National Numbers of Secondary Aortic Reinterventions after Primary Abdominal Aortic Aneurysm Surgery from the Dutch Surgical Aneurysm Audit

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Background: Long-term secondary aortic reinterventions (SARs) can be a sign of (lack of) effectiveness of abdominal aortic aneurysm (AAA) surgery. This study provides insight into the national number of SARs after primary AAA repair by endovascular aneurysm repair (EVAR) or by open surgical repair in the Netherlands.

Methods: Observational study included all patients undergoing SAR between 2016 and 2017, registered in the compulsory Dutch Surgical Aneurysm Audit (DSAA). The DSAA started in 2013, SARs are registered from 2016. Characteristics of SAR and postoperative outcomes (mortality/complications) were analyzed, stratified by urgency of SAR. Data of SARs were merged with data of their preceded primary AAA repair, registered in the DSAA after January 2013. In these patients undergoing SAR, treatment characteristics of the preceded primary AAA repair were additionally described, with focus on differences between stent grafts.

Results: Between 2016 and 2017, 691 patients underwent SAR, this concerned 9.3% of all AAA procedures (infrarenal/juxtarenal/suprarenal) in the Netherlands (77% elective/11% acute symptomatic/12% ruptured). Endoleak (60%) was the most frequent indication for SAR. SARs were performed with EVAR in 66%. Postoperative mortalities after SAR were 3.4%, 11%, and 29% in elective, acute symptomatic, and ruptured patients, respectively. In 26% ($n = 181$) of the patients undergoing SAR their primary AAA repair was performed after January 2013 and data of primary and SAR procedures could be merged. In 93% ($n = 136$), primary AAA repair was EVAR. Endografts primarily used were nitinol/polyester (62%), nitinol/polytetrafluoroethylene (8%), endovascular sealing (21%), and others (9%), compared with their national market share of 76% (odds ratio [OR], 0.52; 95% confidence interval [CI], 0.38−0.71), 15% (OR, 0.50; CI, 0.29−0.89), 4.9% (OR, 5.04; CI, 3.44−7.38), and 4.1% (OR, 2.81; CI, 1.66−4.74), respectively.

Conclusions: In the Netherlands, about one-tenth of the annual AAA procedures concerns an SAR. A quarter of this cohort had an SAR within 1−5 years after their primary AAA repair. Most SARs followed after primary EVAR procedures, in which an overrepresentation of endovascular sealing grafts was seen. Postoperative mortality after SAR is comparable with primary AAA repair.

INTRODUCTION

The choice of surgical technique in primary abdominal aortic aneurysm (AAA) repairs is mainly based on patient and aneurysm-related characteristics. Because of lower postoperative mortality and morbidity after treatment with endovascular aneurysm repair (EVAR) compared with conventional open surgical repair (OSR), EVAR has become the preferred procedure in the elective setting and in many centers even in the acute setting.[1−3] However, when choosing a treatment strategy, it is also important to take long-term outcomes into account, such as surgical secondary reinterventions. Secondary reinterventions are undesirable for the patient and additionally contributes to higher costs of care. Follow-up studies of the EVAR-1 trial and Dutch Randomized Endovascular Aneurysm Management (DREAM) trial, comparing EVAR and OSR in patients with elective AAA, demonstrated a similar long-term survival but a significantly higher overall secondary reintervention rate in patients treated with EVAR.[4−6] After the DREAM (12 years) and EVAR-1 trial (15 years), the secondary reintervention rate was, respectively, 38% and 26% in patients treated with EVAR, compared with 21% and 12% in patients treated with OSR.[6,7] Over a period of time, endovascular devices and techniques have been further developed aiming to improve its safety and durability, which possibly affects the generalizability of these results for today practice.[8] In addition, the use of EVAR has continued to increase over the past decades and is currently used in almost 80% of all patients undergoing elective AAA surgery in the Netherlands.[9] Presumably both factors will influence the amount of secondary aortic reinterventions (SARs) that is carried out in daily practice. However, it is unclear what the current extent of this problem is on a national scale and what the consequences are for patients.

With the use of the nationwide Dutch Surgical Aneurysm Audit (DSAA), which registers all SAR procedures since 2016, first, we aimed to provide

insight into the national number of open surgical and endovascular SARs after primary OSR or primary EVAR. Second, we aimed to describe patient, aneurysm and treatment characteristics, and outcomes of patients undergoing SAR.

