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

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Carotid artery surgery

CHAPTER 8

The Dutch Audit for Carotid Interventions: Transparency in Quality of Carotid Endarterectomy in Symptomatic Patients in the Netherlands

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ABSTRACT

Background & objective

The Dutch Audit for Carotid Interventions (DACI) registers all patients undergoing interventions for carotid artery stenosis in the Netherlands. We describe the design of the DACI and results of patients with a symptomatic stenosis undergoing carotid endarterectomy (CEA). We aimed to evaluate variation between hospitals in process of care and (adjusted) outcomes, as well as predictors for major stroke/death after CEA.

Methods

We identified all patients with a symptomatic stenosis, undergoing CEA and registered in the DACI between 2014-2016. Descriptive analyses on patient characteristics, process of care and outcomes were performed. Case-mix adjusted hospital procedural outcomes as (30-day/in-hospital) mortality, stroke/death and major stroke/death, were compared with the national mean. A multivariable logistic regression model (backward elimination at $p>0.10$) was used to identify predictors for major stroke/death.

Results

6459 patients, registered by 52 hospitals, were included. The majority (4832, 75%) was treated <2 weeks after their first hospital consultation, varying from 40-93% between hospitals. Mortality, stroke/death and major stroke/death were respectively 1.1%, 3.6% and 1.8%. Adjusted major stroke/death rates for hospital comparison varied between 0-6.5%. Nine hospitals performed significantly better, none performed significantly worse. Predictors for major stroke/death were: sex, age, pulmonary disease, presenting neurologic symptoms and perioperative shunt.

Conclusion

CEA in the Netherlands is associated with an overall low mortality and (major) stroke/death. Whereas the indicator time-to-intervention varied between hospitals, mortality and (major) stroke/death are not significantly distinctive to identify worse practices and therefore unsuitable for hospital comparison in the Dutch setting. Additionally, predictors for major stroke/death on population level could be identified.

INTRODUCTION

In patients with a recent transient ischemic attack (TIA) or ischemic stroke in the presence of a high-grade ipsilateral carotid artery stenosis, recurrent stroke can be best prevented by carotid endarterectomy (CEA).[1] Optimal care for patients undergoing carotid artery surgery is summarized in guidelines, based on large randomized controlled trials.[1-4] However, actual daily practice is not always consistent with these guidelines, allowing practice and patient outcomes to vary between healthcare providers.[5] This variation could indicate a difference in quality of care on a national level.

The increasing demand for quality-control methods and the introduction of a minimum threshold on hospital volume of 20 CEA per year in the Netherlands has led to the initiation of the Dutch Audit for Carotid Interventions (DACI).[6] This nationwide audit was initiated in 2012 and mandatory since June 2013 for all vascular surgeons performing carotid artery interventions. The main objective of this audit is to measure and improve quality of care in carotid artery interventions in the Netherlands. By registering important parameters on process of care and patient outcomes, a comparison of hospitals can be made and surgeons can be provided with benchmarked information on their quality of care. Providing insight into possible variation between hospitals can subsequently incite quality improvement. Additionally, information from the DACI can be used to monitor national guideline adherence and outcomes in patients undergoing carotid interventions.

This report describes the design of the DACI and provides an overview of the results of patients with a symptomatic carotid artery stenosis undergoing CEA in the Netherlands in the first years of the audit. It was our aim to report evaluation of variation between hospitals in processes of care and (adjusted) patient outcome, as well as identification of independent predictors for major stroke and/or death related to CEA.

METHODS

DICA

The DACI is facilitated by the Dutch Institute for Clinical Auditing (DICA).[6] The DICA facilitates and organizes the initiation of nationwide audits for various medical professions and offers a uniform format. In collaboration with DICA, the Dutch Society for Vascular Surgery initiated the Dutch Audit for Carotid Interventions (DACI). The DACI is related to a scientific committee, which is responsible for the interpretation and accountability of the data.

