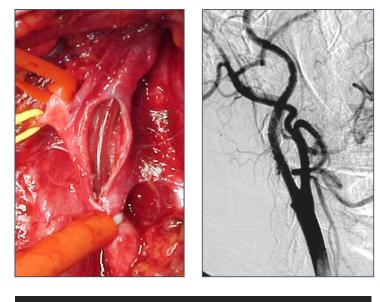
Decision making in symptomatic carotid artery disease CEA, CAS, TCAR?

Mauro Gargiulo

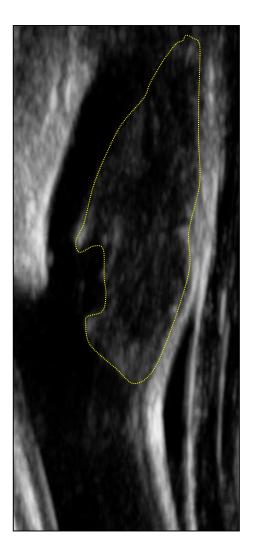


Vascular Surgery University of Bologna - DIMES Policlinico S.Orsola-Malpighi Bologna, Italy mauro.gargiulo2@unibo.it

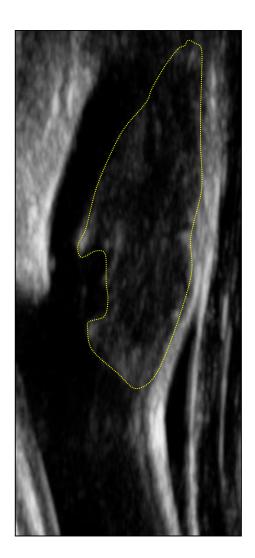


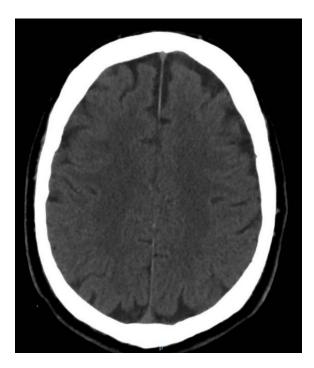


- Male, 74 years old
- Hypertension, Diabetes
- Right TIA: amaurosi fugax + left arm paresis
- No history of CAD or atrial fibrillation
- Cardiac Echo: no disease

