Title: Carotid Endarterectomy – the change in practice over 11 years in a stroke centre

Short title: Carotid Endarterectomy – practice change

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The corresponding author is not a recipient of a research scholarship

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: [10.1111/ans.14241](https://doi.org/10.1111/ans.14241)

Abstract word count: 242 words

Total word count: (Abstract [242], body [2313] and reference [686] = 3241 words, plus 3 tables [750]) 3991 words. A supplementary table has been added in the end in response to reviewer's comments

Abstract

Background: Recent research evidence has impacted on the practice of carotid endarterectomy (CEA). We aim to characterize changes in the practice and outcome of CEA over time in a single large volume stroke centre.

Methods: All patients who underwent CEA from 2004-14 and carotid angioplasty and stenting (CAS) from 2003-08 at an Australian metropolitan tertiary stroke centre hospital were included. Clinical data were analysed to identify time trends in choice of intervention, patient selection, pre-operative imaging utilization, surgical timing and outcome.

Results: There were 510 CEA performed in 2004-14 and 95 CAS in 2003-08. The proportion of patients undergoing CEA compared to CAS increased from 60% to 90% from 2004-08 ($p<0.001$). CAS patients were more likely to have cardiac comorbidities. From 2004-14, the proportion of CEA patients ≥ 80 years old increased ($p=0.001$) and the proportion of asymptomatic patients decreased ($p=0.003$) over time. Median time from symptom onset to surgery decreased from 52 days (Q1:25, Q3:74) in 2004 to 8 days (Q1:5, Q3:37) in 2014 ($p<0.001$). Use of pre-operative ultrasonography decreased whilst CT angiography and the number of imaging modalities applied to each patient increased over time ($p<0.001$). Overall,

5.9% of CEA were complicated by death, stroke, or acute myocardial infarction with no significant change over time.

Conclusions: The trends in CEA practice at our centre align with international trends and guidelines. This study provides a representative indicator of Australian hospital practice, and illustrates how evidence from research is translated into clinical care.

Introduction

Carotid endarterectomy (CEA) has been the standard of practice for effective stroke prevention in those with high-grade symptomatic carotid artery stenosis since the landmark NASCET¹ and ESCT² trials in the 1990s. In recent years, new data about optimal timing of surgery, patient selection and choice of endovascular versus surgical intervention has become available. This new evidence has been reflected accordingly in national guidelines.

The role of endovascular carotid angioplasty and stenting (CAS) as an alternative to CEA has also evolved over the past decade. This, together with CEA for asymptomatic carotid artery stenosis, remains a topic of debate and guideline recommendations vary.^{3,4}

Our aim was to investigate changes in the practice of CEA, frequency of complications, and outcomes over time, in an Australian metropolitan hospital that is a large volume stroke and vascular surgery referral centre. The results were evaluated to determine if the practice within this centre changed appropriately with the publication of new evidence, and if practice aligned with national guidelines and international benchmarks.

Methods

This study was conducted at Box Hill Hospital (BHH), a tertiary referral University Hospital located in eastern metropolitan Melbourne, Australia. BHH serves a large metropolitan and semirural catchment area (750,000 core population plus 398,000 in the greater community) and provides comprehensive stroke care for this population, with >900 stroke or transient ischaemic attack (TIA) presentations annually. Since 2004, the Department of Neurosciences, BHH has maintained a clinical quality assurance database for all patients undergoing CEA, with demographic and clinical data collected prospectively by Stroke Unit nurses. In addition,

the Department of Cardiology kept a similar database for all patients undergoing CAS from 2003 to 2009. The CAS audit was stopped in mid 2009 due to the small number of cases being performed. For the purposes of this study, data collected for CEA between 2004 and 2014 and CAS between 2003 and 2008 were reviewed.

The CEA database was cross-referenced with a list generated by hospital diagnosis codes to ensure data completeness. For cases that were missed in the prospective database, data were extracted retrospectively from medical records by the principal researcher (GT). Patient outcome were collected up to 30 days or till the end of their hospital stay. Data on the symptom onset time were collected retrospectively by reviewing medical records for the pre-specified years 2004, 2010 and 2014. The year 2004 were chosen as it was the year Rothwell et. al.⁵ published the landmark study that recommended early surgical intervention for symptomatic carotid artery stenosis. The CEA database was revised, and in cases where data accuracy was uncertain, relevant medical records and investigations were reviewed to ensure that correct information was obtained. To minimise reporting bias, all clinical data from the year 2010 and 2014 were collected using consistent methodology either by the principal researcher or a stroke nurse.