DACI data source

Since June 2013, the DACI is mandatory for all vascular surgeons and registers all patients undergoing a carotid intervention because of a high-grade carotid artery stenosis in the Netherlands. This includes CEA with or without patch angioplasty, eversion CEA or carotid artery stenting (CAS). Of each registered patient 77 items, grouped into three categories, are scored (appendix 1.). The first category includes patient characteristics and clinical presentation required to enable an adjusted comparison of data between hospitals. The second category includes items regarding the process of care and surgical treatment. The postoperative period and patient outcomes (30-day/in-hospital) are registered in the third category. The data is prospectively collected via a web-based survey or provided by the hospitals via a batch data file. Hospitals may decide who registers the data (e.g. data managers, nurse practitioners or physician). However, in all participating hospitals the final responsibility for registration of patients lies with the physician. The content of the dataset is evaluated on an annual basis and if necessary alterations are made. Verification of the DACI data was carried out in 2015 by a third trusted party. The process of verification was coordinated by an independent data verification committee, which consisted of medical experts, a biostatistician, a deputy of the Dutch Health Care Inspectorate and a deputy from the Dutch patient federation. Data was verified through a random sample of 15 hospitals, and will be continuously repeated in the future.

Patient selection

All patients undergoing CEA for a symptomatic stenosis and registered in the DACI between January 2014 and December 2016 were included. Date of birth, date of surgery, type of surgical procedure performed and patient survival status (30-days/in-hospital) had to be known to consider a patient eligible for further analysis. In the Netherlands, asymptomatic patients usually do not receive surgical intervention outside the margins of randomized clinical trials and CAS is not performed as standard primary treatment for a symptomatic carotid stenosis, therefore asymptomatic patients and patients treated with CAS were excluded. Additionally, patients treated in a hospital that stopped performing CEA's during the first year of the study period were also excluded.

Definitions

Within the DACI, time-to-intervention was defined as the time from first consultation at the hospital until CEA, instead of the time from first neurological symptoms until intervention, because this is the timeframe that hospitals can influence themselves and can improve. Postoperative mortality was defined as mortality within 30 days after CEA and/or during the primary admission (30-day/in-hospital). A postoperative stroke was described as a new neurological deficit 30-day/in-hospital, which lasted longer than 24 hours. A stroke resulting in a decline of more than 2 points in postoperative modified Rankin Scale (mRS) was considered as a major stroke, all other strokes as a minor stroke.[7,8] The combined outcome

parameters stroke and/or death (stroke/death) and major stroke and/or death (major stroke/death) consists the patients who had a (major) stroke and/or death 30-day/in-hospital. Cranial nerve injury (CNI) was defined as the loss of function of a cranial nerve, measured 30-day/in-hospital. Only a postoperative wound hemorrhage that required a re-intervention was considered as a postoperative wound hemorrhage.

Analyses

Descriptive analyses for patient characteristics, process of care and patient outcomes were performed. The percentage of patients with a time-to-intervention of <2 weeks, was calculated per hospital and compared with the national mean in a funnel plot. The national mean was derived from this dataset.

Possible associations between patient characteristics and outcomes, as mortality and (major) stroke/death were evaluated with a multivariable logistic regression model at a p-value of 0.05 using an ENTER model. This analysis was used to adjust hospital outcomes for the case-mix of their patients. Patient characteristics included in this analysis were based on the V(p)-POSSUM predictive score: sex, age, pulmonary status, cardiac status, preoperative electrocardiogram, preoperative creatinine level and presenting symptoms.[9] A funnel plot with a confidence interval (CI) of 95% around the national mean was used to show hospital variation for case-mix adjusted outcomes. Hospitals with a significantly lower major stroke/death than the national mean were identified as 'hospitals with better outcomes' and hospitals with a higher major stroke/death as 'hospitals with worse outcome'. Hospital and practice related factors were compared between hospitals with better outcomes and the other hospitals using chi-square tests. Finally, to identify risk factors for postoperative major stroke/death, a prediction model was formed, using a multivariable logistic regression model at a p-value of 0.10 with backward elimination.

For missing data in continuous variables, the mean of each variable was imputed. Missing data in continuous variables were not exceeding 5% of the total of each variable.