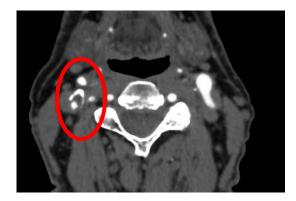


ICA Stenosis > 70%



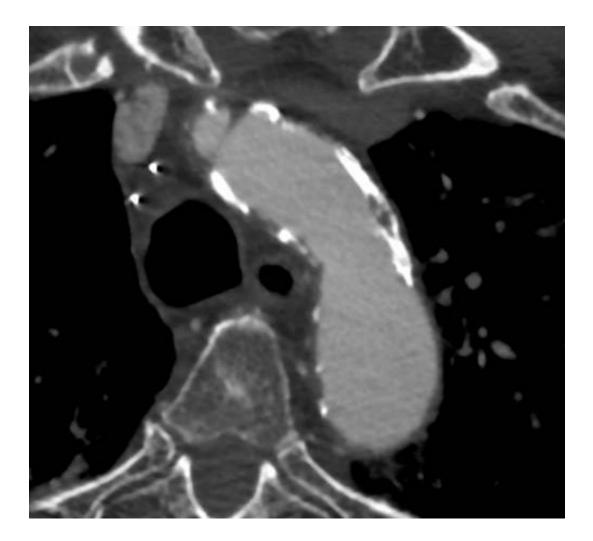


No brain ischemic lesions





ICA Stenosis > 70%







Postoperative period

- no MAE
- deficit VII cranial nerve
- Discharge: day 2 + BMT

• Follow up 3 months

- no MAE
- regression deficit VII cranial nerve
- no ICA restenosis

• Follow up 12 months

- no MAE
- no ICA restenosis

Current guidelines

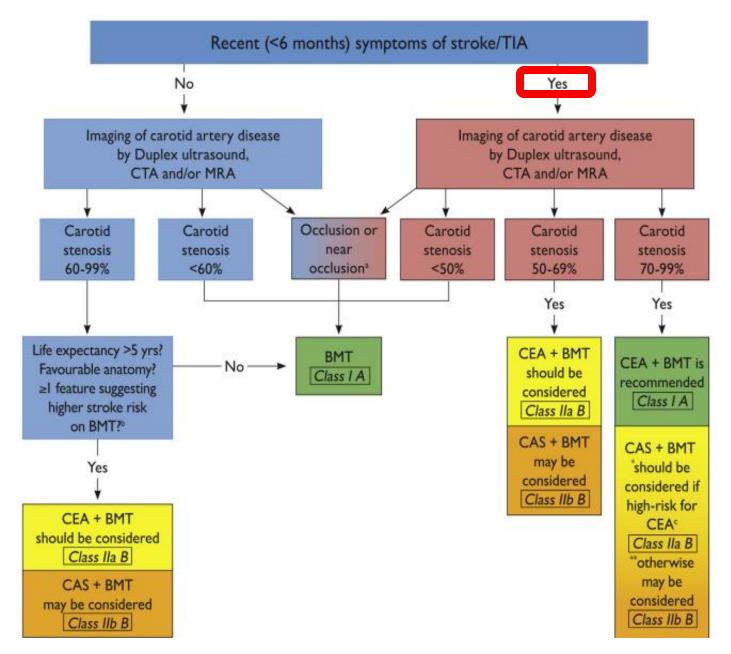
Eur J Vasc Endovasc Surg (2018) 55, 3-81

Editor's Choice — Management of Atherosclerotic Carotid and Vertebral Artery Disease: 2017 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS)

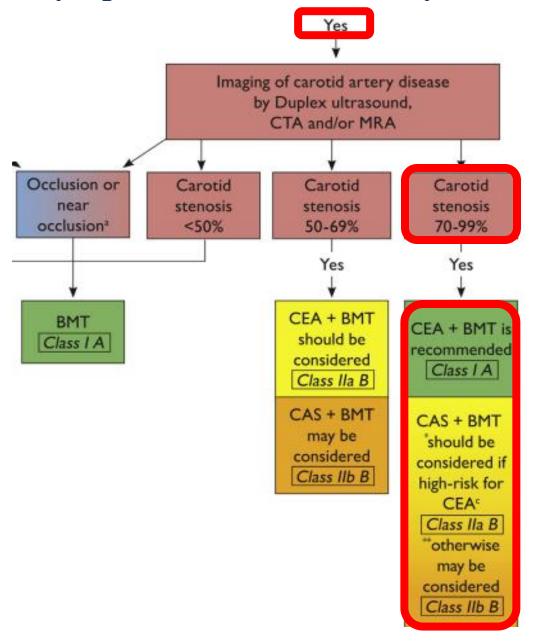
A.R. Naylor^a, J.-B. Ricco^a, G.J. de Borst^a, S. Debus^a, J. de Haro^a, A. Halliday^a, G. Hamilton^a, J. Kakisis^a, S. Kakkos^a, S. Lepidi^a, H.S. Markus^a, D.J. McCabe^a, J. Roy^a, H. Sillesen^a, J.C. van den Berg^a, F. Vermassen^a, ESVS Guidelines Committee^b, P. Kolh, N. Chakfe, R.J. Hinchliffe, I. Koncar, J.S. Lindholt, M. Vega de Ceniga, F. Verzini, ESVS Guideline Reviewers^c, J. Archie, S. Bellmunt, A. Chaudhuri, M. Koelemay, A.-K. Lindahl, F. Padberg, M. Venermo

Keywords: Carotid, Vertebral, Stroke, Transient ischaemic attack, Endarterectomy, Stenting, Medical therapy, Screening, Dementia, Asymptomatic, Symptomatic, Thrombolysis, Imaging, Bypass, Surgical techniques, Complications, Patch infection, Restenosis

Algorithm of management strategies



Symptomatic carotid artery stenoses



Percutaneous transluminal balloon angioplasty and stenting for carotid artery stenosis (Review)

Bonati LH, Lyrer P, Ederle J, Featherstone R, Brown MM



Cochrane Database Syst Rev. 2012 Sep 12;(9):CD000515.

11 randomized controlled trial for Symptomatic carotid artery stenosis (1998-2010)