During the study period, the policy within the Department of Vascular Surgery was to perform all CEA under general anaesthetic and to close all CEA with a polyurethane patch. Data was available for 466 patients from the Australasian Vascular Audit for the study period, in which 99.6% had general anaesthetic, and 95.3% was closed with a patch.

Differences between demographics, degree of stenosis and comorbidities for CEA and CAS patients were compared to identify trends in and factors influencing the choice of intervention. For CEA patients, sub-analyses compared trends over time for baseline

demographics, degree of stenosis, time interval from symptom onset to surgery, pre-operative imaging, complications and short-term outcomes. Standard statistical tests were applied for non-parametric categorical (X^2 test for trend) and continuous variables (Mann-Whitney U test).

Logistic regression models were fitted to assess whether there was a year effect for demographics or symptomatic status, pre-operative imaging, degree of stenosis for CEA patients. Multivariable logistic regression models were fitted to assess whether there was a year effect for outcomes (e.g. complications). These models were adjusted for age, gender, pre-morbid level of function and comorbidities (including ischaemic heart disease (IHD), congestive heart failure (CCF), diabetes mellitus and coronary artery bypass surgery). Significance level was determined to be two-sided $\alpha=0.05$. Statistical analyses were undertaken using Intercooled Stata 12.1 for Windows (Stata Corporation, 2014).

Ethics approval for this project was obtained from Eastern Health Human Research Ethics Committee.

Results

There were 510 CEA performed from 2004-2014, and 95 CAS from 2003-2008. The baseline demographics of the CEA and CAS patients are summarised in Table 1. CEA patients had lower pre-operative National Institutes of Health Stroke Scale¹⁰ (NIHSS) score than CAS patients ($p=0.006$). A higher proportion of CAS patients had a history of dyslipidaemia, IHD and CCF than CEA patients. There were no significant differences in most of the high risk features between those who underwent CEA and CAS with the exception of those with restenosis, who were more likely to receive CAS (OR 16.8, 95% CI: 2.0,139.0). Only a small

number of patients had previous cervical radiotherapy and the difference was of borderline significance.

The annual number of CEA performed ranged from 29 patients in 2005 to 63 patients in 2011. The number of CAS performed peaked at 32 in 2004 and decreased to 5 in 2008. The number of CEA done as a percentage of total number of carotid stenosis intervention has steadily increased from 60% in 2004 to almost 90% in 2008. ($p<0.001$).

Over the years of 2004-2014, the proportion of patients aged ≥ 80 years undergoing CEA has increased significantly ($p=0.001$, Table 2) and this group was less likely to be asymptomatic in recent years. ($p=0.03$) There was no significant change in gender, pre-operative mRS, or degree of stenosis distribution in CEA patients over time.

Overall 75.3% of CEA were undertaken for symptomatic disease. Indications were stroke (41.8%), TIA (26.3%), amaurosis fugax (14.8%), and retinal infarct (2.6%), with some patients having more than one indication. The overall proportion of patients with asymptomatic disease significantly decreased over the time period (OR 0.9 [0.87, 0.99] $p=0.003$). There was no difference by gender over time in the asymptomatic patients ($p=0.73$). More patients who underwent CEA for asymptomatic disease had $>69\%$ stenosis than those with symptomatic disease (asymptomatic 97%, symptomatic 83%, $p<0.001$).

Prior to their CEA, 83.1% of patients had duplex ultrasonography, 35% had computed tomographic angiography (CTA), 4.9% had magnetic resonance angiography (MRA) and 5.1% had digital subtraction angiography (DSA). Patients with symptomatic stenosis (39%) were more likely to have CTA than asymptomatic patients (23%, $p=0.001$). The use of duplex ultrasonography has significantly decreased from 100% in 2004 to 61% in 2014 (X^2 for trend,

p<0.001). The use of CTA has increased from 4.3% in 2004 to 83% in 2014 (p<0.001). The number of imaging modalities used has significantly increased from 15% for two or more modalities in 2004 to 47% in 2014 (p<0.001).

