Evaluating abdominal aortic aneurysm and carotid artery surgery in the Netherlands: variations in indication, treatment and outcomes measures

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Abdominal aortic aneurysm surgery

CHAPTER 2

Variation in Surgical Treatment of Abdominal Aortic Aneurysms with Small Aortic Diameters in the Netherlands

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ABSTRACT

Background and objective

Guidelines recommend surgical treatment for asymptomatic abdominal aortic aneurysms (AAA) with a diameter of at least 55mm for men and 50mm for women. We evaluate reasons to deviate from these guidelines and focus on the difference in how Dutch vascular surgical units (VSU) perceive their deviation and their actual deviation.

Methods

All patients undergoing elective AAA-repair between 2013-2016 registered in the Dutch Surgical Aneurysm Audit (DSAA) were included. Surgery at diameters of <55mm for men and <50mm for women were considered guideline deviations. National deviation and hospital variation in deviation were evaluated over time. Questionnaires were distributed among all Dutch VSUs, inquiring for acceptable reasons for guideline deviation. VSUs were asked to estimate the guideline deviation percentage in their hospital which were then compared with their DSAA-percentage.

Results

9039 patients were included. In 15% we found guideline deviation, varying from 2-40% between VSUs. Over time, 21 VSUs were identified with a lower percentage of deviation than the national mean each year and 8 VSUs with a higher percentage. 44/60 VSUs completed the questionnaire. Most commonly reported reasons to deviate were concomitant large iliac diameter (91%) and saccular aneurysm (82%). The majority of the VSUs (77%) estimated their guideline deviation to be <5%. 11 VSUs (25%) estimated their deviation concordant with their DSAA-percentage, but 75% of VSUs underestimated their deviation.

Conclusion

Dutch VSUs regularly deviate from the guidelines regarding aneurysm diameter, with variation between VSUs. Consensus exists amongst VSUs on acceptable reasons for guideline deviations, however the majority underestimates their actual deviation percentage.

INTRODUCTION

The indication for elective surgical treatment in patients with an asymptomatic abdominal aortic aneurysm (AAA) depends on multiple factors, of which the diameter of the aneurysm is the most important one, as the risk of rupture increases with the diameter of the aneurysm.[1] International guidelines recommend surgical treatment in patients with an asymptomatic abdominal aortic aneurysm with a diameter of 55 mm or more in males and 50 mm or more in females.[2,3] These diameter thresholds for intervention have been studied extensively and early intervention in asymptomatic patients with a small abdominal aortic aneurysm (<55mm in males, <50mm in females) has not proven to be beneficial compared to watchful waiting.[4-8] Since 2013, all patients undergoing aortic aneurysm surgery in the Netherlands are registered in a nationwide audit, the Dutch Surgical Aneurysm Audit (DSAA)[9]. This audit reported previously that 17% of all patients undergoing elective aneurysm surgery is operated with a smaller diameter than recommended in the guidelines, with variation between hospitals.[10] Other studies have also confirmed variation in practice regarding the aneurysm diameter, nationally and internationally.[11-13] There are reasons why surgeons could decide to deviate from this guideline, for example a saccular-shaped aneurysm, a large iliac component, rapid growth etc.[14] However, unnecessarily large variation in clinical practice is undesirable, because it can result in unnecessary adverse outcomes for patients[13] and will lead to unnecessary costs.[15,16] To minimize differences in practice, to improve quality of care and to use health care more efficiently, it is important to have more insight into the reasons for this variation in clinical practice.

The aim of this study is first to evaluate patient and disease characteristics associated with performing surgical therapy on patients with a smaller aortic diameter than recommended in the guideline and secondly to investigate reasons to deviate from this guideline with a focus on how often Dutch vascular surgical units (VSUs) think they deviate from the guidelines and actually do.

METHODS

This study consists of three parts:

1. Analysis of national data from the DSAA
2. Survey questionnaire among Dutch Vascular Surgeons
3. Comparison of the outcomes of the survey questionnaire and DSAA data

Part 1 – Analysis of national data from the Netherlands

Data source and patient selection

The dataset is derived from the DSAA. This compulsory nationwide audit was initiated in 2013 and prospectively registers all patients undergoing surgery for an aortic aneurysm or dissection. Data are registered via a web-based survey or provided by the hospitals as a batch data file. All patients with a juxta- or infrarenal abdominal aortic aneurysm undergoing primary elective surgery between January 2013 and December 2016 were included. All patients with symptomatic or ruptured abdominal aortic aneurysms, isolated iliac artery aneurysms, thoracic aortic aneurysms or/and dissections, undefined aneurysms and patients undergoing revision surgery were excluded. Additionally, patients operated in hospitals that stopped performing aneurysm surgery after the first year of the study period were also excluded.

Aneurysm diameter

In the survey of the DSAA, the largest measured aortic aneurysm diameter, anterior-posterior measured with ultrasound or computed tomography angiography (CTA) and extracted from the radiology report, is registered. The diameter thresholds for surgical treatment in asymptomatic abdominal aortic aneurysms according to the Dutch national guideline are used: 55mm or more for males, 50 mm or more for females. We have made a distinction between 'any deviations' from this guideline (diameter <55mm in males, diameter <50mm in females), 'small deviations' (diameter from 50-54mm in males, 45-49mm in females) and 'large deviations' (diameter <50mm in males, diameter <45mm in females).

Dutch health care policies regarding elective AAA surgery.

For the treatment of elective AAA, there is an annual minimum volume standard of 20 elective AAA repairs per hospital in the Netherlands. This minimum volume standard is monitored with the use of DSAA-data. All patients undergoing elective AAA surgery are pre-operatively discussed in a multidisciplinary team or vascular meeting. This is also a quality indicator that is monitored in the DSAA.