METHODS

Data Source and Patient Selection

The data set is retrieved from the DSAA. This mandatory and nationwide audit was initiated in 2013 and prospectively registers all patients undergoing surgery for an aortic aneurysm or dissection. Initially, only patients undergoing a primary abdominal aortic (infrarenal/juxtarenal) repair were registered in the DSAA. Since January 2016, all primary aortic procedures (EVAR and OSR) for an infrarenal/juxtarenal/suprarenal AAA and all SARs (endovascular or open procedure) after a primary AAA repair were also included in the audit. Data are registered via a web-based survey or provided via a batch data file per hospital and are collected on procedural level. Of each individual surgical procedure, corresponding patient characteristics, procedure characteristics, and 30 days or in hospital postoperative outcome are registered. With each procedure, the vascular surgeon must then indicate whether it concerns a primary AAA procedure or an SAR. Patients undergoing multiple surgical aortic procedures are thereby re-registered in each case.

In this study, we included all patients undergoing SAR, concerning the iliac and/or abdominal aorta, after the start of registration in January 2016 until December 2017. To consider a patient eligible for analysis the date of birth, date of surgery, type of surgical procedure, urgency of surgical procedure, and survival status at the time of discharge, and 30 days postoperatively had to be known. In these patients undergoing SAR (i.e. individual procedural records) we have no standard information about the primary AAA procedure. However, when patients undergoing SAR had undergone their primary AAA repair between January 2013 (start of the DSAA) and December 2017 and were registered in the DSAA, data of the primary AAA repair and SAR were merged (Fig. 1) and formed a subcohort. When the primary AAA repair was performed before January 2013, data on the primary AAA repair were not available and could not be merged with the SAR data.

All patients undergoing thoracic aortic surgery were excluded from this study.

Verification of the DSAA data was carried out in 2015 by a third trusted party, through a random sample of hospitals and will be continued in the future.[10]

Definitions

All surgical SARs after primary AAA repair concerning the iliac and/or abdominal aorta are considered as an SAR. All reintervention procedures occurring within 30 days after primary AAA repair or during initial admission were considered as postoperative reinterventions and not as SAR. Secondary reinterventions performed by other specialties, such as interventional radiologists, and all other secondary reintervention procedures not related to the aorta were not registered in the DSAA and therefore not included as an SAR in this study. Postoperative mortality was defined as mortality within 30 days after SAR or during admission (30 days/in hospital). Postoperative complications were categorized by surgical and nonsurgical complications. A hybrid procedure is defined as a procedure in which open and endovascular techniques are combined.

Statistical Analysis

Patient and aneurysm characteristics, treatment, and outcomes of the total cohort of patients undergoing SAR were stratified by the urgency of SAR (i.e., elective, acute symptomatic, and acute ruptured) and analyzed with descriptive statistics. In addition, postoperative outcomes of SARs were compared with outcomes of primary AAA repairs with *t*-tests and chi-squared tests. In case the missing data in a categorical or continues variable was exceeding 5%, a category ''missing/unknown'' was added. In the subcohort of patients with both data on the primary AAA procedure and the SAR, combined treatment characteristics, time to SAR, and outcomes were described using descriptive statistics. The ratio of different types of stent grafts, used at primary AAA repair, in patients undergoing SAR was compared with the ratio of the national market share of these grafts. All statistical analyses were performed using SPSS statistical software (version 24; IMB Corp, Armonk, NY).

RESULTS

Between January 2016 and December 2017, 8,234 patients were registered in the DSAA and eligible for analysis, of which 7,425 (90.2%) patients were undergoing AAA surgery, 718 (8.7%) patients were undergoing thoracic aortic aneurysm surgery, and in 91 (1.1%) patients the location of the aneurysm was

unspecified. Of all patients undergoing AAA surgery, 691 patients (9.3%) underwent an SAR after primary AAA surgery, of which 21 patients (3.0%) also underwent a second SAR. These 691 patients who underwent SAR were included in this study.

All Patients Undergoing Secondary Aortic Reconstruction Surgery

The total SAR cohort consisted predominantly of males (n = 613, 89%) and had a mean age of 75 years (standard deviation 7.8). Patient characteristics are shown in Table I.

