Tandem Lesions: How I manage these cases and European experience with the C-Guard CAS system

Adnan H. Siddiqui, MD PhD

Chief Executive Officer & Chief Medical Officer,
Jacobs Institute

UB Distinguished Professor &
Vice Chair, Department of Neurosurgery
Director, Canon Stroke & Vascular Research Center
SUNY University at Buffalo

Director, Neurosurgical Stroke Service
Kaleida Health

JACOBSINSTITUTE.ORG

UBNS Neurosurgery
UNIVERSITY AT BUFFALO

CANON STROKE & VASCULAR RESEARCH CENTER
UNIVERSITY AT BUFFALO

Gates Vascular Institute
Buffalo General Medical Center
A Kaleida Health Facility

University at Buffalo
The State University of New York

JACOBS INSTITUTE

Disclosures

Current Research Grants: Co-investigator for NIH - 1R01EB030092-01, Project Title: High Speed Angiography at 1000 frames per second; Mentor for Brain Aneurysm Foundation Carol W. Harvey Chair of Research, Sharon Epperson Chair of Research, Project Title: A Whole Blood RNA Diagnostic for Unruptured Brain Aneurysm: Risk Assessment Prototype Development and Testing

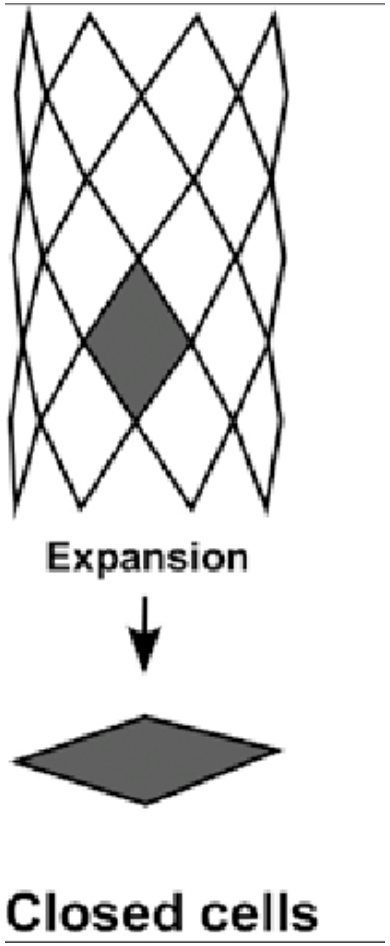
- **Financial Interest/Investor/Stock Options/Ownership:** Adona Medical, Inc., Bend IT Technologies, Ltd., BlinkTBI, Inc, Cerebrotech Medical Systems, Inc., Cognition Medical, CVAID Ltd., E8, Inc., Endostream Medical, Ltd, Galaxy Therapeutics, Inc., Imperative Care, Inc., InspireMD, Ltd., InspireMD, Ltd., Instylla, Inc., IRRAS AB, Launch NY, Inc., NeuroRadial Technologies, Inc., NeuroTechnology Investors, Neurovascular Diagnostics, Inc., Peijia Medical, PerFlow Medical, Ltd., Q'Apel Medical, Inc., QAS.ai, Inc., Radical Catheter Technologies, Inc., Rebound Therapeutics Corp. (Purchased 2019 by Integra Lifesciences, Corp), Rist Neurovascular, Inc. (Purchased 2020 by Medtronic), Sense Diagnostics, Inc., Serenity Medical, Inc., Silk Road Medical, Sim & Cure, SongBird Therapy, Spinnaker Medical, Inc., StimMed, LLC, Synchron, Inc., Three Rivers Medical, Inc., Truvic Medical, Inc., Tulavi Therapeutics, Inc., Vastrax, LLC, Viseon, Inc.

- **Consultant/Advisory Board:** Apellis Pharmaceuticals, Inc., Boston Scientific, Canon Medical Systems USA, Inc., Cardinal Health 200, LLC, Cerebrotech Medical Systems, Inc., Cerenovus, Cordis, Corindus, Inc., Endostream Medical, Ltd, Imperative Care, InspireMD, Ltd., Integra, IRRAS AB, Medtronic, MicroVention, Minnetronix Neuro, Inc., Peijia Medical, Penumbra, Q'Apel Medical, Inc., Rapid Medical, Serenity Medical, Inc., Silk Road Medical, StimMed, LLC, Stryker Neurovascular, Three Rivers Medical, Inc., VasSol, Viz.ai, Inc.

