending aorta diameter  $\leq 38$  mm.
  - Uniform ascending aorta with no significant angulation/kinking.
  - Sealing zone in the ascending aorta with true, centre-line length  $\geq 40$  mm and/or outer-curve length  $\geq 49$  mm, inner-curve length  $\geq 24$  mm.
  - Suitable innominate and left common carotid artery landing zone with diameters  $\leq 18$  mm.
  - Iliac artery access accommodating a minimum 22 French sheath.
  - Native or biological aortic valve, i.e., mechanical aortic valve contraindicated.
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\*Written correspondence with Cook Medical (Bloomington, IN, USA) custom aortic stentgraft representatives.

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450 Table 2: Baseline patient characteristics for the 198 patients followed after open surgical repair of  
 451 an acute Stanford Type-A aortic dissection or ascending aorta intramural hematoma.  
 452  
 453

Variable <sup>a</sup>	Total (n=198)
Age, years	61.4 (59.8-62.9)
Male Sex	124 (62.6%)
BMI, kg/m <sup>2</sup>	26.6 (26.1-27.1)
Smoking, No.	
Never	110 (55.6%)
Previous	32 (16.2%)
Active	56 (28.3%)
Hypertension	133 (67.2%)
Diabetes Mellitus	8 (4.0%)
Ischemic Heart Disease	12 (6.1%)
COPD	13 (6.6%)
Connective Tissue Disease	6 (3.0%)
Aortic Bovine Trunk	15 (7.6%)
Bicuspid aortic valve	8 (4.0%)
Ascending aortic IMH	8 (4.0%)
Aortic dissection	
Debakey Type I	158 (79.8%)
Debakey Type II	32 (16.2%)

454

455 *BMI*, Body mass index

456 *COPD*, Chronic Obstructive Pulmonary Disease

457 *IMH*, Intramural Hematoma

458 <sup>a</sup>Continuous data are shown as the mean (95% Confidence Intervals) and categoric data as number  
 459 (%).

460

461 Table 3: Comparison of patient characteristics, pathology, and technical aspects for the 129 patients  
 462 evaluated for AIBS eligibility, as well reasons for ineligibility.  
 463

	Eligible AIBS candidates (n=89)	Ineligible AIBS candidates (n=40)	p
Mean Age	60.2 (58.0-62.4)	55.7 (52.0-59.3)	.027 <sup>a</sup>
Patient Sex			
Male (%) /Female (%)	56 (62.9) / 33 (37.1)	26 (65.0) / 14 (35.0)	.820 <sup>a</sup>
Pathology			
Type I AAD	68 (76.4%)	36 (90.0%)	.071
Type II AAD	18 (20.2%)	3 (7.5%)	.070
IMH	3 (3.4%)	1 (2.5%)	.792
Bovine Trunk	7 (7.9%)	6 (15.0%)	.213
CTD	5 (5.6%)	3 (7.5%)	.682
Ascending aortic seal length, mm	48.3 (46.4-50.1)	38.2 (34.0-42.3)	<.001 <sup>a</sup>
Ascending aortic diameter, mm	32.2 (31.5-32.9)	32.7 (31.6-33.8)	.410 <sup>a</sup>
Circulatory Arrest, no distal clamp (%)	79 (88.8)	29 (72.5)	.021
CABG or coronary reimplantation (%)	2 (2.2)	13 (32.5)	<.001
Mechanical valve (%)	0	20 (50.0)	<.001
Biological valve (%)	8 (9.0)	3 (7.5)	.779
Reason for ineligibility			
Mechanical Valve only (%)		16 (40.0)	
Inadequate seal only (%)		12 (30.0)	
AI/Root dilatation (%)		2 (5.0)	

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Diameter (%)	2 (5.0)
Kink (%)	1 (2.5)
Combination (%)	7 (17.5)