RESULTS

Patient characteristics

From January 2014 to December 2016, 6861 patients with a carotid artery stenosis undergoing carotid intervention were registered by 52 hospitals in the Netherlands. After exclusion of all asymptomatic patients (274, 4.0%), all patients treated with CAS (122, 1.9%) and patients operated in a hospital that stopped performing CEA's during the study period (6, 0.9%), 6459 patients were eligible for analysis and included in this study. The cohort consisted predominantly of males (4479, 69%) and had a mean age of 72.1 years. Patient characteristics are shown in Table 1.

Table 1. Patient and disease characteristics

	2014-2016	
Number of patients	6459	
Age	72.1 ± 9.3	
Sex		
Male	4479	69%
Female	1980	31%
Comorbidity		
Malignancy		
None	5485	85%
Current malignancy	152	2.4%
History of malignancy, curatively treated	822	13%
Pulmonary status		
No dyspnea	5117	79%
Dyspnea during exercise	1079	17%
Disabling dyspnea	161	2.5%
Dyspnea at rest/fibrosis	34	0.5%
Unknown	68	1.1%
Cardiac status		
None	2155	33%
Medication for hypertension	3624	56%
Peripheral edema	589	9.1%
Raised CVP	71	1.1%
Unknown	20	0.3%
Preoperative ECG		
No abnormalities	3616	56%
Atrial fibrillation	428	6,60%
Ischemia	127	2.0%
Other abnormalities	2062	32%
No preoperative ECG performed	226	3.5%
Preoperative laboratory results		
Hemoglobin	8.6 ± 1.04	
Sodium	139 ± 3.00	
Potassium	4.2 ± 0.42	
Creatinine	86 IQR 31	
Preoperative systolic blood pressure	148 ± 23.0	
Preoperative heart rate	74 ± 13.7	
Side of carotid artery stenosis		
Left	3318	51%
Right	3103	48%
Unknown	38	0.6%
Presenting symptoms		
Ocular symptoms	1192	19%
Cortical symptoms	5158	79%
Vertebrobasilar and other	109	1.7%
Previous CEA		
None	6162	95%
Yes, ipsilateral	66	1.0%
Yes, contralateral	218	3.4%
Yes, both sides	13	0.2%

Clinical presentation and process of care.

The majority of patients presented with cortical symptoms (5158, 79%) (table 1). In 75% (4832) of patients the time-to-intervention was <2 weeks after the first hospital consultation. Figure 1a shows the hospital comparison of the percentage patients undergoing CEA <2 weeks after the first consultation. The median time-to-intervention varied between hospitals from 7-16 days.

A CEA with patch angioplasty was performed in the majority of patients (4958, 77%), followed by eversion CEA (808, 12%) or CEA without patch angioplasty (693, 11%) (table 2). General anesthesia during intervention was used in 94% of all patients, in which 93% intraoperative neurologic monitoring was used. Intraoperative shunting was used in 20% of all patients undergoing CEA, of which 69% was carried out with intra-operative neurologic monitoring and 31% was done without. A small minority of 16 patients (0.2%) received no intraoperative neurological monitoring and no shunt, while operated under general anesthesia.

Clinical Outcomes

The 30-day/in-hospital postoperative mortality was 1.1% (69) (table 3.). Mortality rates slightly differed between surgical procedures, but differences were not significant: CEA with patch angioplasty 0.4%, CEA without patch angioplasty 1.6% or eversion CEA 0.9% (P = 0.371). Of all patients, 3.2% (206) had a postoperative stroke, of which 62% (127) had a minor stroke and 38% (79) had a major stroke. The combined major stroke/death and any stroke/death rate were 1.8% (115) and 3.6% (235) respectively. CNI and postoperative wound hemorrhage were observed in 2.8% (183) and 4.1% (262) of patients respectively. A re-intervention was performed in 4.7% (305), of which the majority (86%) was indicated because of a postoperative wound hemorrhage and in 14% the indication was unknown.

Hospital comparison of outcomes

The multivariable logistic regression analyses for mortality, major stroke/death and stroke/death are displayed in table 4. Pulmonary state (severe dyspnea) and presenting with cortical symptoms were found to be significantly associated with all three outcome measures. Increasing age and female gender were associated with mortality and major stroke/death. Abnormalities on the last pre-operative electrocardiogram were associated with stroke/death.