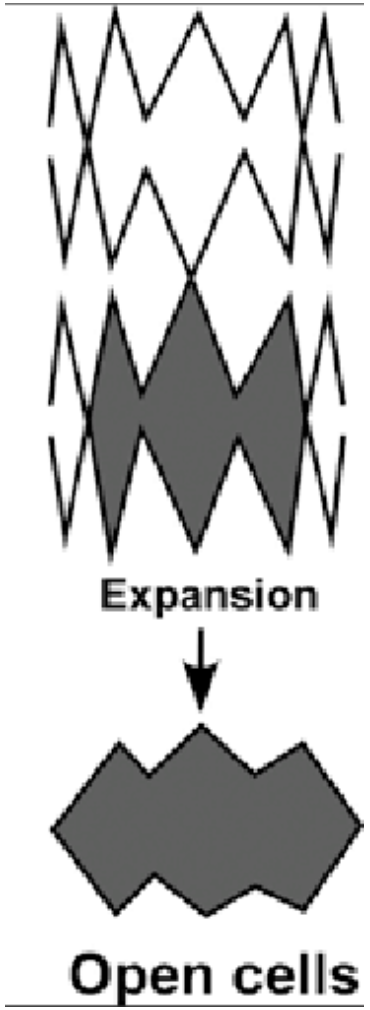
- **National PI/Steering Committees**: Cerenovus EXCELLENT and ARISE II Trial; Medtronic SWIFT PRIME, VANTAGE, EMBOLISE and SWIFT DIRECT Trials; MicroVention FRED Trial & CONFIDENCE Study; MUSC POSITIVE Trial; Penumbra 3D Separator Trial, COMPASS Trial, INVEST Trial, MIVI neuroscience EVAQ Trial; Rapid Medical SUCCESS Trial; InspireMD C-GUARDIANS IDE Pivotal Trial

Carotid Stents
The final protection

Stent design: Flexibility and scaffolding are key characteristics



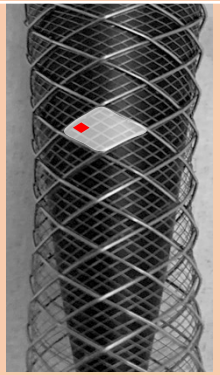
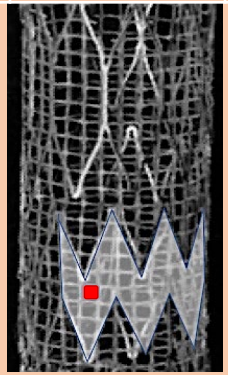
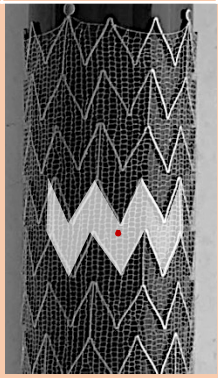
- less flexible
- may develop kinks and incomplete expansion
- offer better plaque coverage



- conform well to angulated vessels or tortuous anatomy
- less thromboembolic protection

Open, Close, Hybrid (O&C), Dual Layer, Mesh, and Micromesh Covered

1st generation self-~~expandible stents~~

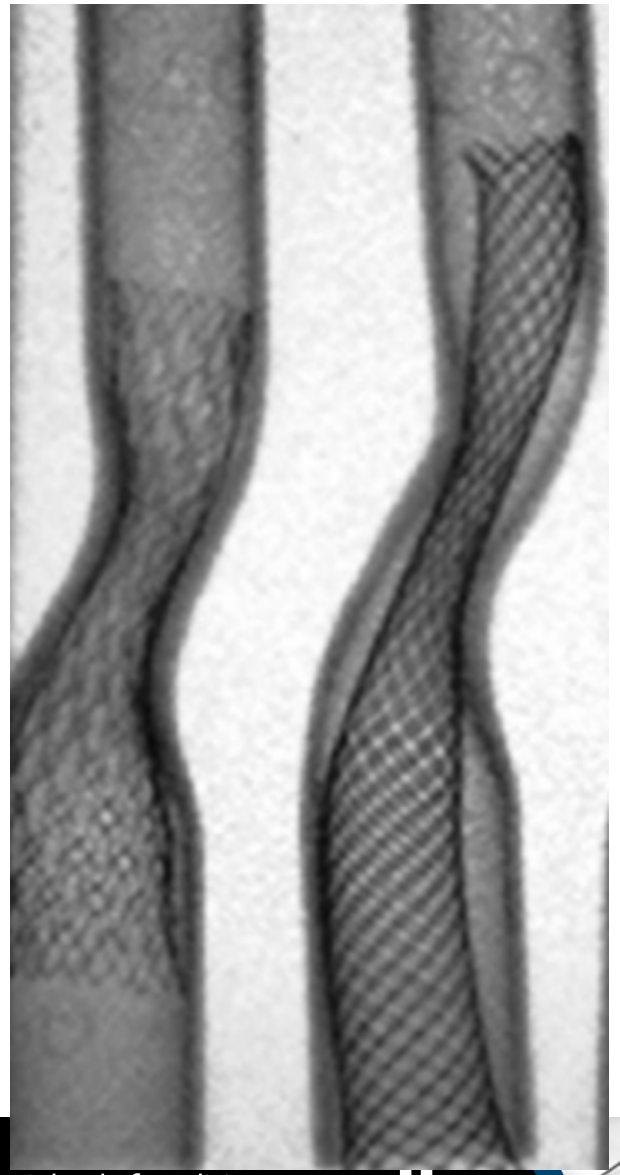
Small pore size in the lesion site and high plaque coverage			High wall apposition and flexibility for vessel anatomical adaptability			Combining characteristics		
Closed cell 1994 EU	**Closed cell 2003 EU**	**Hybrid cells 2008 EU**	**Open cell 2001 EU**	**Open cell 2003 EU**	**Open cell 2004 EU**	**Dual Layer 2013 EU**	**Mesh stent 2015 IDE USA**	**Micromesh covered 2013 EU**
								