Study or subgroup	Endovascular	Endarterectomy	Odds Ratio M-	Weight	Odds Ratio M-
	n/N	n/N	H,Random,95%		H,Random,95% Cl
Leicester 1998	5/7	0/10		0.8 %	46.20 [1.87, 1141.18]
Wallstent 2001 (1)	13/107	5/112		6.3 %	2.96 [1.02, 8.61]
CAVATAS-CEA 2001	38/221	28/231	-	17.2 %	1.51 [0.89, 2.55]
Kentucky 2001	0/53	1/51		0.8 %	0.31 [0.01, 7.90]
TESCAS-C 2006 (2)	2/82	3/84	- _	2.4 %	0.68 [0.11, 4.15]
EVA-35 2006	27/265	11/262		11.5 %	2.59 [1.26, 5.33]
SPACE 2006	45/607	39/589	+	20.6 %	1.13 [0.72, 1.76]
BACASS 2008	0/10	1/10		0.8 %	0.30 [0.01, 8.33]
Beijing 2009 (3)	2/23	1/23	<u> </u>	1.3 %	2.10 [0.18, 24.87]
ICSS 2010	65/853	34/857	+	21.4 %	2.00 [1.30, 3.06]
CREST 2010	40/668	21/653	-	16.8 %	1.92 [1.12, 3.29]
Total (95% CI)	2896	2882	•	100.0 %	1.72 [1.29, 2.31]
Total events: 237 (Endovascu	ılar), 144 (Endarterecto	этту)			
Heterogeneity: Tau ² = 0.06;	Chi ² = 13.73, df = 10	(P = 0.19); I ² =27%			
Test for overall effect $Z = 3$.	65 (P = 0.00027)			Ctralso /d	e e th
Test for subgroup differences	Not applicable			Stroke/d	eath
			0.01 0.1 1 10 100		

Favours endovascular

Favours endarterectomy

CEA vs. CAS: the RCTs

Randomized Clinical Trials

- CAVATAS 2001
- SAPPHIRE 2004
- EVA-3S 2006
- SPACE 2006
- ICSS 2010
- CREST 2010

G . 1	Centres	N pts	Pts risk	Asympt	Filters	Stent	Outcome
Study		(CAS/CEA)					
CAVATAS	22 centres in Europe,	505	1	100/			
2001	Australia, and Canada	(252/253)	normal	10%			
SAPPHIRE	29 centres,	334	high	29%			
2004	USA	(167/167)	Ingn 2970				
EVA-3S 2006	30 centers in France	527 (265/262)	normal	0			
SPACE 2007	35 centres in Germany, Austria and Switzerland	1214 (613/601)	normal	0			
ICSS 2009	50 academic centers in Europe, Australia, New Zealand, and Canada	1713 (855/858)	normal	0			
CREST 2010	108 centers in the USA and 9 centers in Canada	2522 (1271/1251)	normal	47%			

30-day outcomes

	30-day death, stroke	р
Study	CEA vs. CAS	
EVA3S 2006	4.1% vs. 10.1%	0.01
SPACE 2007	6.6 % vs. 7.4 %	0.51
ICSS 2009	3.9 % vs. 7.6 %	0.001

30-day outcomes

	30-day death, stroke	р	30-day death, stroke,	р
Study	CEA vs. CAS		or <mark>MI</mark>	
			CEA vs. CAS	
EVA3S 2006	4.1% vs. 10.1%	0.01	4.6% vs. 10.5%	0.02
SPACE 2007	6.6 % vs. 7.4 %	0.51	6.6 % vs. 7.4 %	0.51
ICSS 2009	3.9 % vs. 7.6 %	0.001	4.5 % vs. 7.6 %	0.006

ICA Stenosis > 70% - Which Strategy?

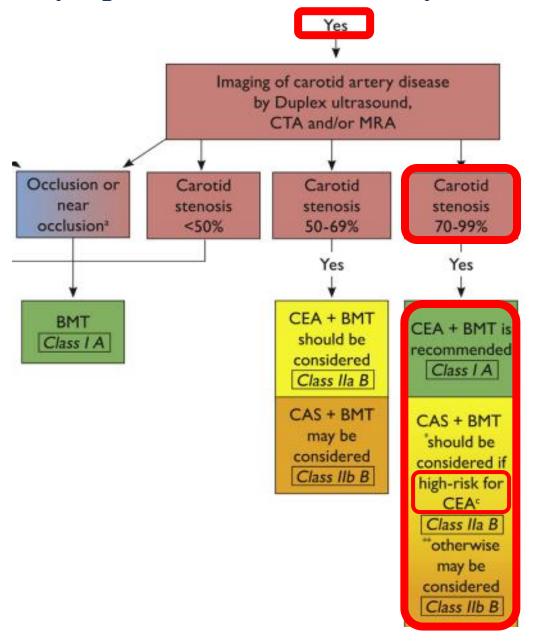








Symptomatic carotid artery stenoses



Study	Centres	N pts (CAS/CEA)	Pts risk	Asympt	Filters	Stent	Outcome
CAVATAS 2001	22 centres in Europe, Australia, and Canada	505 (252/253)	normal	10%	0%	26%	Stroke/death
SAPPHIRE 2004	29 centres, USA	334 (167/167)	high	29%	100%	100%	Stroke/death/MI
EVA-3S 2006	30 centers in France	527 (265/262)	normal	0	92%	100%	Stroke/death
SPACE 2007	35 centres in Germany, Austria and Switzerland	1214 (613/601)	normal	0	27%	100%	Stroke/death
ICSS 2009	50 academic centers in Europe, Australia, New Zealand, and Canada	1713 (855/858)	normal	0	80%	100%	Stroke/death/MI
CREST 2010	108 centers in the USA and 9 centers in Canada	2522 (1271/1251)	normal	47%	96%	100%	Stroke/death/MI

Carotid endarterectomy in **SAPPHIRE-eligible high-risk** patients: implications for selecting patients for carotid angioplasty and stenting.