Most patients (n = 530, 76.7%) were undergoing SAR in elective setting, and 10.9% (n = 75) and 12.4% (n = 86) were undergoing SAR because of an acute symptomatic or ruptured AAA, respectively. Endoleaks after EVAR (n = 412, 60%) were most often the indication for SAR, followed by progression of aneurysmatic disease (aneurysm growth not caused by an endoleak) (n = 185, 26.8%), false aneurysm (n = 49, 7.1%), and infected prostheses (n = 42, 6.1%). In most patients (n = 453, 65.6%), SAR was performed with an endovascular procedure, 21% (n = 145) with an open procedure, in 3.2% (n = 22) the SAR was converted from endovascular to open procedure, and in 1.3% (n = 9) a hybrid procedure was performed. In the remaining 8.9% (n = 62) of SARs, the procedure was unspecified.

Postoperative complications after SAR occurred in 26.5% (n = 141) of elective patients, in 48.7% (n = 29) of acute symptomatic patients, and in 62.7% (n = 54) of patients with a ruptured aneurysm (Table II). In 7.2%, 10.7%, and 25.6% postoperative reintervention was necessary within 30 days after the SAR or during the hospital stay. More than 50% of these postoperative reinterventions were open procedures, most of them after an open SAR. Postoperative mortality (30 days/in hospital) was 3.4%, 10.7%, and 29.1% in elective, acute symptomatic, and ruptured aneurysm patients, respectively. Table III shows the comparison of observed (unadjusted) postoperative outcomes of SARs and of primary AAA procedures in the same period. Postoperative mortality after SAR was comparable to primary AAA repair in all urgency settings. There were more postoperative complications after elective SARs compared with elective primary AAA repairs.

Patients Undergoing SAR Matched to Their Primary AAA Repair Registered in the DSAA

Of all patients undergoing an SAR, 26% (n = 181) was registered in the DSAA with their primary AAA repair between January 2013 and December 2017 and could be evaluated for the combined treatment characteristics of the primary AAA repair and of the SAR (Fig. 1). In the remaining 74% (n = 510) of patients undergoing SAR the primary AAA was not registered in the DSAA, which implies that they, in all probability, had undergone their primary AAA repair before 2013. The primary procedure in these patients is thereby unknown.

In the matched subcohort of 181 patients, the median maximum AAA diameter at the moment of primary AAA repair was 60 mm (interquartile range 55−73 mm). The median time from primary AAA procedure until SAR was 25 months (interquartile range 11−35 months).

Of the 181 patients, 93% (n = 169) was primarily treated with EVAR, 6.1% (n = 11) with OSR, and 0.6% (n = 1) with a hybrid procedure. Figure 2 provides an overview of the surgical technique used in the primary AAA procedures and after SARs. Types of endovascular grafts that were most frequently used in the primary EVAR procedures were nitinol/polyester stent grafts (n = 104; 62%), nitinol/polytetrafluoroethylene stent grafts (n = 14; 8%), endovascular sealing stent grafts (n = 35; 21%), and others (n = 16; 9%). Table IV specifies the indications for SAR per type of endovascular stent and the market share per type in the Netherlands. The proportion of primary endovascular sealing stent grafts in patients with an SAR is significant (21% vs. 4.9%, [odds ratio, 5.04; 95% confidence interval, 3.44−7.38]). All other types of stent grafts were equally represented in the SAR group, relative to their market share.

In the 12 patients (6.7%) with a primary OSR or hybrid procedure, the indications for SAR were progression of aneurysmatic disease (n = 5, 45%), infected prosthesis (n = 4, 36%), false aneurysm (n = 1, 9.1%), and other unspecified reasons (n = 2, 18.2%).

The majority of the subcohort (n = 136, 75.1%) was primarily treated in an elective setting, 10.5% (n = 19) in acute symptomatic, and 14.4% (n = 26) in ruptured setting. Figure 3 shows the urgency settings of the primary procedures and after SARs. A total of 80% of patients with an elective primary AAA repair did undergo their SAR in an elective setting as well (n = 109, 80.1%). The remaining 8.1% (n = 11) and 11.8% (n = 16) of primary elective patients underwent an SAR in an acute symptomatic or ruptured setting. Of these 27 patients, 6 (22%) died of complications of the SAR procedure.