Analysis

Using descriptive analysis (T-test and chi-square tests), patient, disease and treatment characteristics were compared between two separate groups: all patients treated according to the national guidelines and all patients in which was ''deviated from the guidelines". Patient, treatment and hospital characteristics independently associated with any deviation from the guidelines were evaluated using a multivariable logistic regression analysis with p-value of 0.05 using an enter model. Co-variables used in this multivariable logistic regression analysis were: sex, age, pulmonary state, cardiac state, results of last preoperative electrocardiogram, malignancy, pre-operative hemoglobin and creatinine, type of surgical procedure and hospital

volume. Additionally, variation in surgical treatment of small aneurysms (diameter <55mm in males, diameter <50mm in females) between hospitals was evaluated over time, by comparison of the percentage of deviation from the guideline per hospital over the years 2013-2016. All statistical analyses were performed using SPSS statistical software (version 24; IBM Corp, Armonk, NY).

Part 2 – Survey questionnaire among Dutch Vascular Surgeons

In order to obtain insight in the reasons why vascular surgeons decide to operate patients with a small abdominal aortic aneurysm diameter, an online survey questionnaire was distributed among VSUs in the 60 hospitals that perform AAA surgery in the Netherlands. The contact person for the DSAA of each VSU, chief of the department of vascular surgery, was contacted to fill in the questionnaire for his/her VSU. The survey consisted of 14 questions (appendix 1). In the first section, units were asked to estimate how often they perform surgery on patients with a small aortic aneurysm diameter in 2 multiple choice questions. Subsequently, they were asked what they thought to be acceptable reasons to deviate from the guideline, in which multiple reasons were proposed. Finally, they were asked to estimate to what extent these 11 reasons were applicable to or did occur in their hospital, by using a Likert scale. In order to compare the results of the questionnaire with the DSAA data, units were asked to report the name of their hospital, making the questionnaire not anonymous.
Descriptive analyses were used to evaluate outcomes.

Part 3 – Comparison of the outcomes of the survey questionnaire and DSAA data

Results of de survey questionnaire were compared with the DSAA data on hospital level. Discrepancies between the estimated percentage of guideline deviation by the VSUs and their actual practice were evaluated, as well as the differences in reasons to deviate from guidelines between hospitals with high and low guideline adherence.

RESULTS

Part 1 – Analysis of national data from the Netherlands

Between January 2013 and December 2016, 10186 patients underwent elective aneurysm surgery in the Netherlands. After exclusion of 546 patients with an isolated iliac aneurysm, 212 with a (concomitant) thoracic aneurysm/dissection, 209 with an undefined aneurysm, 166 with revision surgery and 14 patients operated in hospitals that stopped performing AAA surgery, a total of 9039 patients was included for analysis. Out of these patients, 15% (1324 patients) had a smaller abdominal aortic diameter than in which surgical treatment

is recommended by the national guideline, 16% of all male patients and 9.0% of all female patients. In 11% (969) this concerned a small deviation from the guideline and in 3.9% (355) a large deviation.

Compared to the group of patients treated according to the guideline, there were more male patients in the group in which was deviated from the guideline (91% versus 85%, p<0.001) and this group was on average 3 years younger (mean 70.9 SD 8.0 versus 73.5 SD 7.5, p<0.001). Additionally, pulmonary state, cardiac state, pre-operative ECG, malignancies, preoperative hemoglobin and type of surgical procedure were unequally distributed between the two groups (table 1).

Characteristics associated with deviation from the guideline

Characteristics independently associated with deviation from the guideline were: male gender (odds ratio [confidence interval]: 1.709[1.386-2.109]) and treatment with EVAR (1.432[1.232-1.664]). (table 2) Characteristics with a low odds ratio for deviation from the guideline were: age (0.958[0.950-0.966], per additional year), peripheral edema (0.644[0.510-0.864]), current malignancy (0.560[0.399-0.786]), and hospital volume (0.998[0.997-0.999], per additional procedure).

Hospital variation

Between hospitals, the percentage deviations from the guideline varied between 2-40% (median: 13%). (0-33% small deviations; 0-17% large deviations) (figure 1). When the variation in surgical treatment of small abdominal aortic aneurysms was evaluated over time, 21 hospitals could be identified with a lower percentage of deviations than the national mean (15%) of deviations every year (Appendix 2). Respectively, twelve, six and fourteen hospitals had a higher percentage deviations than the national mean of deviations in 1, 2 or 3 years. Finally, seven hospitals could be identified that had a higher percentage of deviations than the national mean in every year.

Part 2 – Survey questionnaire among Dutch Vascular Surgical teams

A total of 44 (out of 60) VSUs completed the online survey questionnaire (73% response rate). The majority of the units (n=34, 77%) estimated to deviate from the guideline in less than 5% of their patients. The remaining 9 (21%) and 1 (2%) estimated to deviate from the guidelines in respectively 5-15% and >15% of their patients. Additionally, 42 (95.5%) and 2 (4.5%) units answered that they perform surgery on patients with an aneurysm of more 5 mm smaller than the recommended threshold (large deviation) in respectively <5% and 5-15% of their patient.