Figure 1b-d shows the case-mix adjusted outcomes for respectively mortality, major stroke/death and any stroke/death by hospital volume for individual hospitals. The case-mix adjusted mortality, major stroke/death and any stroke/death rates varied respectively from 0-6.5%, 0-6.4% and 0-9.6% between hospitals. Five hospitals had a significantly lower adjusted percentage stroke/death, when compared to the national mean. Additionally, nine hospitals had a significantly lower adjusted percentage major stroke/death. No hospital performed significantly worse than the mean.

Figure 1a Hospital comparison of time to intervention

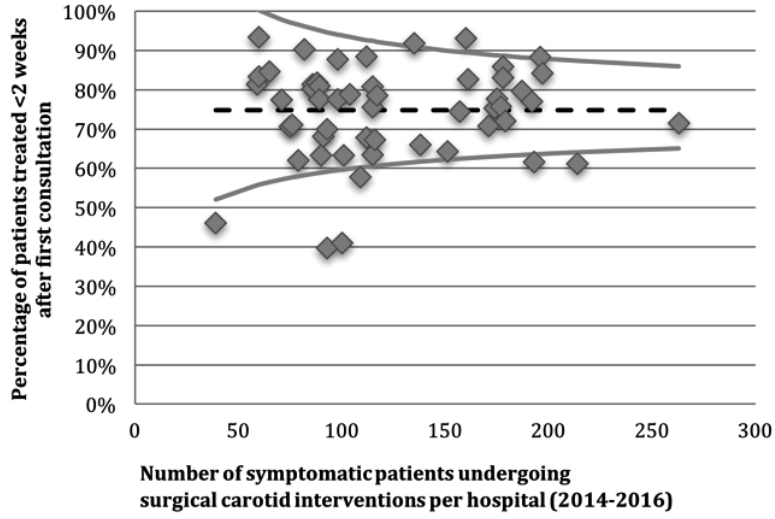

Figure 1b Hospital comparison for mortality

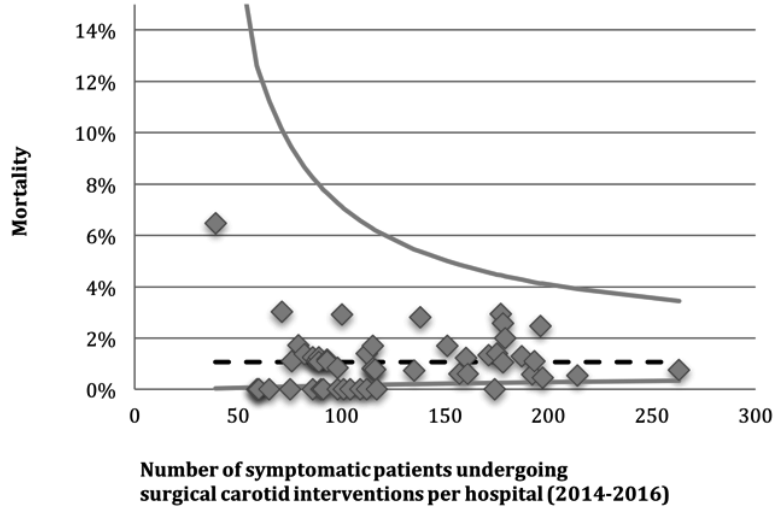

Figure 1c. Hospital comparison for Major Stroke and/or death

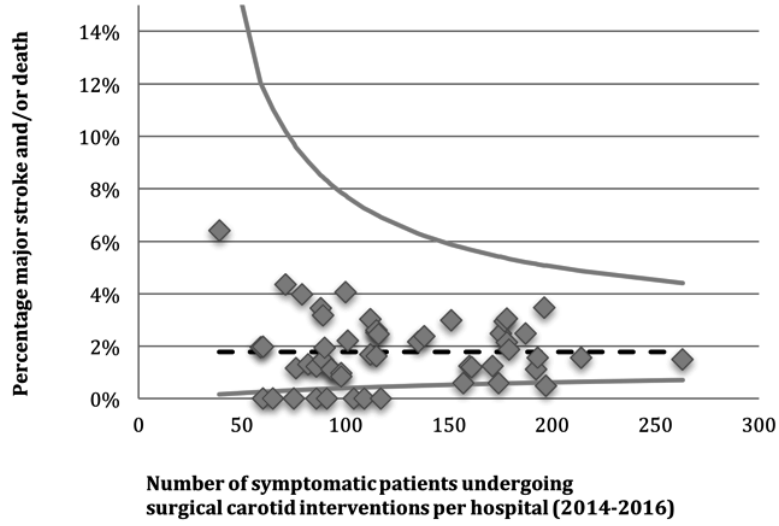

Figure 1d Hospital comparison for stroke and/or death

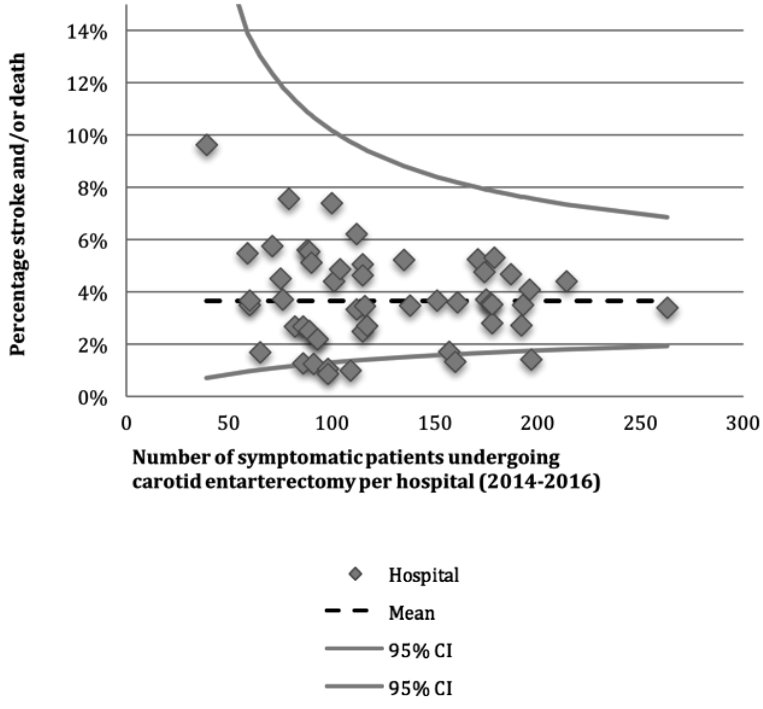

Table 2. Treatment characteristics.

	2014-2016	
Number of patients	6459	
Imaging*		
Duplex	6311	98%
CTA	4237	66%
MRA	1313	20%
DSA	35	0.5%
Referral		
Internally	5267	82%
Tertiary	1188	18%
Unknown	4	0.1%
Time until carotid intervention**		
< 2 weeks	4832	75%
> 2 weeks	1582	25%
Unknown	45	0.7%
Surgical procedure		
CEA without patch angioplasty	693	11%