DISCUSSION

Between January 2016 and December 2017, 691 patients underwent a SAR in the Netherlands, which

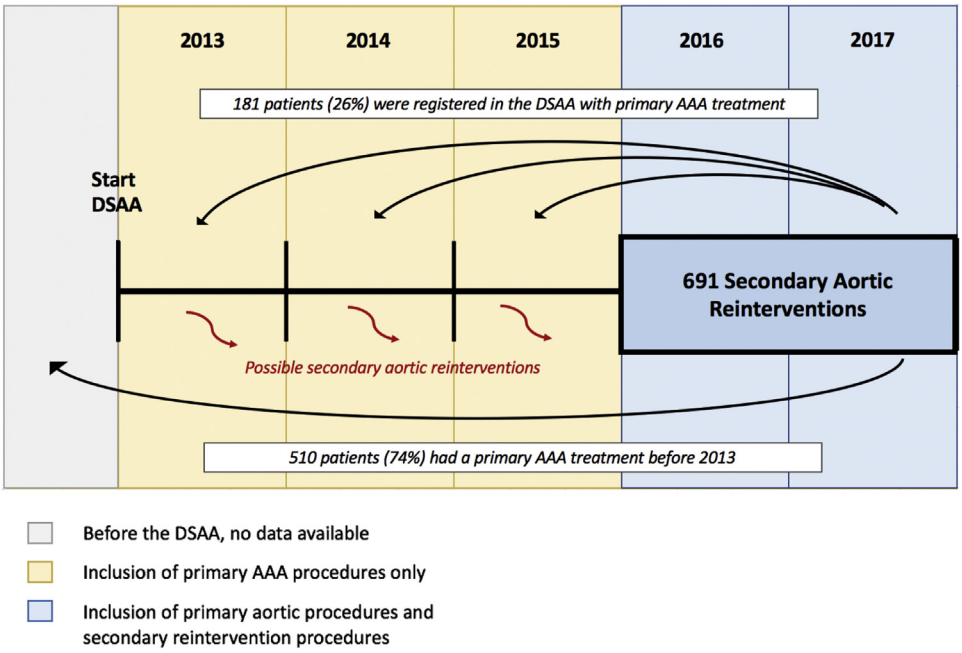

Fig. 1. Flow chart of patients included in this study.

counts for 9.3% of all AAA procedures performed. Endoleak was the most frequent indication for SAR, from which we can conclude that at least 60% of all SARs followed after primary EVAR. Most SARs were performed in an elective setting and more than half with an endovascular procedure. Postoperative mortality after SAR was 3.4%, 11%, and 29% in patients with elective, acute symptomatic, and ruptured AAA, respectively, which is in line with the results after primary procedures. About a quarter of the patients was previously registered in the DSAA for their primary AAA repair between 2013 and 2017 (i.e., short-term/midterm SAR). This implies that the remaining 3-quarters had their primary AAA repair before the start of the audit and therefore information on their primary AAA repair (i.e., long-term SAR) is lacking.

The vast majority of SARs followed after primary DSAA registered EVAR procedures (169/181), in which an overrepresentation of endovascular sealing stent grafts was seen. Only half of these primary EVAR procedures could be treated with again an endovascular procedure during SAR. Furthermore, one-fifth of patients with a primary elective AAA procedure underwent an acute symptomatic or ruptured SAR.

Although elective EVAR is known to have a lower postoperative mortality than elective OSR, this survival benefit disappears after about 2 years.[11] In addition, it appears that EVAR entails more SARs, which in turn leads to higher costs. Although the follow-up study of the Open versus Endovascular Repair trial did not demonstrate higher overall secondary reintervention rate in patients treated with EVAR compared with OSR, the first follow-up studies of the DREAM and EVAR-1 trial did.[4,5,12] However, these 2 studies did not include all laparotomy-related reinterventions. More recently, 12- and 15-year follow-up studies of these same trials included all secondary reinterventions directly and indirectly related to the primary AAA repair and confirmed a significantly higher overall secondary reintervention rate in elective patients treated with EVAR compared with OSR.[6,7] The same results were seen in a large American observational study.[11] To evaluate how the outcomes of these studies relate to daily practice (real world), you would ideally follow a large cohort of patients with primary AAA, such as registered in the DSAA, over a period of time.