High Risk Patient for CEA

- Age > 80 years
- Contralateral Carotid Occlusion
- Severe Cardiac Dysfunction
- Severe Pulmonary Dysfunction
- Local and Anatomic Problems

Carotid endarterectomy in SAPPHIRE-eligible high-risk patients:

implications for selecting patients for carotid angioplasty and stenting.

CEA outcomes

		High-risk	Low-risk				
	Symptomatic		Symptomatic				
Ipsilateral							
¹ Major stroke	2.3		0.8				
Minor stroke	2.3		0.8				
Any stroke	4.6		1.6	P = .01			
Contralateral							
Major stroke	0.0		0.8				
Minor stroke	0.0		0.0				
Any stroke	0.0		0.8				
Any side							
Major stroke	2.3		0.8				
Minor stroke	2.3		0.8				
Any stroke	4.6		1.6				

Mozes G et al, J Vasc Surg. 2004

Carotid endarterectomy in SAPPHIRE-eligible high-risk patients: implications for selecting patients for carotid angioplasty and stenting.

CEA outcomes Death, stroke, MI

P < .005

Table VII. Odds ratios of predictive factors for postoperative stroke and myocardial infarction at significance level of P < 0.1

10 —	9,3		-	Odds ratio	95% Confidence interval	e P
0			Stroke			
8 —			Age ≤ 60 y	7.7	2.3-25.7	< .01
			Symptomatic presentation	3.3	1-11	< .05
6 —			Cervical radiation therapy	15.2	1.6-142.2	< .05
			Class III/IV angina	10.8	1.2-96.4	< .05
4			Myocardial infarction			
4 —			Contralateral occlusion	3.0	0.8 - 11.1	< .1
		1.0	History of CAD	6.5	1.4-29.0	< .05
2 —		1,6	Class III/IV angina	8.3	1.0-72.4	< .1
			Positive cardiac stress test	3.5	1.1 - 10.7	< .05
0 —			SAPPHIRE high-risk	3.6	1.1-11.5	<.05
-	high risk	low risk	<i>CAD</i> , Coronary artery disease; <i>SA</i> Protection in Patients at High Ris	,	0 0 1	sty with

Mozes G et al, J Vasc Surg. 2004

ICA Stenosis > 70% - Which Strategy?

Symptomatic

Clinical Standard risk





Clinical High risk for CEA



TF-CAS is preferable in specific settings

Clinical characteristics

- Age > 80 years
- Severe Cardiac Dysfunction
- Severe Pulmonary Dysfunction

Mozes G et al; J Vasc Surg. 2004

Contralateral Carotid Occlusion in Endovascular and Surgical Carotid Revascularization: A Single Centre Experience with Literature Review and Meta-analysis

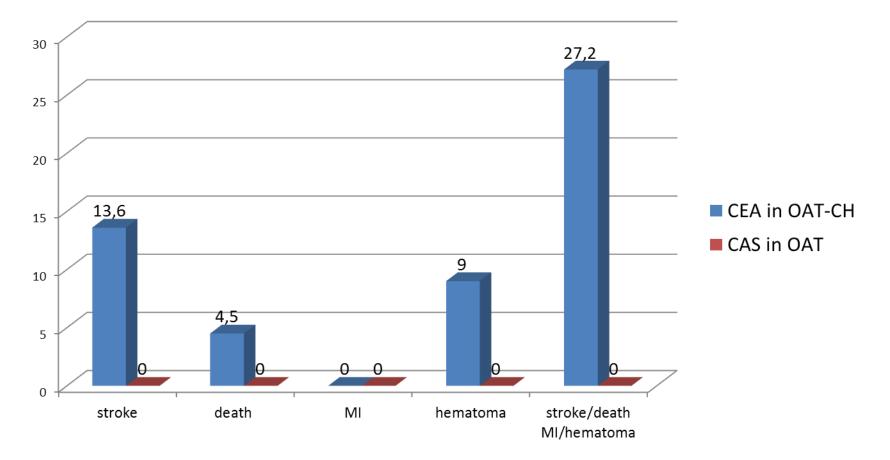
G. Faggioli, R. Pini, R. Mauro, A. Freyrie, M. Gargiulo, A. Stella