CEA with patch angioplasty	4958	77%
Eversion CEA	808	12%
Anesthesia		
Local anesthesia	368	5.7%
General anesthesia	6084	94%
Unknown	7	0.1%
Neurologic monitoring		
No monitoring	435	6.7%
Awake patient	314	4.9%
EEG	2822	44%
Stump pressure	130	2.0%
EEG & TCD	2693	42%
Other combinations	65	1.0%
Shunting during surgery		
No shunting	4629	72%
Shunting	1262	20%
Unknown	568	8.8%
Postoperative medication		
Acetylsalicylic acid	2441	38%
Statin	5519	85%
Dipyridamole	851	13%
Coumarin	364	5.6%
Clopidogrel	4247	66%
Antihypertensive medication	4348	67%
New anticoagulants	90	1.4%
Heparin***	5378	83%

* In 79.9% a combination of diagnostic imaging was used.
** Time from first consultation at the hospital until CEA.
*** Postoperative use of heparin as venous thromboembolism prophylaxis is protocoled in the Netherlands

Table 3. Outcomes 30 days postoperatively and/or during admission

	2014-2016	
Number of patients	6459	
Postoperative period		
Stroke	206	3.2%
Cranial nerve injury	183	2.8%
Hemorrhage	262	4.1%
Complications		
Other surgical complication	109	1.7%
General complication	384	5.9%
Other	108	1.7%
Reintervention	305	4.7%
Death	69	1.1%
Major stroke and/or mortality	115	1.8%
Stroke and/or mortality	235	3.6%

Table 4. Patient characteristics predictive for Mortality, Stroke / Mortality and Major Stroke/ Mortality.