Because the DSAA was initially set up without the registration of SARs, which was added only 3 years after the start of the audit, it is not (yet) possible to make statements about the national incidence of SARs after primary AAA (Fig. 1). However, almost 10% of all AAA procedures performed in 2016–2017 concerns an SAR. No other national quality registry ever reported their national annual

Table I. Patient and treatment characteristics of patients undergoing SAR between 2016 and 2017

	Elective		Acute symptomatic		Acute ruptured		Total	
	N	%	*N*	%	*N*	%	*N*	%
Number of patients	530		75		86		691	
Age (mean, years)	74.9 SD 7.4		75.9 SD 8.9		74.4 SD 9.3		74.9 SD 7.8	
Sex								
Male	478	90.2	59	78.7	76	88.4	613	88.7
Female	52	9.8	16	21.3	10	11.6	78	11.3
Year of surgery								
2016	211	39.8	31	41.3	45	52.3	287	41.5
2017	319	60.2	44	58.7	41	47.7	404	58.5
Pulmonary state								
No dyspnea	348	65.7	42	56.0	49	57.0	439	63.5
Dyspnea	147	27.7	20	26.7	17	19.8	184	26.6
Severe dyspnea	25	4.7	4	5.3	3	3.5	32	4.6
Unknown	10	1.9	9	12.0	17	19.8	36	5.2
Cardiac state								
No abnormalities	189	35.7	19	25.3	31	36.0	239	34.6
Peripheral edema	54	10.2	13	17.3	11	12.8	78	11.3
Raised central venous pressure	14	2.6	4	5.3	0	0	18	2.6
Antihypertensive medication	261	49.2	35	46.7	38	44.2	334	48.3
Unknown	12	2.3	4	5.3	6	7.0	22	3.2
Last preoperative electrocardiography								
No abnormalities	209	39.4	21	28.0	29	33.7	259	37.5
Atrial fibrillation	56	10.6	8	10.7	9	10.5	73	10.6
Ischemia	22	4.2	0	0	1	1.2	23	3.3
Other abnormalities	185	34.9	34	45.3	25	29.1	244	35.3
No electrocardiography performed	58	10.9	12	16.0	22	25.6	92	13.3
Type of aneurysm								
Infrarenal	295	55.7	46	61.3	54	62.8	395	57.2
Juxtarenal	87	16.4	6	8.0	9	10.5	102	14.8
Suprarenal	19	3.6	2	2.7	2	2.3	23	3.3
Unknown	129	24.3	21	28.0	21	24.4	171	24.7
Pathogenesis								
Infected prosthesis	24	4.5	8	10.7	10	11.6	42	6.1
Endoleak	329	62.1	41	54.7	42	48.8	412	59.9
False aneurysm	32	6.0	6	8.0	11	12.8	49	7.1
Progression of aneurysmatic disease	143	27.0	18	25.4	23	26.7	185	26.8
Unknown	2	0.4	1	1.3	0	0.0	3	0.4
Surgery								
Endovascular	365	68.9	41	54.7	47	54.7	453	65.6
Open	93	17.5	20	26.7	32	37.2	145	21.0
Converted to open	16	3.0	4	5.30	2	2.3	22	3.2
Hybrid	3	0.6	4	5.30	2	2.3	9	1.3
Other	53	10.0	6	8.0	3	3.5	62	8.9

volume of SARs and let alone the outcome.[13–16] Since EVAR was introduced in 1991 and now performed in a steady percentage of approximately 80% of patients with elective AAA, one can state that the national annual number of SARs provides a good insight into the extent of the problem in daily practice.[9,17]

There is a presumption that the number of patients treated with EVAR outside the instructions for use (IFU) is increasing. Unfortunately, this is information not yet registered in the DSAA. In the literature only relatively small series are reported comparing outcomes after EVAR within and outside IFU, which showed conflicting results in

Table II. Postoperative outcomes of patients undergoing SAR

	Elective		Acute symptomatic		Acute ruptured		Total	
	N	%	*N*	%	*N*	%	*N*	%
Postoperative complications								
No complication	389	73.4	46	61.3	31	36.0	466	67.4
Surgical complication	40	7.5	5	6.7	13	15.1	58	8.4
Nonsurgical complication	72	13.5	17	22.7	26	30.2	115	16.6
Surgical and nonsurgical complication	29	5.5	7	9.3	15	17.4	51	7.4
Unknown complication	0	0.0	0	0.0	1	1.2	1	0.1
Permanent injury because of complication[a]								
No	100	70.9	17	58.6	20	36.4	137	61.2
Yes	29	20.6	8	27.6	28	50.9	65	29.0
Unknown	12	8.5	4	13.8	7	12.7	23	10.3
Reintervention within 30 days/in hospital								
No	492	92.8	66	88.0	63	73.3	621	89.9
Yes	38	7.2	8	10.7	22	25.6	68	9.8
Unknown	0	0.0	1	1.3	1	1.2	2	0.3
Type of reintervention[b]								
Endovascular procedure	8	21.1	3	37.5	6	27.3	17	25.0
Percutaneous procedure	1	2.6	0	0.00	1	4.5	2	2.9
Endoscopic procedure	1	2.6	0	0.00	0	0.0	1	1.5
Reoperation open procedure	21	55.3	4	50.0	14	63.6	39	57.4
Other	7	18.4	1	12.5	1	4.5	9	13.2
Re-admission (within 30 days after discharge)	30	5.70	9	12.0	7	7.0	46	6.7
Postoperative mortality (30 days/in hospital)	18	3.4	8	10.7	25	29.1	51	7.4