Table 1. Comparison of patient characteristics between patients with guideline adherence and guideline deviation

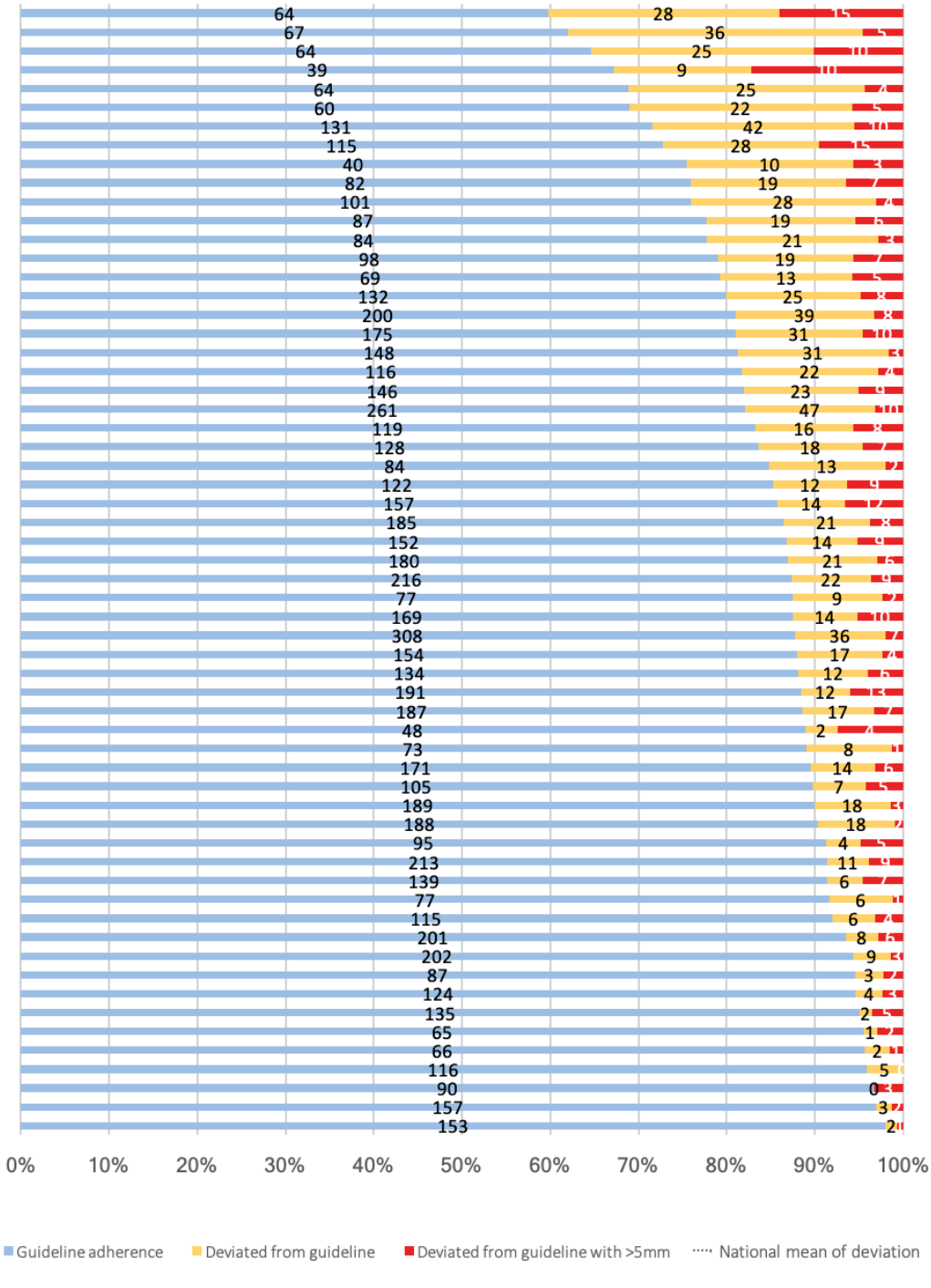
	Guideline adherence		**Guideline deviation**		
	Aneurysm diameter s(males ≥55 mm, female ≥50 mm)		Aneurysm diameter (males <55 mm, female <50 mm)		
	N	%	N	%	P value
Number of patients	7715	85%	1324	15%	
Age (mean, years)	73.5 SD 7.5		70.9 SD 8.0		<.001
Sex					<.001
Male	6532	85%	1207	91%	
Female	1183	15%	117	8.8%	
Year of surgery					.009
2013	1636	21%	332	25%	
2014	2090	27%	361	27%	
2015	1964	26%	318	24%	
2016	2025	26%	313	24%	
Cardiac state					<.001
No abnormalities	3511	46%	670	51%	
Peripheral edema	672	8.7%	75	5.7%	
Raised CVP	119	1.5%	22	1.7%	
Antihypertensive medication	3103	40%	503	38%	
Unknown	310	4.0%	54	4.1%	
Pulmonary state					.044
No dyspnea	5633	73%	1015	77%	
Dyspnea	1655	22%	242	18%	
Severe dyspnea	314	4.1%	51	3.9%	
Unknown	113	1.5%	16	1.2%	
Malignancy					.002
None	6217	81%	1102	83%	
Current	392	5.1%	39	2.9%	
History of malignancy	1106	14%	183	14%	
Last pre-operative ECG					.021
No abnormalities	4235	55%	781	59%	
Abnormalities	2731	35%	429	32%	
No ECG performed/Unknown ECG	749	9.7%	114	8.6%	
Hart rate (mean, BPM)	73 SD 13		73 SD 14		.174
Systolic blood pressure (mean, mmHg)	140 SD 20		140 SD 20		.930
Preoperative laboratory results					
Hemoglobin (mmol/L)	8.6 SD 1.0		8.8 SD 1.0		<.001
Leukocytes (10^9/L)	8.5 SD 2.8		8.4 SD 3.0		.284
Creatinine (mmol/L)	90 IQR 77-107		89 IQR 77-104		.183
Sodium					.555
Normal sodium (135-145 mmol/L)	7294	95%	1257	95%	
Hypo/hypernatremia	421	5.5%	67	5.1%	
Potassium					.160
Normal potassium (3.5-5.0 mmol/L)	7256	94%	1232	93%	
Hypo/hyperpotassemia	459	5.9%	92	6.9%	
Treatment					.002
OSR	1808	23%	258	20%	
EVAR	5907	77%	1066	81%	