Time from symptom onset to surgery for those with symptomatic disease has significantly decreased over time. The median time interval was 52 days (Q1:25, Q3:74) in 2004, 16 days in 2010 (Q1:9, Q3:49) and 8 days (Q1:5, Q3:37) in 2014 (p<0.001). Data was available in 94% of patients (33/36 in 2004, 42/44 in 2010, 42/45 in 2014).

Complications and patient outcomes for CEA interventions are summarised in Table 3. There were no significant differences in complications between the symptomatic and asymptomatic group. In adjusted analyses, a downward yearly trend in wound infection complication risk and an upward yearly trend for post-operative hypotension requiring treatment were observed. Importantly, there was no significant difference in frequency of complications between patients aged ≥ 80 and <80 years. No correlation was found between the timing of surgery, the use of antiplatelets or anticoagulants and post-operative complications (all complications, death, stroke, AMI, or significant haematoma) in our patient group.

At one month, 90.0% of patients had no or mild disability with a mRS of 0-2 following CEA (including patients who died). After adjusting for age and gender, there was no year trend in disability at one month (Table 3). Overall, 88% of patients were discharged home after CEA, 10.7% were discharged to either a rehabilitation centre or nursing care facility (data available in 90.1%).

Discussion

In this study we observed a number of significant changes in the practice of carotid stenosis intervention in our centre over the past decade, which illustrated how evidence arising from the publication of scientific research is translated into clinical practice.

Trials in the early 2000s⁶ demonstrated non-inferiority of CAS as compared to CEA. However, CAS has not been consistently recommended in recent years as a routine intervention after randomized controlled trials results suggesting that it is potentially more hazardous than CEA. The number of CAS performed at our centre decreased significantly after 2006, which correlated with the publication of EVA¹¹ and SPACE¹², two of the large trials that favoured the use of CEA over CAS. The Australian guideline recommend that CAS should only be considered in selected patients that are deemed less suitable for CEA due to high surgical risk features³. In our study, we found a positive correlation between restenosis following previous CEA and the choice of CAS, but not for other high-risk features. This could be due to the small number of such patients, but may also reflect that these recommendations are not absolute indications with a lack of trial evidence. There are, however, consistent data indicating that CAS is associated with a lower risk of peri-operative AMI.^{7,12} In our study, CAS patients were more likely to have cardiac comorbidities than CEA patients, suggesting that endovascular was chosen over surgical treatment in this group to avoid cardiac complications.

The proportion of patients undergoing CEA that are ≥ 80 years of age has increased over time in our study. They were less likely to be asymptomatic in the more recent years, and did not have a higher frequency of complications. This is consistent with the evidence from literature, which has shown that CEA in asymptomatic carotid stenosis benefits younger patients more,⁸ whereas CEA in symptomatic stenosis benefits older patients more and often with good

outcome.⁵ Importantly, despite operating on more elderly patients in recent years, there was no change in functional outcome as measured by the one month mRS.

Optimal management of patients with asymptomatic carotid stenosis has been a topic of debate for many years. We have found a reduction in the proportion of asymptomatic patients in our institute over the past 11 years. This is probably not surprising because although previous studies reported benefit in asymptomatic CEA,⁸ the role of intervention in asymptomatic patients has been seriously questioned more recently with recommendation of a medical approach to management.⁹ Careful selection of patients with low perioperative complication risk and significant long-term stroke risk remains crucial. Ongoing clinical trials such as CREST-2¹⁴ and ECST-2¹⁵ may provide further evidence to help determine the optimal management in asymptomatic carotid stenosis.