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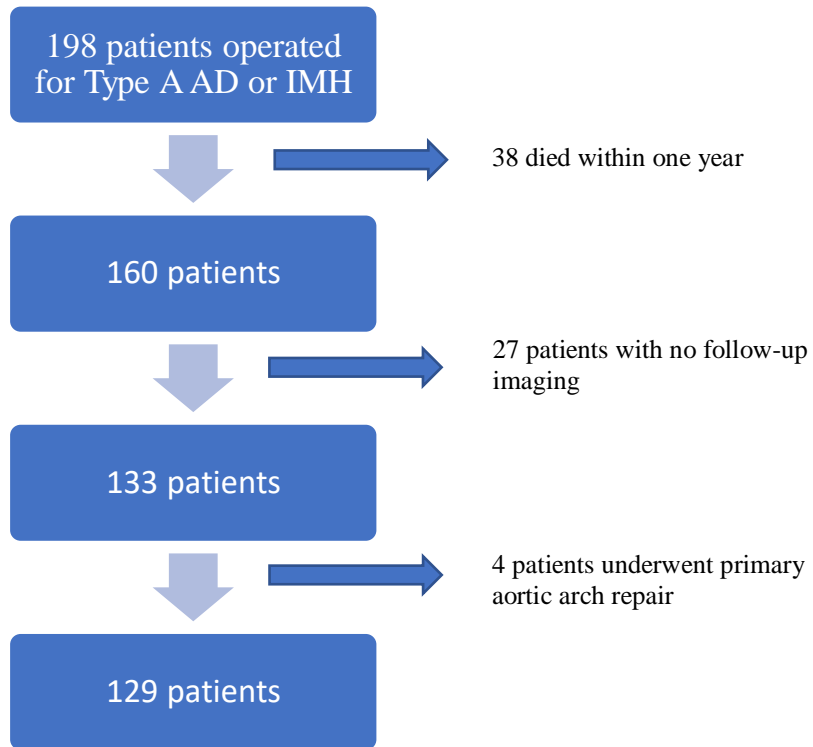
- 464
- 465 *AAD*, Stanford Type A aortic dissection
- 466 *AI*, aortic insufficiency
- 467 *AIBS*, arch inner-branched stent
- 468 *CABG*, coronary artery bypass graft
- 469 *CTD*, connective tissue disease
- 470 *IMH*, intramural hematoma
- 471 <sup>a</sup>Compared using t-tests; all other tests were performed using Chi-squared tests.
  
- 472

473 **Figures and Figure Legends**

474

475 Figure 1:

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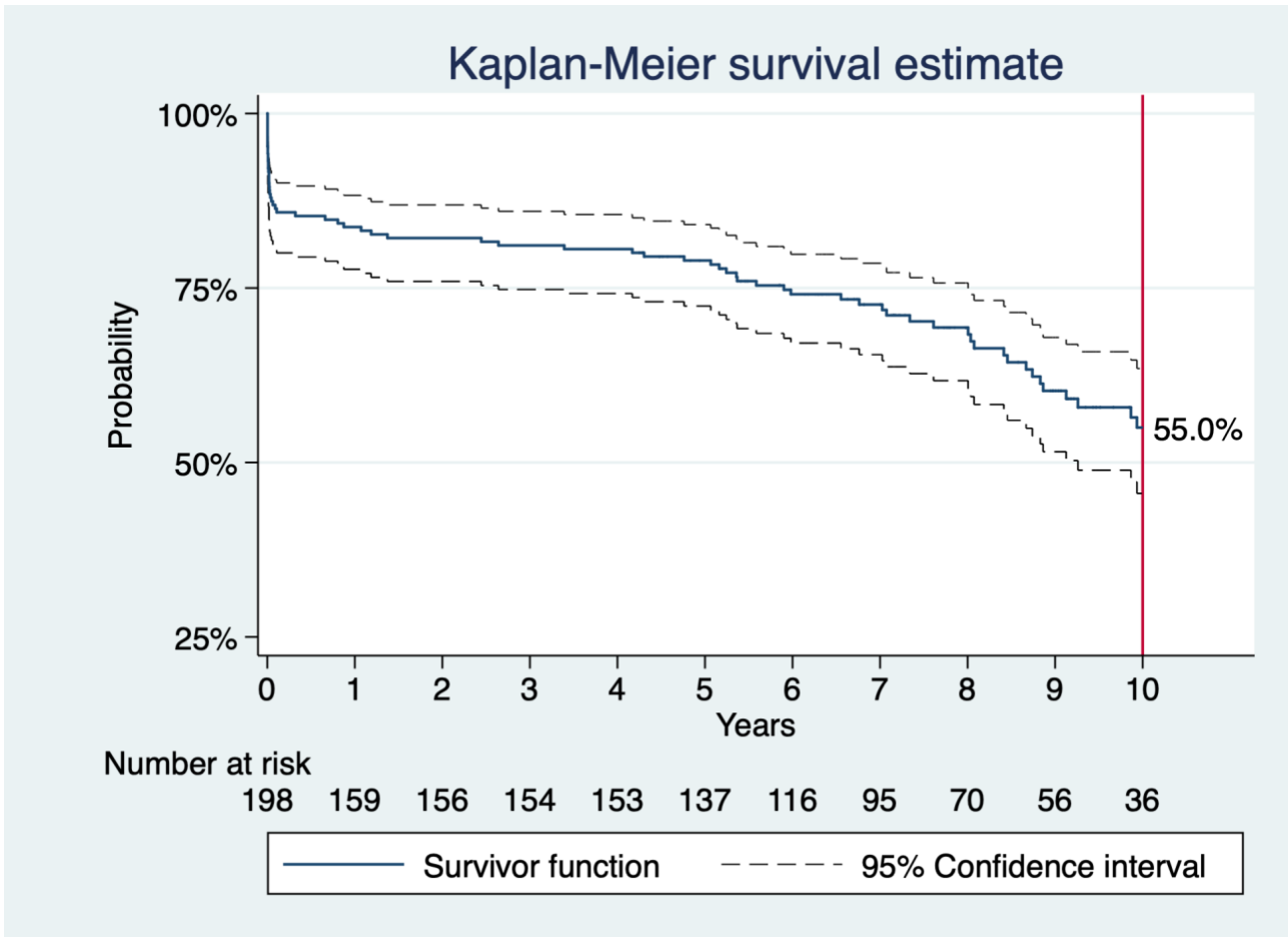
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479 Figure 1: Flowchart for the exclusion and selection of 129 patients evaluated for technical