Table 2. Patient and hospital characteristics independently associated with deviation from the guideline

	Deviation from the guideline	
	0dds Ratio	95% CI
Number of patients	9039	
Age (mean, years)	0.958	0.950-0.966
Sex		
Female	Ref.	
Male	1.709	1.386-2,109
Pulmonary state		
No dyspnea	Ref.	
Dyspnea	0.895	0.767-1.045
Severe dyspnea	1.017	0.746-1.386
Unknown	0.870	0.508-1.491
Cardiac state		
No abnormalities	Ref.	
Peripheral edema	0.664	0.510-0.864
Raised CVP	1.042	0.647-1.679
Antihypertensive medication	0.899	0.789-1.023
Unknown	0.988	0.724-1.348
Last pre-operative ECG		
No abnormalities	Ref.	
Abnormalities	0.994	0.868-1.138
No ECG performed	0.862	0.692-1.074
Malignancy		
None	Ref.	
Current	0.560	0.399-0.786
History of malignancy	1.024	0.861-1.216
Preoperative laboratory results		
Hemoglobin (mmol/L)		
<7.5	Ref.	
7.5-8.5	1.096	0.869-1.382
8.6-9.5	1.112	0.893-1.386
>9.5	1.136	0.896-1.441
Creatinine (mmol/L)		
<80	Ref.	
80-100	1.062	0.916-1.230
101-120	1.043	0.867-1.255
>120	0.994	0.814-1.214
Treatment		
OSR	Ref.	
EVAR	1.432	1.232-1.664
Hospital volume 2013-2016*	0.998	0.997-0.999

* Volume of elective AAA repairs between 2013-2016.

Figure 1. Percentage deviations from guideline per vascular surgical unit



Acceptable reasons mentioned to deviate from the guideline were aorto-iliac aneurysm with large iliac diameter (n=40, 91%), saccular aortic aneurysm (n=36, 82%), rapid aneurysm growth (n=35, 80%) and a chronic painful aneurysm (non-acute mild abdominal pain during physical examination) (n=27, 61%) (Appendix 3). Other suggested reasons were patients desire to undergo aneurysm surgery (n=15, 34%), a connective tissue disorder (n=10, 23%), younger age of the patient (n=6, 14%), a positive family history for aortic aneurysm rupture (n=5, 11%), afraid that treatment with EVAR would not be possible when the aneurysm would grow further (n=1, 2%), other reasons (n=3, 7%) and no good reasons (n=0, 0%). The reasons to deviate from the guideline that were reported to in fact occur in their own practice were (Appendix 4): 'concomitant large iliac aneurysm' (regularly 39%, often 39%), 'saccular aneurysm' (regularly 39%, often 30%) and 'rapid aneurysm growth' (regularly 32%, often 25%). 'Space on the operating room schedule' and 'achieving volume standard' were never (0, 0%) reported. 'Afraid that EVAR would not be possible when the aneurysm grows', 'young age of the patient' and 'positive family history' were answered to never occur in respectively 93%, 61% and 57% of the units.

Part 3 – Comparison of survey questionnaire and DSAA data

The percentage of deviations from the guideline per vascular surgical unit as registered in the DSAA (figure 2 left column) were compared to the in the survey estimated percentage of deviations per unit (figure 2 right column). Eleven units had an estimated percentage concordant (green) to their actual practice registered in the DSAA and 33 had not (red). Of the 33 units with non-concordant estimations, 11 units estimated to deviate from the guideline in <5% of the patients while doing that in >15%. The percentage of large deviations from the guideline per unit as registered in the DSAA compared to the estimated percentage deviations per unit is given in figure 3. There were 31 units with concordant estimations of large deviations and 13 with non-concordant estimations. Not responding to the survey (hospitals in grey) does not seem to be associated with higher percentage deviations from the guideline. Differences in patient and hospital characteristics between units that did and did not respond to the survey are shown in table 3. In the group of non-responders, there were more high-volume hospitals and an EVAR procedure was more common.

DISCUSSION

Dutch VSUs regularly decide to deviate from the guideline regarding aneurysm diameter. Male gender, young age, absence of peripheral edema and current malignancy, treatment with EVAR and lower hospital volume are factors that are independently associated with performing elective aneurysm repair on patients with a smaller aneurysm diameter than recommended in the guidelines. Guideline deviation varied considerably between units, both

Figure 2. Comparison of actual percentage deviations and estimated percentage per vascular surgical unit.