[a]Calculated in all patients with a postoperative complication.
[b]Calculated in all patients with a reintervention.

postoperative outcomes and reintervention rates.[18–20] However, other studies have already demonstrated that anatomic characteristics of the AAA are predictive for reintervention after EVAR.[21,22] Although larger studies with longer follow-up periods are needed to evaluate the influence of treatment outside IFU on SARs, the increasing use of EVAR outside IFU most likely affects the number of SARs.

As a new aneurysm, graft infection, and graft stenosis are reported indications for SAR in patients primarily treated with EVAR or OSR, endoleak and graft migration only occurs in EVAR patients.[7,8,23–25] In most of our patients, endoleak (60%) was the indication for SAR. So at least 60% of all SARs performed between 2016 and 2017 followed after a primary EVAR procedure. By merging data of SARs with data on the corresponding primary AAA procedures, we were able to provide insight into combined treatment characteristics in 26% of the DSAA. Although we already concluded that at least 60% of SARs in the total cohort occurred after a primary EVAR procedure, this was actually the case in 93% of the subcohort. This high percentage

Table III. Surgical treatment and outcomes of SAR compared with primary AAA repairs 2016–2017

	Elective					Acute symptomatic					Acute ruptured				
	Primary repair		SAR			Primary repair		SAR			Primary repair		SAR		
	N	%	*N*	%	*P* value	*N*	%	*N*	%	*P* value	*N*	%	*N*	%	*P* value
Surgical procedure					0.000					0.000					0.003
Endovascular	3,974	77	365	69		370	65	41	55		403	41	47	55	
Converted to open	5	0.1	16	3.0		3	0.5	4	5.3		7	0.7	2	2.3	
Open	1,102	22	93	18		195	34	20	27		556	56	32	37	
Hybrid	24	0.5	3	0.6		2	0.3	4	5.3		11	1.1	2	2.3	
Other	31	0.6	53	10		4	0.7	6	8.0		10	1.0	3	3.5	
Postoperative complications					0.001					0.623					0.855
No complication	4,100	80	389	73		386	67	46	61		315	32	31	36	
Surgical complication	284	5.5	40	7.5		38	6.6	5	6.7		134	14	13	15	
Nonsurgical complication	586	11	72	14		116	20	17	23		334	34	26	30	
Surgical and nonsurgical complication	155	3.0	29	5.5		34	5.9	7	9.3		197	20	15	17	
Unknown complication	11	0.2	0	0.0		0	0.0%	0	0.0		7	0.7	1	1.2	
Permanent injury because of complication[a]					0.014					0.282					0.388
No	839	81	100	71		136	72	17	59		307	46	20	36	
Yes	129	13	29	21		38	20	8	28		296	44	28	51	
Unknown	65	6.3	12	8.5		14	7.4	4	14		67	10	7	13	
Reintervention within 30 days/in hospital					0.015					0.166					0.315
No	4,896	96	492	93		536	94	66	89		789	80	63	73	
Yes	228	4.4	38	7.2		37	6.5	8	10.8		192	20	22	26	
Unknown	5	0.1	0	0.0		0	0.0	0	0.0		6	0.6	1	1.2	
Re-admission (within 30 days after discharge)	301	5.9	30	5.7	0.855	46	8.0	9	12.2	0.230	60	6.1	6	7.1	0.718
Postoperative mortality (30 days/in hospital)	86	1.7	18	3.4	0.005	35	6.1	8	10.7	0.135	313	32	25	29	0.613

[a]Calculated in all patients with a postoperative complication.