Historically, the optimal timing of surgery has been one of the major controversies in the practice of CEA. Rothwell et al. published a meta-analysis in 2004 which showed that benefit was greatest in those who had surgery within two weeks from the most recent ischaemic event, and fell rapidly with time⁵. This study had a great impact on current recommendation of surgical timing.^{4,16,17} In our study, the median time from symptom onset to surgery has decreased substantially over time. This correlates well with the publication of the landmark meta-analysis. However, the median time to surgery was only approaching the national guideline of 14 days in 2010 (16 days), and meeting the guideline in 2014 (8 days). This lag has also been demonstrated in other studies conducted internationally.^{18,19}

Catheter angiography remains the gold standard for carotid stenosis assessment, but carries procedural complication risks.²⁰ There has been a global trend of increasing use of non-invasive angiography such as CTA and MRA as they become more readily available. This

change has also been observed in our study, partly explained by the introduction of CTA as part of the routine acute stroke imaging assessment in 2009 at the study centre. There is no clear consensus on the optimal number of imaging modalities required prior to CEA, with some guidelines suggest two modalities in all patients,¹⁷ while others made no specific recommendation. In our study, the proportion of patients with more than one modality of pre-operative imaging increased significantly over time.

The post-operative major complication rate (including death, AMI and stroke) is recommended to be lower than 7% in centres that performs CEA to ensure clinical benefit, as guided by the pooled data from trials.²¹ The cumulative major complication rate was 5.9% over the 11 years period at our centre, which meets the recommendation and is comparable to the rates reported in recent major trials such as ICSS²² (5.2%) and CREST¹³ (4.5%). Hypotension requiring treatment is the only complication that increased over time, and many factors may have contributed to this observation, such as variability in reporting and change in treatment threshold over time.

Strengths of this study include good data completeness, and prospective data collection for the majority of cases. A limitation is that it is a single centre study. However, this hospital is a specialised stroke centre with a large catchment area and we believe the results from this study may provide a representative indicator of Australian hospital practice in general. An extensive literature search revealed no other recent similar studies performed in the Australian public hospital setting, with the latest study published in 2008.²³ Our study provides a contemporary description of the current practice of CEA in Australia.

Conclusion

This study described the current practice of CEA in Australia, and has illustrated how new knowledge arising from the publication of scientific research is translated into clinical practice. The findings align with international trends and guidelines. These include increased proportion of patients having CEA performed for carotid artery stenosis over CAS, reduced time from symptom onset to surgery, increased proportion of patients aged 80 years or more, reduced proportion of asymptomatic patients, and increased use of non-invasive pre-operative vascular imaging.

Acknowledgments:

The authors would like to thank Tanya Frost (Department of Neurosciences, Eastern Health), Skye Coote (Department of Neurosciences, Eastern Health), and Louise Roberts (Department of Cardiology, Eastern Health) for their contributions in maintaining the databases used in this study. We acknowledge the contribution of the late Associate Professor Gishel New to this work.

Conflicts of interest: none.

References

1. North American Symptomatic Carotid Endarterectomy Trial Collaborators (NASCET). Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991; 325(7):445-53.
2. European Carotid Surgery Trialists' Collaborative Group. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). *Lancet* 199; 351(9113):1379-87.
3. Bladin C, Chambers G, Crimmins D, et al. Guidelines for patient selection and performance of carotid-artery-stenting: inter-collegiate committee of the RACP/RACS/RANZCR. *Intern Med J* 201;41(4):344-7.
4. Brott TG, Halperin JL, Abbara S, et al. ASA/ACCF/AHA/AANN/AANS/ACR/ASNR/CNS/SAIP/SCAI/SIR/SNIS/SVM/SVS. Guideline on management of patients with extracranial carotid and vertebral artery disease. *Stroke* 2011;42:e464-e540.
5. Rothwell PM, Eliasziw M, Gutnikov SA, et al; the Carotid Endarterectomy Trialists Collaboration. Endarterectomy for symptomatic carotid stenosis in relation to clinical subgroups and timing of surgery. *Lancet* 2004; 363(9413):915-24.
6. Yadav JS, Wholey MH, Kuntz RE, et al; Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy Investigators. Protected carotid-artery stenting versus endarterectomy in high-risk patients. *N Engl J Med* 2004; 351(15):1493–501.