	Mortality		Major Stroke / Mortality		Stroke / Mortality	
	Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Number of patients	6459		6459		6459	
Age	1.05	1.015-1.077	1.035	1.012-1.058	1.014	0.999-1.030
Sex						
Male	Ref		Ref		Ref	
Female	1.970	1.217-3.187	1.585	1.074-2.337	1.218	0.917-1.616
Pulmonary State						
No dyspnea	Ref		Ref		Ref	
Dyspnea	0.529	0.238-1.178	0.803	0.472-1.368	1.047	0.740-1.481
Severe dyspnea	3.978	1.907-8.298	3.013	1.567-5.795	2.323	1.373-3.930
Cardiac State						
No abnormalities*	Ref		Ref		Ref	
Cardiac co-morbidities	1.188	0.675-2.090	1.265	0.809-1.893	1.280	0.933-1.757
Last preoperative ECG						
No abnormalities	Ref		Ref		Ref	
Abnormalities (atrial fibrillation, ischemia and others)	1.402	0.848-2.317	1.282	0.868-1.893	1.470	1.116-1.936
Presenting symptoms						
Ocular symptoms	Ref		Ref		Ref	
Cortical symptoms	3.065	1.109-8.472	2.345	1.179-4.664	2.345	1.179-4.664
Vertebrobasilar or other symptoms	2.320	0.255-21.086	2.175	0.462-10.252	2.175	0.462-10.252
Preoperative laboratory results						
Creatinine			1.001	0.996-1.005	1.001	0.996-1.005

**Preoperative creatinine level not included in the multivariable logistic regression analysis for mortality because of the limited degrees of freedom.*

As shown in table 5, the patients operated in the 9 hospitals with better outcomes, were more frequently referred from other hospitals, compared to patients operated in hospitals with a major stroke/death within the CI's. In contrast, these 9 hospitals were more often hospitals with relatively lower volumes. The time-to- intervention did not differ between the two groups. General anesthesia and CEA without patch angioplasty were more frequently used in these 9 hospitals compared to the other hospitals. Additionally, perioperative shunting was less often performed in these 9 hospitals.

Patient, practice and hospital related factors predictive for major stroke/death

Sex, age, pulmonary state, neurologic presenting symptoms and perioperative shunting are predictive for major stroke/death, with an area under the curve of 0.691 (table 6). All

Table 5. Comparison of hospital related factors between hospital with a lower percentage major stroke/ death and hospitals performing within the CI's

	Not treated in 'best practice'		Treated in 'best practices'		
	N = 5555	%	N =904	%	P
Referral					
Internal	4633	83%	634	70%	.000
Tertiary	920	17%	268	30%	
Hospital volume (3 years)					.000
Low volume (0-110)	1668	30%	590	65%	
Normal volume (111-175)	2107	38%	117	13%	
High volume (176-263)	1780	32%	197	22%	
Time to intervention					
>2 weeks	1383	25%	199	22%	.170
<2 weeks	4134	74%	698	77%	
Unknown	38	0.7%	7	0.8%	
Anesthesia					.000
Local	363	6.5%	6	0.7%	
General	5193	94%	898	99%	
Surgical procedure					.000
CEA without patch	554	10%	139	15%	
CEA with patch	4303	78%	655	73%	
Eversion CEA	698	13%	110	12%	
Perioperative shunting					.000
No shunting	3901	70%	728	81%	
Shunting	1159	21%	103	11%	
Unknown	495	8.9%	73	8.1%	
Neuro-monitoring					.000
No monitoring	428	7.7%	7	0.8%	
EEG	2283	41%	539	60%	
Stump pressure	130	2.3%	0	0.0%	
Awake patient	314	5.7%	0	0.0%	
EEG / TCD	2342	42.2%	351	38.8%	
Other (combinations of) monitoring	58	1.0%	7	0.8%	