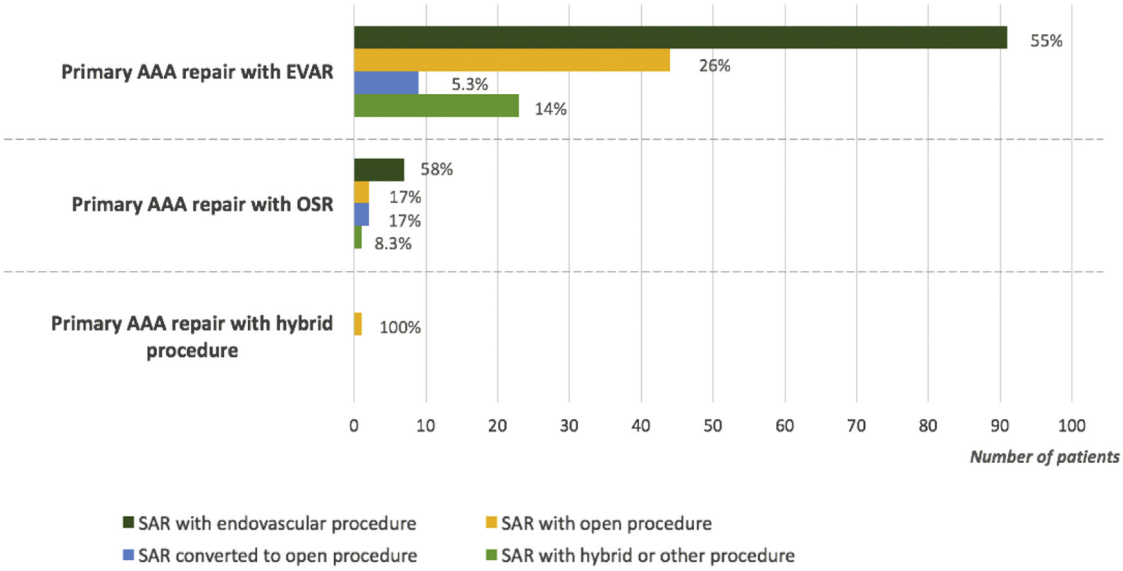

Fig. 2. Type of primary surgical procedure followed by type of SAR in patients undergoing a primary AAA procedure after 2013 and an SAR between 2016 and 2017.

Table IV. The indication for secondary aortic reintervention per type of endovascular graft used in the primary AAA procedure

	Infected prosthesis		Endoleak		Progression of aneurysmatic disease		Unknown		Total	%	Use of endovascular prosthesis in the Netherlands 2013–2017
Nitinol/polyester	2	1.9%	87	84%	15	14.9%	0	0%	104	62	76%
Nitinol/PTFE	3	21%	10	71%	1	7.1%	0	0%	14	8	15%
Endovascular sealing	0	0%	28	80%	7	20%	0	0%	35	21	4.9%
Other	0	0%	13	81%	2	13%	1	6.3%	16	9	4.1%
	5	3.0%	138	82%	25	14.8%	1	0.6%	169	100	100%

may partly be explained by the fact that about 70% of all primary AAA repairs is performed with EVAR.[9] Furthermore, we only report on SARs, where part of secondary reinterventions after primary OSR is not related to the aorta (i.e., laparotomy related).[5,11] Finally, the maximal follow-up of 5 years and the way the audit was set up (i.e., missing the early SARs in 2013–2015) could have influenced the proportion of primary EVAR in this subcohort, as SARs after primary EVAR usually occur at different times of follow-up than SARs after primary OSR.[6,7,26] In addition, as 3-quarters of the SARs occur at least more than 4 years after the primary AAA repair, long-term follow-up seems to be necessary.

The large proportion of nitinol/polyester stent grafts in patients who underwent SAR from the subgroup analysis is in accordance with the high percentage of national use of these stents. However, 21% of primary endovascular sealing stent grafts in patients who underwent SAR was significantly higher than the national use. The endovascular sealing system was designed to overcome common issues with endovascular systems, such as endoleaks and graft migration, by which more patients with a difficult anatomy of the aorta might be eligible for treatment with endovascular technique. Although previous studies demonstrated that these endovascular sealing systems were safe and had low SAR rates, others raised their concerns about more reinterventions and risk of rupture.[27–30] Again, the missing early SARs of patients undergoing primary AAA repair between 2013 and 2015 in