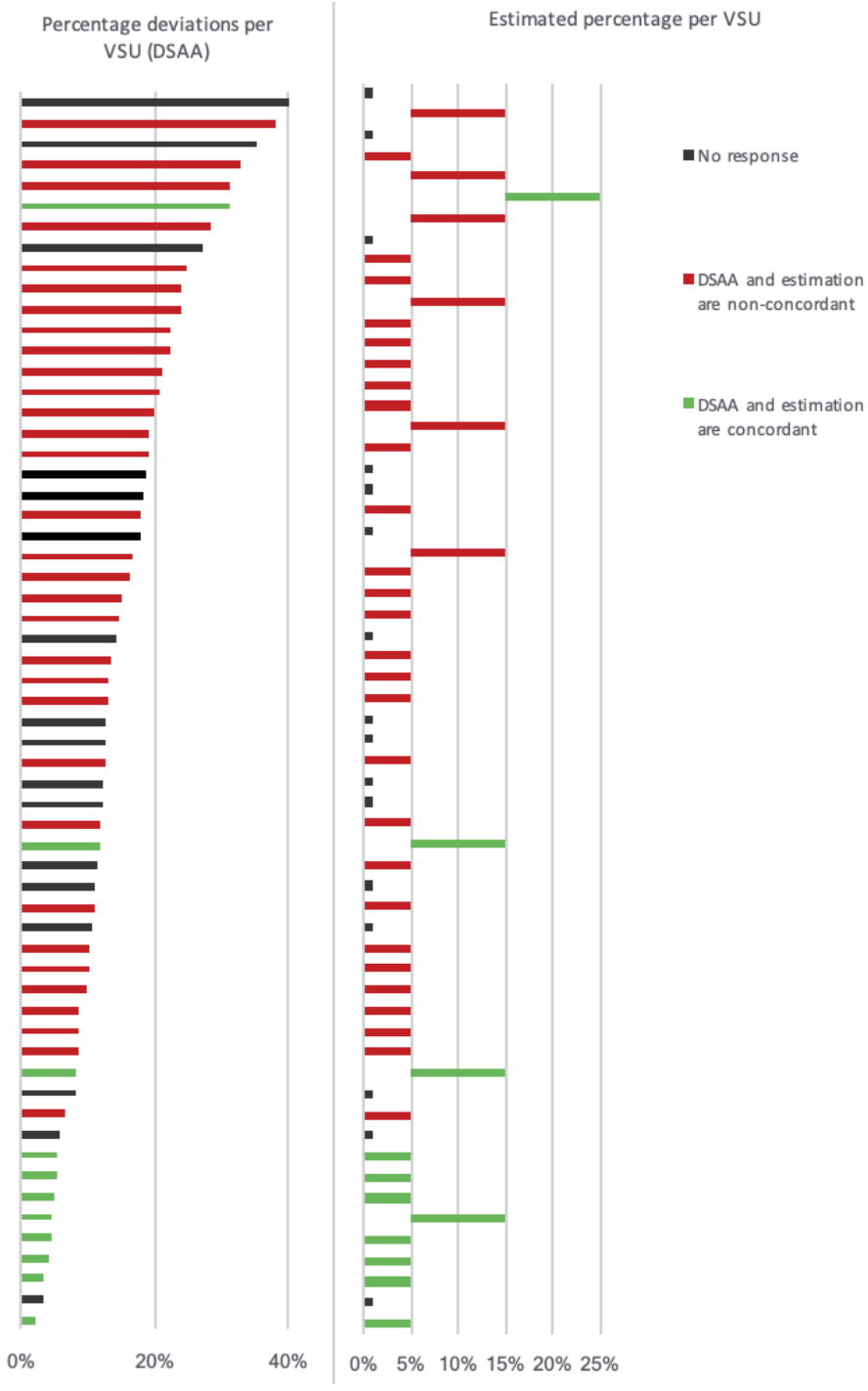


Figure 3. Comparison of actual percentage large deviations and estimated percentage per vascular surgical unit.