	CEA C	co	CEA no-	cco		Odds Ratio		Odds	Ratio
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% Cl	Year	M-H, Rand	om, 95% Cl
Mackey et al. 1990 ¹²	3	63	18	607	6.4%	1.64 [0.47, 5.72]	1990		•
da Silva et al. 1996 35	4	108	11	592	7.4%	2.03 [0.63, 6.50]	1996		
Aungst et al. 1998 34	2	37	2	74	2.5%	2.06 [0.28, 15.22]	1998		
Julia et al. 1998 25	1	58	8	583	2.3%	1.26 [0.15, 10.26]	1998		
Locati et al. 2000 26	8	198	25	1068	15.2%	1.76 [0.78, 3.95]	2000		
Karmeli et al. 200127	1	50	2	94	1.7%	0.94 [0.08, 10.61]	2001	• •	
Rockman et al. 2002 1	2	82	16	1242	4.5%	1.92 [0.43, 8.48]	2002		
Pulli et al. 2002 28	10	338	44	2082	20.6%	1.41 [0.70, 2.83]	2002		
Reed et al. 2003 30	5	75	27	1295	10.3%	3.35 [1.25, 8.97]	2003		
Dalainas et al. 2007 31	8	373	52	2959	17.6%	1.23 [0.58, 2.60]	2007	3 	
Duncan et al. 20087	5	93	20	1512	9.9%	4.24 [1.55, 11.56]	2008		
Goodney et al. 2012 10	1	62	2	245	1.7%	1.99 [0.18, 22.33]	2012		
Total (95% CI)		1537		12353	100.0%	4 93 14 34 3 531			-
10tal (35% CI)		1991		12333	100.070	1.83 [1.34, 2.52]			-
Total events	50	1278549 2010 1070 1070	227			1.63 [1.34, 2.52]		an an an a	
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z =	00; Chi ²	= 6.38,	227 df = 11 (P			1.03 [1.34, 2.32]	С	0.1 0.2 0.5 1 CO protective factor	· · · · · · · · · · · · · · · · · · ·
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z =	00; Chi ² : = 3.77 (P	= 6.38, = 0.00	227 df = 11 (P	= 0.85)		0dds Ratio	С	CO protective factor	· · · · · · · · · · · · · · · · · · ·
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = Routine shunting	00; Chi ² : = 3.77 (P	= 6.38, = 0.00	227 df = 11 (P 02) CEA no	= 0.85)	; I ² = 0%			CO protective factor	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = Routine shunting Study or Subgroup	00; Chi ² = = 3.77 (P CEA (= 6.38, = 0.00	227 df = 11 (P 02) CEA no	= 0.85)	; l ² = 0%	Odds Ratio	l Year	CO protective factor Odds r M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = ROUTINE Shunting Study or Subgroup Sachs et al. 1984 ¹¹	00; Chi ² : = 3.77 (P CEA (Events	= 6.38, = 0.00 CCO Total	227 df = 11 (P 02) CEA no Events	= 0.85) o-CCO Total	: I ² = 0% Weight 10.4%	Odds Ratio M-H, Random, 95% C	I Year 1984	CO protective factor Odds M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = ROUTINE Shunting Study or Subgroup Sachs et al. 1984 ¹¹ Perler et al. 1992 ¹³	00; Chi ² : = 3.77 (P CEA (Events	= 6.38, = 0.00 CCO Total 54	227 df = 11 (P 02) CEA no Events 8	= 0.85) o-CCO Total 410	Veight 10.4% 4.2%	Odds Ratio M-H, Random, 95% C 2.96 [0.76, 11.50]	I Year 1984 1992	CO protective factor Odds M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0	00; Chi ² : = 3.77 (P CEA (Events	= 6.38, 6 = 0.00 CCO Total 54 36	227 df = 11 (P 02) CEA no <u>Events</u> 8 7		Veight 10.4% 4.2% 4.5%	Odds Ratio M-H, Random, 95% C 2.96 [0.76, 11.50] 0.66 [0.08, 5.55]	I Year 1984 1992 2000	CO protective factor Odds M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = ROUTINE Shunting Study or Subgroup Sachs et al. 1984 ¹¹ Perler et al. 1992 ¹³ AbuRahma et al. 2000 ³⁷ Domenig et al. 2003 ²⁹	00; Chi ² : = 3.77 (P CEA (Events	= 6.38, = 0.00 CCO Total 54 36 49	227 df = 11 (P 02) CEA no <u>Events</u> 8 7 10	= 0.85) -CCO <u>Total</u> 410 169 350	Veight 10.4% 4.2% 4.5% 17.2%	Odds Ratio M-H, Random, 95% C 2.96 [0.76, 11.50] 0.66 [0.08, 5.55] 0.71 [0.09, 5.66]	1984 1984 1992 2000 2003	CO protective factor Odds M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = ROUTINE Shunting Study or Subgroup Sachs et al. 1984 ¹¹ Perler et al. 1992 ¹³ AbuRahma et al. 2000 ³⁷	00; Chi ² : = 3.77 (P CEA (Events 3 1 1 4	= 6.38, = 0.00 CCO Total 54 36 49 112	227 df = 11 (P 02) CEA no Events 8 7 10 32	= 0.85) -CCO <u>Total</u> 410 169 350 1752	Weight 10.4% 4.2% 4.5% 17.2% 34.6%	Odds Ratio M-H, Random, 95% C 2.96 [0.76, 11.50] 0.66 [0.08, 5.55] 0.71 [0.09, 5.66] 1.99 [0.69, 5.73]	I Year 1984 1992 2000 2003 2008	CO protective factor Odds M-H, Rand	CCO risk factor
Total events Heterogeneity: Tau ² = 0.0 Test for overall effect: Z = ROUTINE ShUNTING Study or Subgroup Sachs et al. 1984 ¹¹ Perler et al. 1992 ¹³ AbuRahma et al. 2000 ³⁷ Domenig et al. 2003 ²⁹ Maatz et al. 2008 ³²	00; Chi ² : = 3.77 (P CEA (Events 3 1 1 4 9	= 6.38, = 0.00 CCO Total 54 36 49 112 161	227 df = 11 (P 02) CEA nd Events 8 7 10 32 38	e = 0.85); -CCO <u>Total</u> 410 169 350 1752 1799	Weight 10.4% 4.2% 4.5% 17.2% 34.6%	Odds Ratio M-H, Random, 95% C 2.96 [0.76, 11.50] 0.66 [0.08, 5.55] 0.71 [0.09, 5.66] 1.99 [0.69, 5.73] 2.74 [1.30, 5.78]	I Year 1984 1992 2000 2003 2008	CO protective factor Odds M-H, Rand	CCO risk factor