Table 6. Factors predictive for major stroke/death

	Odds ratio	95% CI's
Age	1.038	1.016-1.061
Sex		
Male	Ref	
Female	1.486	1.017-2.170
Pulmonary State		
No dyspnea	Ref	
Dyspnea	0.821	0.484-1.392
Severe dyspnea	3.300	1.718-6.340
Presenting symptoms		
Ocular symptoms	Ref	
Cortical symptoms	2.130	1.068-4.246
Vertebrobasilar or other symptoms	2.113	0.448-9.966
Perioperative shunting		
No shunting	Ref	
Shunting	2.484	1.664-3.707
Unknown	1.708	0.910-3.207

Eliminated variables: heart rate, potassium, hospital volume, hemoglobin, creatinine, anesthesia, systolic blood pressure, sodium, surgical procedure, cardiac state, time to intervention, neurologic monitoring, preoperative ECG.

patient, treatment and hospital related factors used in this analyses that were proven not to be predictive for major stroke/death are shown at the bottom of table 6.

DISCUSSION

The DACI has been successfully implemented in the Netherlands and covers all Dutch centers, which allows evaluation of quality of care in CEA nationally and between hospitals. In the Netherlands, CEA is performed with an overall low mortality and (major) stroke/death rate and a reasonable guideline adherence, considering time-to- intervention. Whereas time-to-intervention showed significant variation between hospitals, outcome indicators as mortality and (major) stroke/death are not very distinctive due to low overall event rates and no hospitals with a significantly higher event rate. The lack of hospitals with worse outcomes in these indicators hampers a national hospital comparison in the era with a minimum volume of 20 CEA per year per hospital. However, 9 hospitals with a significantly lower major stroke/death rate than the national mean could be identified, from which others possibly could learn. Additionally, predictors for major stroke/death after CEA in symptomatic patients could be identified with the use of DACI data.

Clinical audits are increasingly appreciated as a tool for quality improvement in surgical care and have proven to be effective.[10] A clinical audit provides insight in the process of care and patient outcomes and enables comparison with other healthcare providers, so that areas for

improvement can be identified and targeted improvements can be started. Moreover, with a nationwide audit, volume standards and national guideline adherence can be monitored. For carotid artery interventions, several national audits have been successfully initiated in recent years.[11-13] Additionally, some countries are collaborating in VASCUNET, a subcommittee of the European Society of Vascular Surgery, which makes it possible to compare practice between countries.[5] The percentage of asymptomatic patients undergoing CEA in other European countries varies from <1% to 53%.[5,11] In the DACI 93% of patients had a symptomatic stenosis and 75% of these patients was treated <2 weeks after their first consultation in the hospital, with a variation of 40%-93% between hospitals. Our national guideline aims to treat at least 80% of symptomatic patients <2 weeks after first consultation, consequently this leaves room for improvement. A score of 100% may not be realistic, as patient delay can always occur. Besides the Scandinavian countries, in which 82.5% of patients are treated <2 weeks, most countries are dealing with logistic obstacles to treat symptomatic patients within this term.[11,14] As we know that the risk of a recurrent stroke is the greatest in the first days after the index-event, ideally symptomatic patients should be treated even sooner.[15] Therefore, time-to-intervention will remain a topic of attention and possibly the allowed timeframe will be shortened in the future. The stroke/death rate in the DACI is comparable with outcomes in other audits, with stroke/death rates varying between 0,9%–4.6%.[5,12,14,16-18] It should be noted that national audits often use the outcome measure any stroke/death while the landmark trials also used major stroke/death.[19,20] We believe it is important to make a distinction in the severity of a postoperative stroke and that major stroke/death is a more uniform measure.
CNI and postoperative wound hemorrhage, measured 30 days/in-hospital, were respectively 2.8% and 4.1%. The reported frequencies of CNI vary widely in other studies, as the study design, method of diagnosing the injury and whether or not the patient was assessed by a neurologist also varies per study. This last point is also applicable to the DACI, which entails the risk of underreporting of stroke and/or CNI. However, it has been shown that the majority of CNI will resolve over the first few months and permanent CNI is rare.[21,22]