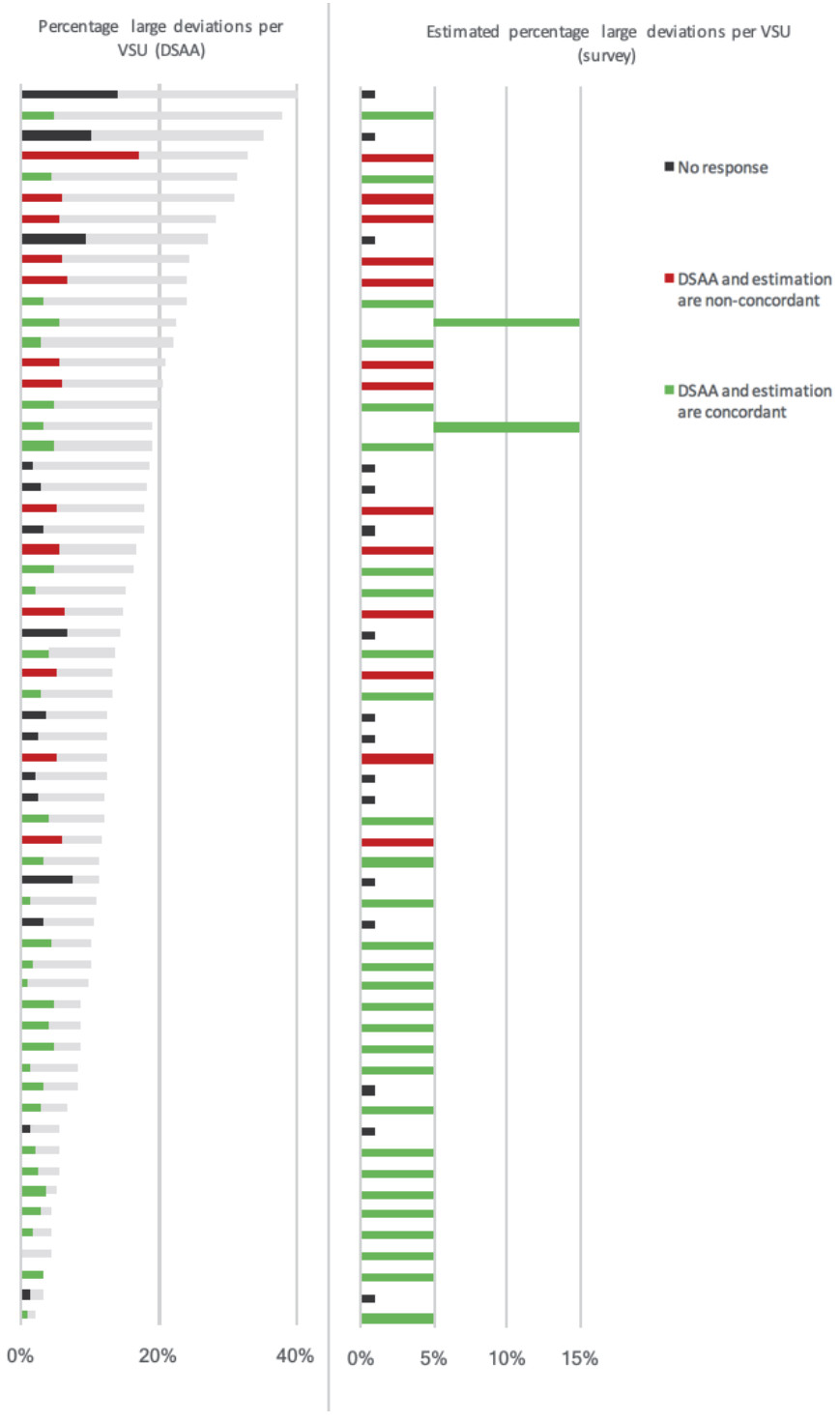


Table 3. Differences in patient and hospital characteristics between VSUs that responded and did not respond to the questionnaire

	Units that responded		Units that did not respond		
	N	%	N	%	
Number of patients	6243	69%	2796	31%	
Age (mean, years)	73,1 SD 7.7		73,2 SD 7.2		.519
Sex					.051
Male	5315	85%	2424	87%	
Female	928	15%	372	13%	
Treatment					.000
OSR	1496	24%	570	20.4%	
EVAR	4747	76%	2226	79.6%	
Hospital volume*					.000
<100	965	16%	241	9%	
100-150	1594	26%	374	13%	
150-200	1507	24%	1051	38%	
>200	2177	35%	1130	40%	
Guideline adherence					.387
Guideline adherence	5342	86%	2373	85%	
Deviation from guideline	901	14%	423	15%	

* Volume of elective AAA repairs between 2013-2016.

for small and large deviations. When the variation in surgical treatment of small abdominal aortic aneurysms was evaluated over time, units that rarely deviate from the guideline could be identified, as well as units that structurally did. Among Dutch VSUs there is agreement on acceptable reasons to perform elective surgery on patients with a small aortic aneurysm. However, there is considerable variation in the extent to which these reasons occur in actual practice. The estimated percentage of guideline deviations of each unit was often non-concordant and much lower than the actual practice as registered in the DSAA.

Since the publication of a retrospective review about the incidence of AAA and AAA rupture in nonspecific autopsies, the maximum aneurysm diameter is generally regarded as an important measure of risk for rupture.[17] International guidelines recommend an aneurysm diameter threshold for elective aneurysm repair of >55 mm in male and >50mm in female, based on the balance between the risk of aneurysm rupture and postoperative mortality in elective aneurysm repair.[2,3,18]

Two large randomized controlled trails, the UKSAT and ADAM trail, have evaluated potential benefit of elective aneurysm repair in asymptomatic patients with a diameter between 40-54mm, compared to watchful waiting.[4,8] In both trials, the postoperative mortality was significantly higher than the rupture rate. Therefore, early intervention is not beneficial. With the advent of EVAR, post-operative mortality in elective aneurysm surgery has strongly decreased. However, more recent studies comparing early EVAR and surveillance, have again not shown a mortality benefit for early intervention.[5,6,14] Therefore, the current

diameter thresholds for intervention in patients with asymptomatic aortic aneurysms have not changed.[2,3]

Nevertheless, this study shows that in reality Dutch VSUs regularly decide to perform surgery on patients with smaller aneurysm diameters than the thresholds, with a wide variation between units. Generally, a saccular shape of the aneurysm or an AAA with a large iliac aneurysm component are accepted for early surgical treatment, but high level of evidence is lacking.[2,3] Moreover, it is suggested that patients with rapid expansion of a small aortic aneurysm may benefit from early repair.[2,19,20] Patients with connective tissue diseases have an increased risk to develop aortic pathology and therefore it is understandable to perform early intervention on these patients.[21,22] However, an isolated abdominal aortic aneurysms is rare in patients with connective tissue diseases and therefore it does not seem to be a good reason to deviate from the guideline.[23,24] The benefit of early intervention for other reasons as young age and positive family history have not been demonstrated or investigated.[3]
Except for connective tissue diseases, mostly treated in centers of expertise, it is plausible that patient and aneurysm characteristics and the occurrence of reasons to deviate from the guideline are about equally distributed among hospitals. However, the questionnaire did show some variation between vascular units in how often these reasons resulted in guideline deviation. Indications as saccular aneurysm or aorto-iliac aneurysms with a large iliac component are relatively uncommon, nevertheless in this study, of all reasons they were most frequently reported as 'regularly' of 'often' occurring.[25,26]