7. Bonati LH, Lyrer P, Ederle J, et al. Percutaneous transluminal balloon angioplasty and stenting for carotid artery stenosis. *Cochrane Database Syst Rev* 2012 Sep 12; 9:CD000515. doi: 10.1002/14651858.CD000515.pub4.
8. Chambers BR, Donnan G. Carotid endarterectomy for asymptomatic carotid stenosis. *Cochrane Database Syst Rev* 2005 Oct 19;(4):CD001923. DOI: 10.1002/14651858.CD001923.pub2.
9. Abbott AL. Medical (nonsurgical) intervention alone is now best for prevention of stroke associated with asymptomatic severe carotid stenosis: results of a systematic review and analysis. *Stroke* 2009; 40(10):e573-83
10. Brott T, Adams HP Jr, Olinger CP, et al. Measurement of acute cerebral infarction: a clinical examination scale. *Stroke* 1989; 20:864–870
11. Mas JL, Chatellier G, Beyssen B, et al; EVA-3S Investigators. Endarterectomy versus stenting in patients with symptomatic severe carotid stenosis. *New Engl J of Med* 2006; 355(16):1660–71.
12. SPACE Collaborative Group. 30 day results from the SPACE trial of stent-protected angioplasty versus carotid endarterectomy in symptomatic patients: a randomised non-inferiority trial. *Lancet* 2006; 368(9543):1239–47.
13. Brott TG, Hobson RW, Howard G, et al; CREST Investigators. Stenting versus endarterectomy for treatment of carotid-artery stenosis. *New Engl J of Med* 2010; 363(1):11–23.

14. Thomas G, Brott, MD; National Institute of Neurological Disorders and Stroke. Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2). In: ClinicalTrials.gov [Internet]. Bethesda (MD): National Library of Medicine (US). 2014- [cited 2015 Sept]. Available from: <http://clinicaltrials.gov/ct2/show/NCT02089217>. NLM Identifier: NCT02089217.
15. University College London (UK); Institute of Neurology, Queen Square, London. European Carotid Surgery Trial 2 (ECST-2). In: ISRCTN [Internet]. 2012-[cited 2015 Sept]. Available from: <http://www.controlled-trials.com/ISRCTN97744893> (accessed Oct 2015). ISRCTN Identifier: ISRCTN97744893.
16. National Stroke Foundation. Clinical Guidelines for Stroke Management. Melbourne, Australia, 2010.
17. Tendera M, Aboyans V, Bartelink ML, et al; European Stroke Organisation. ESC guidelines on the diagnosis and treatment of peripheral artery diseases: document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries: the task force on the diagnosis and treatment of peripheral artery diseases of the European society of cardiology. *Eur Heart J* 2011; 32(22):2851–2906
18. Witt AH, Johnsen SP, Jensen LP, et al. Reducing Delay of Carotid Endarterectomy in Acute Ischemic Stroke Patients. *Stroke* 2013; 44:686-690.
19. Halliday AW, Lees T, Kamugasha D, et al; Carotid Endarterectomy Steering Group; Clinical Effectiveness and Evaluation Unit, Royal College of Physicians; Vascular

Society of Great Britain and Ireland. Waiting times for carotid endarterectomy in UK: observational study. *BMJ* 2009; 338:b1847.

20. Kaufmann TJ, Huston J 3rd, Mandrekar JN, et al. Complications of diagnostic cerebral angiography: evaluation of 19,826 consecutive patients. *Radiology* 2007; 243:812–819.
21. Rerkasem K, Rothwell PM. Carotid endarterectomy for symptomatic carotid stenosis. *Cochrane Database Syst Rev* 2011 Apr 13;(4):CD001081. DOI: 10.1002/14651858.CD001081.pub2.
22. International Carotid Stenting Study investigators. Carotid artery stenting compared with endarterectomy in patients with symptomatic carotid stenosis (International Carotid Stenting Study): an interim analysis of a randomised controlled trial. *Lancet* 2010; 375(9719):985–97.
23. Organ N, Walker PJ, Jenkins J, et al. 15 Year Experience of Carotid Endarterectomy at the Royal Brisbane and Women's Hospital: Outcomes and Changing Trends in Management. *Eur J Vasc Endovasc Surg* 2008; 35:273e