Additionally, this study shows a hospital comparison of outcomes after CEA in symptomatic patients. With our national minimum threshold of 20 CEA per year per hospital, the majority of hospitals have outcomes comparable with the national mean and there are no hospitals performing worse. In order to improve quality of care, one should look for 'best practice hospitals' or variation between hospitals. An outcome measure like mortality, with a low event rate, shows little variation between hospitals. Some hospitals had no mortality, but this was often not significantly better than the mean. With the outcome measure any stroke/death and major stroke/death, more variation was observed and respectively five and nine hospitals with a significantly lower (major) stroke/death rate could be observed. However, most hospitals perform within the CI's. When comparing those 9 hospitals with a significant lower major stroke/death rate than the national mean with the other hospitals, some differences in practice

were seen. Those 9 hospitals mostly had lower volumes, however this is relative and therefore the minimum volume of 20 seems to be sufficient. Patients were more often referred, general anesthesia was more often performed and in almost all patients intraoperative neurologic monitoring was used. Furthermore, perioperative shunting was less often used in these 9 hospitals, which appeared to be predictive for major stroke/death. Noteworthy, is that previous studies showed contradictory results about the association between perioperative shunting and (major) stroke/death.[23,24] Further research is needed to confirm this association. Patient and disease related factors as female sex, increasing age, severe dyspnea and cortical symptoms as presenting symptoms were predictive for major stroke/death in symptomatic patients, which was partly confirmed in a previous study.[25] Whereas another study showed that cardiac disease was also predictive for (major) stroke/death. Additionally, Smoking, diabetes and the emergency of the surgery were proven to be predictive for (major) stroke/death, but these variables were not included in our model.[17,26,27]

Although some differences in outcomes were observed, no hospitals with significantly worse practice could be identified. This may be caused by the low event rate. In the future, other ways to identify the possible existing variation in quality of care of CEA between hospitals need to be explored. A possible solution, that was recently tested for aortic aneurysm surgery, could be the development of a composite measure, Textbook Outcome, combining process and outcome measures by which a more complete picture of care can be provided.[28]

In its current form, the DACI has several limitations. Since the DACI is an audit for carotid interventions, it does not contain information on patients that did NOT receive surgical treatment. Therefore, the audit does not provide information on intervention-rate and neurologic outcome of all patients with a symptomatic stenosis. With a future link between data from the DACI and data from the Dutch Acute Stroke Audit, this will be possible. With this link, the timeframe between first event and intervention can also be provided, which is more important from a patient perspective. Secondly, the severity of the presenting stroke was not captured in all symptomatic patients, which is important if you want to compare hospitals as fair as possible on patient outcomes. This will be altered in the next update of the web-survey. The data is self-reported so it is possible that the reported mortality and complications are slightly underestimated. A continuously repeated independent data verification will be carried out to minimize this possible discrepancy. Additionally, standardizing postoperative care and follow-up could improve quality of care and could contribute to data quality. Lastly, the DACI only provides information on 30-days/in-hospital outcomes, while the long-term complications and re-interventions are just as important. A future possible link with declaration data from health care insurers might be able to provide this information.

Next to the comparison of results between hospitals on a national level, one could also learn from the comparison of practice and outcomes between different countries.

Describing the initiation and first results of our nationwide audit for carotid interventions could be helpful for other countries and may be an incentive for them to establish a similar audit or can encourage the harmonization of existing national audits. A future international collaboration, in which practice and outcomes can be compared and in which one could learn from each other, can contribute to further quality improvements on a wider scale.

CONCLUSION

In the Netherlands CEA is performed with an overall low mortality and (major) stroke/death rate and a reasonable time-to-intervention. Whereas time-to-intervention showed significant variation between hospitals, outcome indicators as mortality and (major) stroke/death are not very distinctive due to low overall event rates and no hospitals with a significantly higher event rate. Hospital comparison and the identification of 'best practices' is hampered by this lack of variation between hospitals in current outcome indicators. However, data from the DACI can be used for national population studies, as the identification of predictors for major stroke/death in symptomatic patients.

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