European Journal of Vascular and Endovascular Surgery, 2013

Carotid Revascularization in Patients with Ongoing Oral Anticoagulant Therapy: The Advantages of Stent Placement

G Faggioli, R Pini, C Rapezzi, R Mauro, A Freyrie, M Gargiulo, A Stella



J Vasc Interv Radiol 2013

CAS is preferable in specific settings

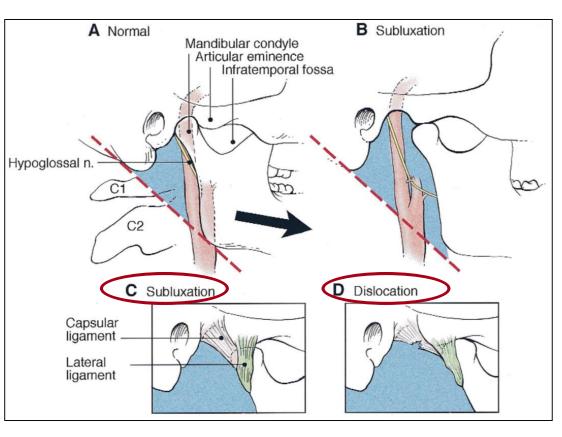
Clinical characteristics

- Age > 80 years
- Severe Cardiac Dysfunction
- Severe Pulmonary Dysfunction
- Controlateral carotid occlusion
- Oral anticoagulant therapy
- Local and Anatomic Problems

CAS is preferable in specific settings

Lesion Location

- Lesions at or above the level of C2
- Lesions of the the CCA very proximal to the arch



Simonian GT et al; J Vasc Surg. 1999

CAS is preferable in specific settings

The Irradiated Neck or Neck with previous surgery



ICA Stenosis > 70% - Which Strategy?