Table 1: Demographics and comorbidities for patients undergoing CEA and CAS

Characteristic	All patients N=605 n (%)	CEA patients N=510 n (%)	CAS patients N=95‡ n (%)	p-value between CEA/CAS
Gender				
Male	431 (71.2)	361 (70.8)	70 (73.7)	0.566
Age (median, Q1 and Q3)				
72 (66, 78)	72 (66, 78)	73 (66, 78)	72 (65, 78)	0.367
≥80 years	111 (18.4)	94 (18.4)	17 (17.9)	0.901
Pre-operative mRS (after stroke) †				0.103
0-2 (No or mild disability)	518 (89.0)	438 (89.9)	80 (84.2)	
3-5 (Moderate to severe disability)	64 (11.0)	49 (10.1)	15 (15.8)	
Pre-operative NIHSS (after stroke)†*				0.006
0-3	525 (91.5)	440 (91.7)	85 (90.4)	
4-15	47 (8.2)	40 (8.3)	7 (7.5)	
≥16	2 (0.4)	0 (0)	2 (2.1)	
Side of surgery				0.647
Left	306 (50.6)	260 (51.0)	46 (48.4)	
Right	299 (49.4)	250 (49.0)	49 (51.6)	
Degree of stenosis #				0.364
<50%	4 (0.7)	4 (0.8)	0 (0)	
50-69%	73 (12.1)	66 (12.9)	7 (7.5)	
≥69%	525 (87.1)	439 (86.1)	86 (92.5)	
Comorbidities §				
Hypertension	481 (79.5)	401 (78.6)	80 (84.2)	0.216
Dyslipidemia*	401 (66.3)	324 (63.5)	77 (81.1)	0.001
Diabetes mellitus	165 (27.3)	134 (26.3)	31 (32.6)	0.201
Current smoker*	116 (19.2)	106 (20.8)	10 (10.5)	0.020
Ex-smoker (quitted >4weeks ago)	267 (44.1)	218 (42.8)	49 (51.6)	0.111
Atrial fibrillation	64 (10.6)	54 (10.6)	10 (10.5)	0.986
Ischaemic heart disease*	226 (37.4)	173 (33.9)	53 (55.8)	<0.0001
Previous coronary artery bypass graft*	64 (10.6)	48 (9.4)	16 (16.8)	0.031
Congestive heart failure*	24 (3.9)	15 (2.9)	9 (9.5)	0.003
Peripheral vascular disease	94 (15.5)	80 (15.7)	14 (14.7)	0.815
Previous stroke/TIA	278 (46.0)	227 (44.5)	51 (53.7)	0.099
High risk surgical features				
Restenosis*	13 (2.1)	5 (1.0)	8 (8.4)	<0.0001
Contralateral ICA occlusion	25 (4.1)	23 (4.5)	2 (2.1)	0.280
Previous cervical radiotherapy	7 (1.2)	4 (0.8)	3 (3.2)	0.047

Q1: 25th percentile, Q3: 75th percentile; mRS: modified Rankin Scale; NIHSS: National Institutes of Health Stroke Scale scores - range from 0 to 42, with higher scores indicating more severe neurologic deficits; †<5% Missing data; #<1% missing data; ‡20 of the 95 CAS cases included were involved in a clinical trial including EMERGE, SECURITY, and ICSS (2, 10 and 8 patients respectively); §according to the documented medical history in medical records; *p<0.05 between CEA and CAS patient groups.

Table 2: CEA practice over time (2004-2014)