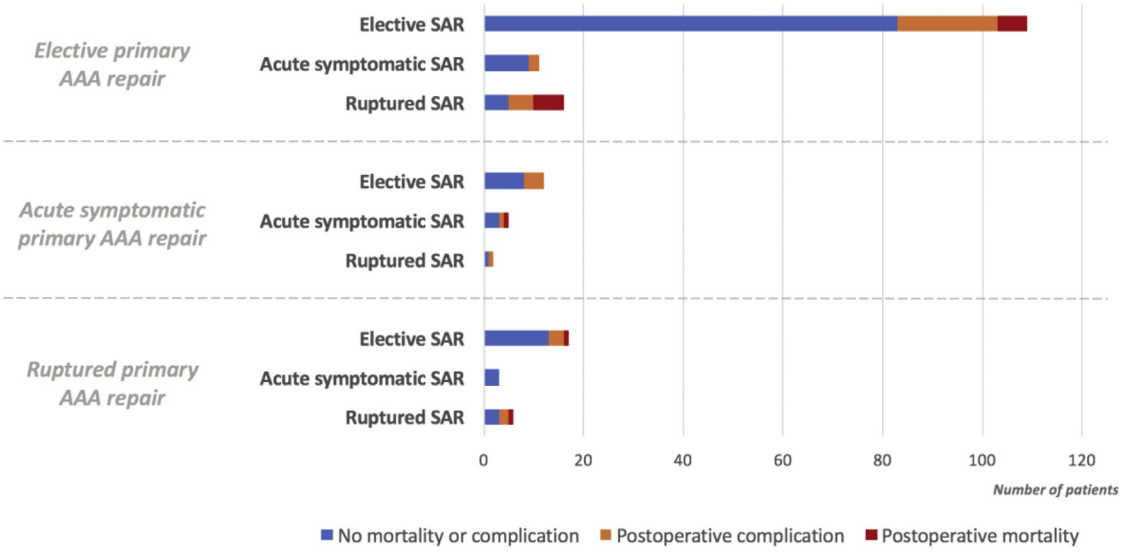

Fig. 3. Urgency of primary surgical procedure followed by urgency of SAR in patients undergoing a primary AAA procedure after 2013 and an SAR between 2016 and 2017.

our study could have influenced the proportion of different stent grafts in our subcohort. Furthermore, it is unclear how many and which patients were treated outside IFU. Nevertheless, the significant overrepresentation of endovascular sealing stent grafts in national SARs is an important finding of this study and needs further attention.

This study has some limitations that need to be addressed. First, as the audit exclusively registers surgical aortic procedures, we were only able to evaluate surgical SARs. All laparotomy-related secondary reinterventions, such as incisional hernia repair and bowel obstruction, that may be needed after primary OSR and all SARs performed by the interventional radiologist are therefore not included in this analysis. Both would probably have increased the number of secondary reinterventions performed after primary AAA surgery considerably. Second, as only patients undergoing surgery are registered, the number of SARs performed does not necessarily correspond to the number of SARs required. Possibly only patients that are fit enough (and did not die) undergo SAR, by which selection-bias might be present. The number of SARs presented in this study will, therefore, be an underestimation of the actual number of SARs that is performed (and possibly required) after primary AAA surgery in the Netherlands.

Although part of our analyses are now hampered because of missing SARs in the period 2013–2015, with time the DSAA will be a complete registration of primary AAA repairs and subsequent SARs. With a few more years of auditing, it will be possible to provide a national incidence of SAR and to evaluate differences in national SAR rates between surgical techniques and additionally between the types of EVAR stent grafts that are used. The latter is an important step forward, as the audit can serve to detect problems with specific stent grafts at an early stage. In addition, one-fifth of patients with an initial elective primary AAA repair underwent SAR in an urgent or acute setting, with the associated increased morbidity, which indicates there might be room for improvement. Finally, as we know that SARs are frequently needed after EVAR, it is a challenge to find out how the optimal follow-up after EVAR should look like.

CONCLUSIONS

Data from the DSAA show that about one-tenth of the annual AAA procedures concerns an SAR. Endoleak was the most frequent reason for SAR. About a quarter of this cohort had an SAR within 1–5 years after their primary AAA repair. Most SARs were performed after a primary EVAR procedure, in which an overrepresentation of endovascular sealing stent grafts was seen. Furthermore, only half of primary EVAR procedures could again be treated with an endovascular procedure during SAR. Postoperative mortality after SAR is comparable to primary AAA repair in all urgency settings. In addition, there were more postoperative

complications after elective SARs compared with elective primary AAA repairs.

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