Symptomatic

Clinical Standard risk



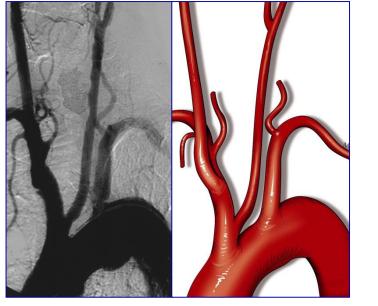


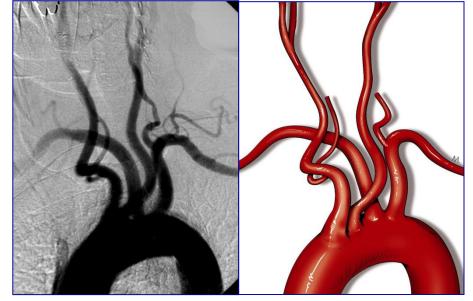
Clinical High risk for CEA and Anatomical high risk for TF-CAS

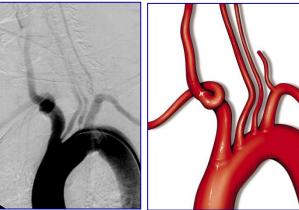
Aortic arch anomalies are associated with increased risk of neurological events in carotid stent procedures

Faggioli GL, Ferri M, Freyrie A, Gargiulo M, Fratesi F, Rossi C, Stella A

Eur J Vasc Endovasc Surg 2007







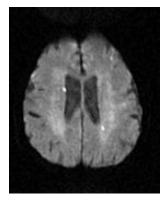
Arch anomaly in CAS

	Technic failur		Neurological complications			
	Ajusted OR (95% CI)	р	Ajusted OR (95% CI)	р		
Age (1 year increment)	1.14 (1.05-1.23	0.001	1.03 (0.94-1.12)	0.5		
Arch (anomalies vs normal)	2.11 (1.25-3.56)	0.005	2.01 (1.09-3.71)	0.026		

Logistic regression

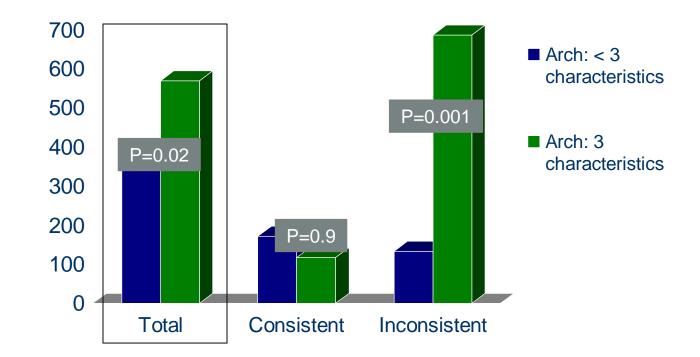
Faggioli GL, et al EJVES 2007

Atherosclerotic aortic lesions increase the risk of cerebral embolism during carotid stenting in patients with complex aortic arch anatomy





Lesion mean volume



Faggioli GL, et al. J Vasc Surg 2009

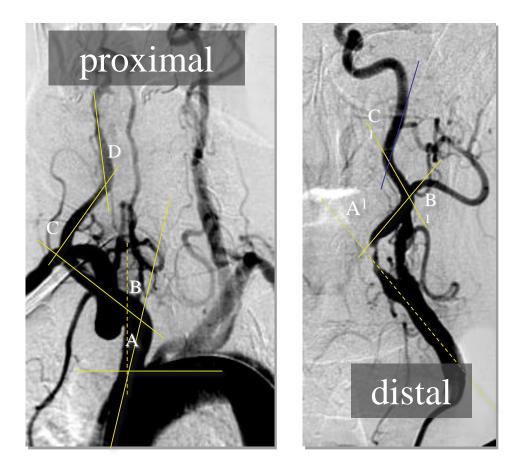
Measurement and impact of proximal and distal tortuosity in carotid stenting procedures

Faggioli GL, Ferri M, Gargiulo M, Freyrie A, Fratesi F, Manzoli L, Stella A

J Vasc Surg 2007; 46: 1119-24

- Evaluation of tortuosity index (TI) in pts undergoing CAS
 - TI = sum of all angles diverging from the ideal straight axis

 Correlation of TI proximal and distal to target lesion Technical results Clinical outcome



Tortuosity in CAS

	Technic Failure	al 9	Neurological complications			
	Ajusted OR (95% CI)	р	Ajusted OR (95% CI)	р		
Age (1 year increment)	1.10 (1.02-1.19)	0.009	1.05 (0.98-1.13)	0.149		
TI proximal > 150	3.07 (1.259-7.49)	0.014	2.72 (1.14-6.47)	0.023		
TI distal > 150	.32 (.117877)	0.027	1.00 (.42-2.37)	0.995		

Logistic regression

Faggioli GL, et al J Vasc Surg 2007

ICA Stenosis > 70% - Which Strategy?