CEA patient characteristics	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Year effect (OR: 95% CI)
	% N=48	% N=29	% N=33	% N=40	% N=44	% N=37	% N=59	% N=63	% N=54	% N=50	% N=53	
Male	64.6	72.4	81.8	72.5	68.2	72.9	67.8	65.1	70.4	74.0	75.5	1.0 (0.95, 1.07)
Age ≥80 years	14.6	17.2	9.1	15.0	6.8	16.2	16.9	20.6	14.8	28.0	35.6	1.1 (1.05, 1.22)*
Pre-operative mRS 0-2	95.2	82.8	87.9	95.0	83.3	83.3	95.9	83.9	90.2	96.0	92.5	0.9 (0.94, 1.13)
Asymptomatic	25.0	24.1	36.4	42.5	27.3	16.2	25.4	23.8	24.1	18.0	15.1	0.9 (0.87, 0.99)*
Degree of stenosis >69%	87.5	89.7	90.9	92.5	79.6	81.1	89.8	76.2	87.0	88.0	94.3	1.0 (0.94, 1.09)
High risk features – surgical												
Contralateral ICA occlusion	6.3	6.9	12.1	0.0	2.3	2.7	5.1	3.2	3.7	2.0	7.6	0.9 (0.84, 1.09)
Previous cervical radiotherapy	2.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	2.0	1.9	1.1 (0.78, 1.52)
Restenosis	2.0	0.0	0.0	0.0	0.0	0.0	5.1	0.0	0.0	0.0	1.9	1.0 (0.76, 1.35)
Premorbid use of: †‡												
Antiplatelets	95.8	96.6	96.7	95.0	93.2	91.9	83.0	88.9	94.4	86.0	92.5	0.9 (0.81, 1.00)
Aspirin and Clopidogrel	8.3	13.8	30.3	12.8	2.3	5.6	10.3	5.2	5.8	2.0	18.9	0.9 (0.86, 1.04)
Anticoagulants	4.2	3.5	6.1	2.5	2.3	8.1	6.8	1.6	0.0	8.0	13.2	1.1 (0.96, 1.26)

mRS: modified Rankin Scale 0-2 No or mild disability; †Adjusted for age, gender, ischaemic heart disease, coronary artery bypass graft surgery, atrial fibrillation and previous TIA/stroke; ‡<3% missing data; *p<0.05

Table 3: CEA intervention complications and patient outcomes (2004-2014)

Patient outcomes	Number (%) N=510	Age <80 n (%)	Age 80+ n (%)	Year effect† (OR; 95% CI)
Complication‡§	143 (28)	114 (27)	29 (31)	1.04 (0.98, 1.11)
Death	6 (1.2)	5 (1)	1 (1)	1.09 (0.82, 1.46)
Stroke	19 (3.7)	15 (4)	4 (4)	1.07 (0.92, 1.26)
Ischaemic	17 (3.3)	13 (3)	4 (4)	
Haemorrhagic	2 (0.4)	2 (1)	0 (0)	
TIA	12 (2.3)	8 (2)	4 (4)	1.07 (0.88, 1.30)
Hyperperfusion syndrome	3 (0.6)	2 (1)	1 (1)	1.01 (0.64, 1.61)
Acute myocardial infarction	5 (1.0)	4 (1)	1 (1)	0.94 (0.69, 1.28)
Hypotension requiring treatment	44 (8.6)	34 (8)	10 (11)	1.17 (1.04, 1.31)*
Local complications‡	81 (16.0)			0.99 (0.92, 1.08)
Cranial nerve injury	43 (8.4)	34 (8)	9 (10)	1.06 (0.96, 1.18)
Significant wound haematoma¶	28 (5.5)	19 (5)	9 (10)	1.02 (0.90, 1.16)
Wound infection	17 (3.3)	17 (4)	0 (0)	0.79 (0.66, 0.93)*
1 month modified Rankin Scale††				
0-2 (No or mild disability)	388 (90.0)	322 (91)	66 (87)	0.94 (0.85, 1.05)
3-5 (Moderate-severe disability)	37 (8.6)	28 (8)	9 (12)	
6 (Death)	6 (1.4)	5 (1)	1 (1)	

OR: Odds ratio; CI: Confidence interval; †Adjusted for age, gender, pre-morbid function and comorbidities (ischaemic heart disease, congestive heart failure, diabetes mellitus and coronary artery bypass grafts); ‡One or more complications; §<1% missing data; ||Causes of death include AMI, intracerebral haemorrhage and respiratory failure; ¶defined by haematoma requiring surgical evacuation or resulting in prolonged hospital stay; ††15% missing data; *p <0.05; defined by haematoma requiring surgical evacuation or resulting in prolonged hospital stay

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Title:

Carotid endarterectomy: the change in practice over 11years in a stroke centre

Date:

2019-04-01

Citation:

Tse, G. T. W., Kilkenny, M. F., Bladin, C., Grigg, M. & Dewey, H. M. (2019). Carotid endarterectomy: the change in practice over 11years in a stroke centre. ANZ JOURNAL OF SURGERY, 89 (4), pp.314-319. <https://doi.org/10.1111/ans.14241>.

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