480 eligibility for an arch inner-branched stentgraft from an initial cohort of 198 patients.

481

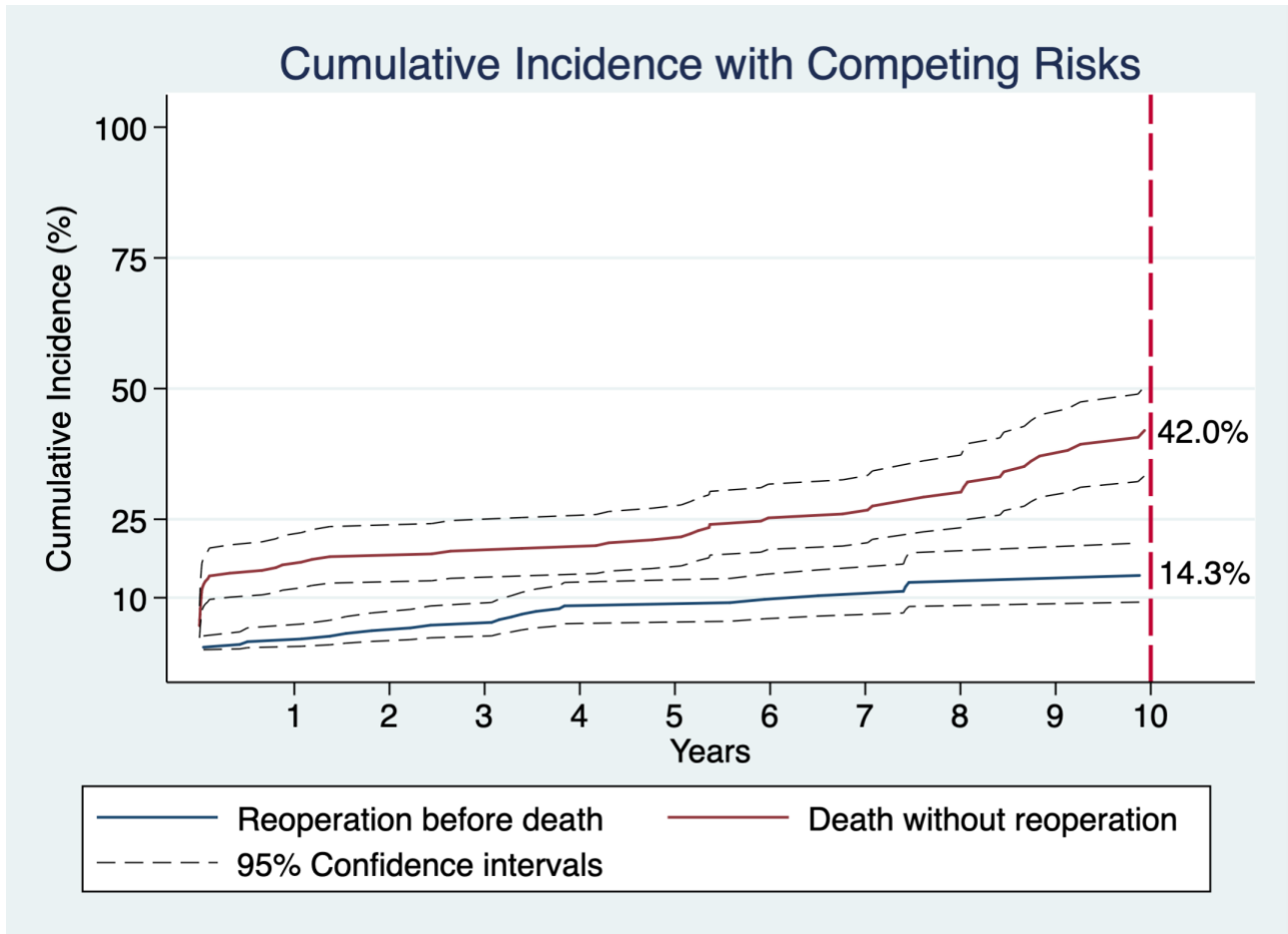
482 Figure 2a:



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485 Figure 2b:



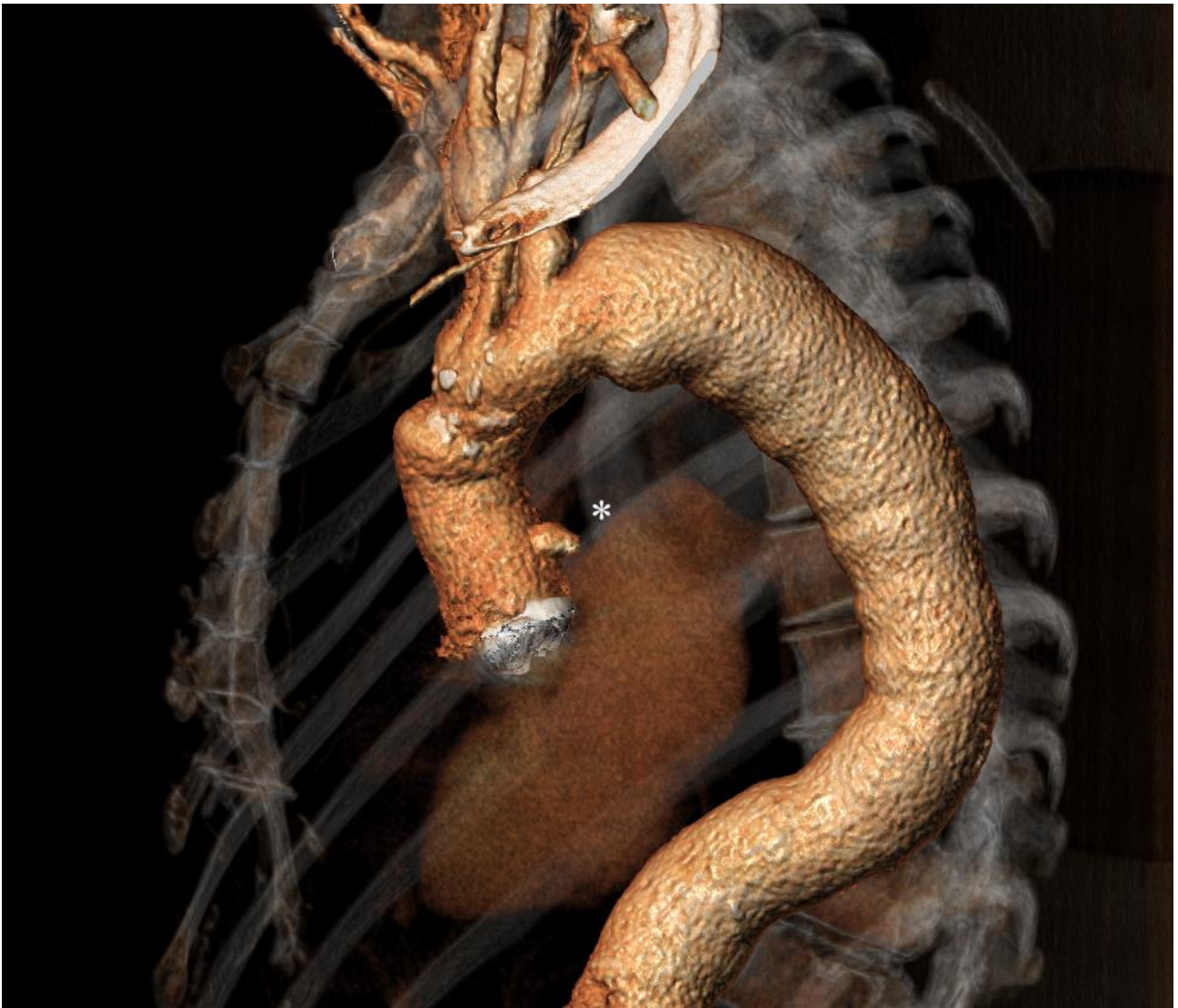
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487 Figures 2a and b: Survival analysis using Kaplan-Meier estimates in 2a, whereas estimates of the  
488 cumulative incidence of aortic reoperation in 2b are demonstrated using a competing-risks  
489 subdistribution model with death as the competing risk. Estimates at are presented with 95%  
490 confidence intervals and truncated at ten years.

491

492 Figure 3:

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495 Figure 3: Three-dimensional reconstructed computed tomographic image of a post-aortic dissection  
496 repair. Reimplantation of the coronary arteries (asterisk) shortens the landing zone of a potential  
497 endovascular arch inner-branched stentgraft. Note, the maximum diameter of the aortic arch was  
498 approximately 5 cm.