Symptomatic

Clinical Standard risk





Clinical High risk for CEA and Anatomical high risk for TF-CAS

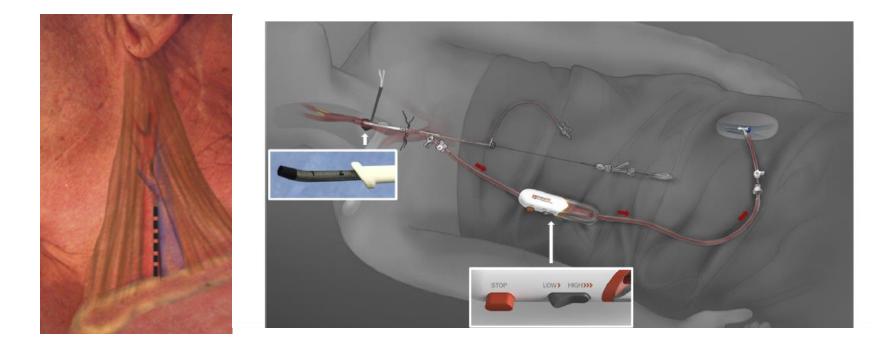
T-CAR

Technical aspects of transcarotid artery revascularization using the ENROUTE transcarotid neuroprotection and stent system



Mahmoud B. Malas, MD, MHS,^a Jose Leal, MD,^b Vikram Kashyap, MD,^c Richard Paul Cambria, MD,^d Christopher J. Kwolek, MD,^d and Enrique Criado, MD,^e Baltimore, Md; Toledo, Spain; Cleveland, Ohio; Boston, Mass; and Midland, Mich

. (J Vasc Surg 2017;65:916-20.)



T-CAR results

Analysis of 12 studies reporting the results of 739 TCS procedures

First author/ year	Patients, No.	age, years	CAS, No.	EPD	Technical success	Complications- treatment	Neurologic complications	Deaths, No.	MI, No.	FU, months	Outcome
Alexandrescu, ³⁴ 2006	26	73.7	29	(+)	28/29	1 inability to cross the lesion-CEA	0	0	0	11.6 (3-38)	1 TIA, 4 unrelated deaths
Feldtman, ³⁵ 2006	15	NR	15	(+)	12/15	3 inability to cross the lesion-CEA	1 stroke (fatal)	1	0	3-18	3 restenoses, PTA
Mathieu, ¹⁹ 2009	160	NR	160	50 (+), 110 (-)	NR)	NR	2 strokes (1 major-fatal, 1 minor) 13 TIA	1	NR	NR	NR
Palombo, ²¹ 2010	44	72.1	44	(+)	44/44	0	1 TIA	0	0	NR	NR

First author/ year	Patients, No.	Mean age, years	CAS, No.	Technical success	Complications- treatment	Neurologic complications	Deaths	MI	FU, months	Outcome
Chang, ³¹ 2004 Lin, ³² 2005	20 31	73 NR	21 31	21/21	No details-CEA	0	0	0	12 NR	OK NR
Lin, 2005	17		17	28/31	No details-CEA	2 TIA 0	0		NR 12	
Pipinos, ³³ 2005 Criado, ¹⁷ 2007	97	NR 72	103	$\frac{17}{17}$ $\frac{100}{103}$	- 1 CCA dissection,	0 2 minor strokes -	0	0	12 3-40	OK 5 unrelated
			103		1 inability to cross, 1 agitation-all CEA 4 CCA access site dissections, 3 resolved after stent placement, 1 interposition graft	2 TIA	0			deaths, 1 stent occlusion
Christopoulos, ²³ 2011	25	79	25	24/25	1 dissection-CEA	1 TIA	0	0	3-24	OK
Pinter, ³⁶ 2011	44	71.4	44	42/44	1 dissection, 1 inability to cross-CEA	0	0	0	-	-
Leal, ²⁴ 2012	31	68.1	31	31/31		0	0	0	23.25	OK
Alvarez, ²⁷ 2012	212	79.9	219	211/219	4 inability to cross-CEA	3 strokes,	1	1	18.8 ± 16.9	1 stroke
					2 CCA dissections- CCA-to-ICA bypass 1 failure of predilatation- CEA 1 stent	1 TIA				
					thrombosis-no treatment					

- Technical success 96.3%
- Stroke, myocardial infarction, and death 1.1%, 0.14% and 0.41%, respectively

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ROADSTER 2

Clinical Outcomes

Symptomatic Patients – Per Protocol

	ROA	ROADSTER 1		ROADSTER 2	
		n=46	n=118		
Stroke/Death/MI	1	2.2%	1	0.8%	
Stroke	0	0.0%	1	0.8%	
Death	1	2.2%	0	0.0%	
MI	0	0.0%	0	0.0%	
Stroke/Death	1	2.2%	1	0.8%	