Male gender and treatment with EVAR were independently associated with deviation from the guideline, whereas increasing age, peripheral edema, current malignancy, and high hospital volume were independently associated with adherence. These characteristics do not necessarily correspond to the generally accepted indications, as the mean age of patients with a saccular aneurysm or aorto-iliac aneurysm with large iliac component is comparable with the mean age of aneurysm patients or even higher.[25] Additionally, as female gender is associated with a higher risk of rupture, it would be expected that guideline deviation would happen more often in female patients than in males.[27,28] This suggest that in relatively young males with little to no co-morbidities that are eligible for treatment with EVAR, surgical treatment is more often chosen for smaller aneurysm diameters than recommended in the guideline. Another interesting finding is that hospitals with lower volumes performed surgery more often on patients with smaller diameter than hospitals with higher volumes. Besides achieving volume standards, financial incentives may also play a role in deviating from the guideline.[11]
When evaluating deviation from the guideline over time between units, units with a lower percentage of deviations than the national mean could be identified, as well as units with a higher percentage of deviations than the national mean in every year. Apparently, there is a certain consistency in the behavior of VSUs to perform surgery or not on patients with a smaller aortic diameter. Remarkably, VSUs with a higher total percentage of guideline

deviations more often had an estimation non-concordant with their actual practice than VSUs with a lower total percentage of deviations. It seems that VSUs that frequently deviate from the guideline are apparently not aware that they are doing this.

This study has several limitations. To evaluate the national performance and difference between surgical teams regarding surgical treatment for small abdominal aortic aneurysms, it would have been useful to know the exact reason to deviate from the guideline for each patient. Unfortunately, this information was not captured in the DSAA. By combining information about the incidence of deviation from the DSAA and information about the reasons and occurrence of these reasons from our questionnaire, we have tried to approach the proportion of different reason per vascular surgical unit in order to get more insight into variation in practice between units.
Secondly, the measurement of aneurysm diameter registered in the DSAA is not standardized. For the surveillance of patients with an asymptomatic AAA ultrasound is the imaging modality of preference. However, it may be possible that diameters measured with Computed Tomography Angiography (CTA) are registered as well. It is known that a diameter of an aneurysm is often larger when measured with CTA compared to ultrasound. This could result in an underestimation of the actual percentage of guideline deviation.[3] As we mainly focus on the decision-making following the measurement, this problem probably is not relevant.
Lastly, although a 73% response rate on a national questionnaire is quite good, we were not able provide information on the reported reasons of all Dutch VSUs. However, as the percentage of guideline deviation was not associated with not responding to the questionnaire and not responding appears to be coincidental, we consider the sample representative.

Guideline deviations happen often and extensively, and most hospitals that frequently deviate from the guideline do not seem to be aware of the fact that they are doing so. Therefore, providing good feedback information to vascular units is important for their process of quality of care improvement. The DSAA has an online portal in which vascular units can review their performance on multiple domains and compare this to other units. From January 2018, the percentage of guideline deviation regarding aneurysm diameter in elective AAA patients, compared to the national mean and the percentage of all other vascular units, will be fed back to the units. Consequently teams will be more aware how they perform and hopefully variation in practice will decrease.[29]

CONCLUSION

Deviations from the guideline regarding aneurysm diameter threshold for repair in the Netherlands is frequent, with a wide variety between vascular surgical teams. Discrepancies between what Dutch vascular surgical teams think they do and they actually do, might be an

explanation for the frequent and wide variation in guideline deviations. Introducing feedback by clinical auditing might create awareness of occurrence of deviation in VSUs.

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Appendix 1. Survey questionnaire that wat send to all VSUs performing aneurysm surgery in the Netherlands.

1. *What percentage of patients, undergoing elective abdominal aortic aneurysm surgery in your hospital,* ***do you think*** *has a* ***smaller*** *aneurysm diameter than in which surgical treatment is recommended by the guideline (males <55mm and female <50mm)?*
   - □ <5%
   - □ 5-15%
   - □ >15%

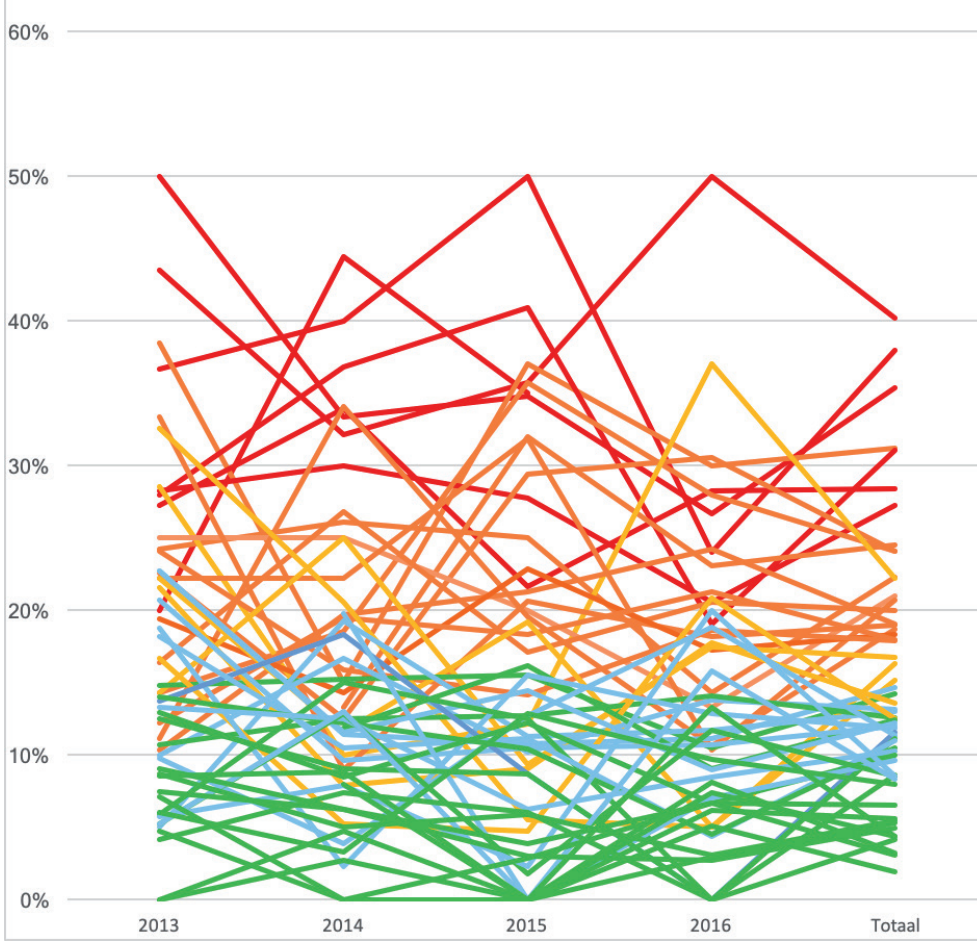
2. *What percentage of patients, undergoing elective abdominal aortic aneurysm surgery in your hospital,* ***do you think*** *has an aneurysm diameter* ***of more than 5mm smaller*** *than in which surgical treatment is recommended by the guideline (males <50mm and female <45mm)?*
   - □ <5%
   - □ 5-15%
   - □ >15%

3. *Which of the patient related factors mentioned below is in your opinion an acceptable reason to deviate from the national guideline regarding aneurysm diameters? (Possible to fill in multiple reasons)*
   - □ *Desire of patient to undergo surgical treatment*
   - □ *Rapid aneurysm growth*
   - □ *Chronical painful aneurysm*
   - □ *Connective tissue disorder*
   - □ *Positive family history of aortic aneurysm rupture*
   - □ *Patient with a young age*
   - □ *Saccular shaped aneurysm*
   - □ *Iliac aneurysm of >40mm*
   - □ *Afraid that EVAR would not be possible when the aneurysm would grow further*
   - □ *None*
   - □ *Other, namely…*

4. *To which extend do the reasons mentioned below play a role in the decision to deviate from the guideline?*

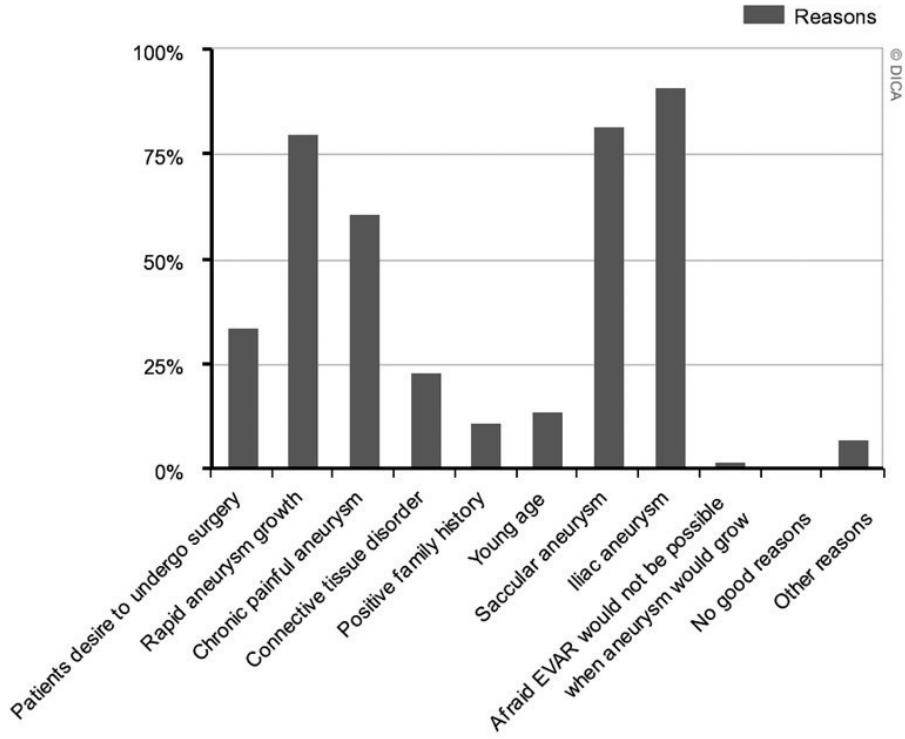
	Never		*Sometimes*		*Always*
Desire of patient to undergo surgical treatment	o	o	o	o	o
Rapid aneurysm growth	o	o	o	o	o
Chronical painful aneurysm	o	o	o	o	o
Connective tissue disorder	o	o	o	o	o
Positive family history for aortic aneurysm rupture	o	o	o	o	o
Patient with a young age	o	o	o	o	o
Saccular shaped aneurysm	o	o	o	o	o
Iliac aneurysm of >40mm	o	o	o	o	o
Afraid that EVAR would not be possible when the aneurysm would grow further	o	o	o	o	o
Space on the operating room schedule	o	o	o	o	o
Achieving the annual volume threshold	o	o	o	o	o

Appendix 2. Percentage deviations from the guideline per vascular surgical unit over time (2013-2016).



Explanation of figure: The green lines represents the VSUs with a lower percentage of deviations than the national mean (15%) of deviations every year. The blue, yellow and orange lines represents VSUs with a higher percentage deviations than the national mean of deviations in respectively 1, 2 or 3 years. The red lines represent the VSUs with a higher percentage of deviations than the national mean in every year.

Appendix 3. Reported acceptable reasons to deviate from the guidelines



Appendix 4. The extent to which the reasons to deviate from the guideline occur in practice.