Boston Scientific Corporation	**Abbott Laboratories**	**Medtronic Inc. Invatec**	**Abbott Laboratories**	**Medtronic ev3 Inc. Covidien**	**Cordis Corp.**	**Microvention Terumo**	**Gore**	**InspireMD**
WALLSTENT MONORAIL ® DEVICE	XACT® DEVICE	CRISTALO IDEALE DEVICE	ACCULINK® RX DEVICE	PROTÈGÈ RX® DEVICE	PRECISE PRO® RX DEVICE	CASPER® & ROADSAVER® DEVICES	GORE CAROTID STENT	CGUARD™ Carotid Embolic Prevention System

Updated from Dr. Marc Bosiers, CACVS 2014

Bench test results may not necessarily be indicative of clinical performance.

Images at approximate scale despite not exact

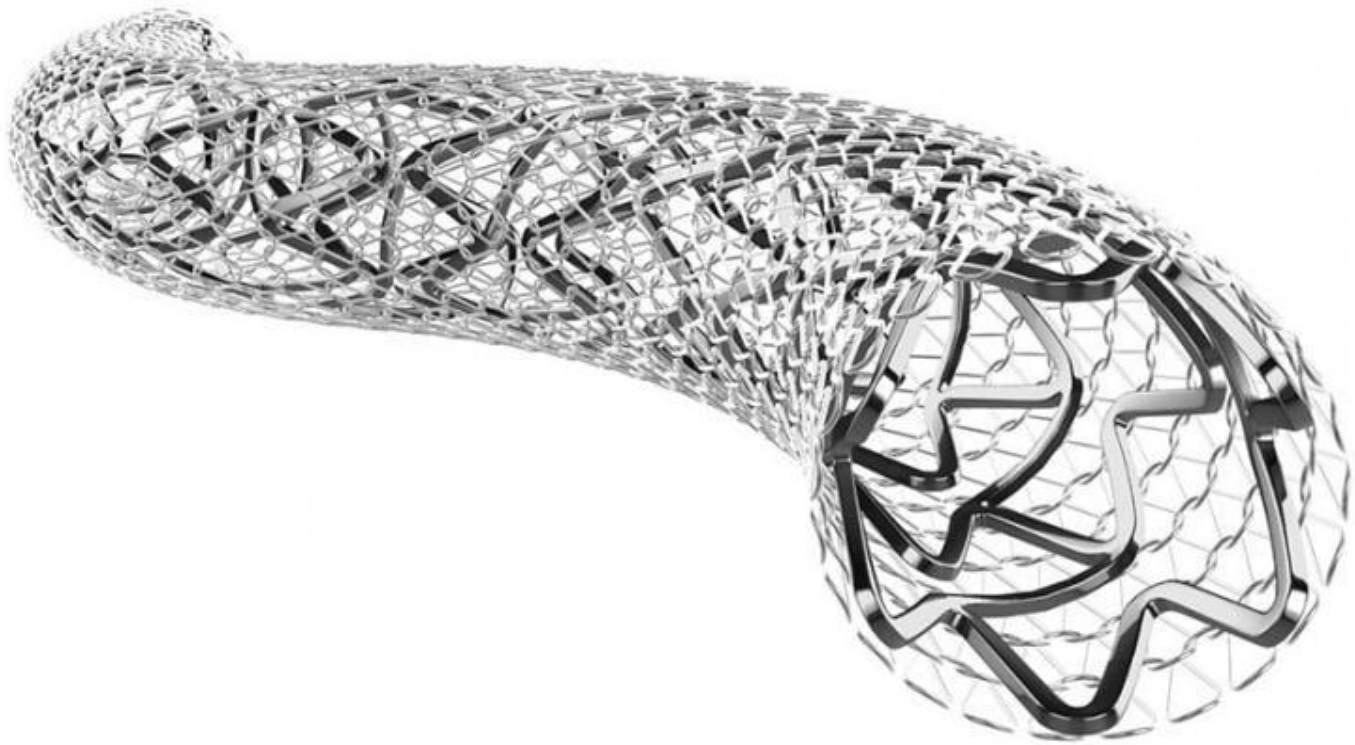
- Open Cell Stents are the most conformable within a vessel, however allow plaque prolapse
- Closed Cell Stents limit plaque prolapse within a vessel, however cause straightening/kinking of arteries



Dual layer stents - the best of both?

CGUARD

- inner open-cell nitinol stent
- outer closed-cell, single knitted polyethylene terephthalate (PET)



CGUARD (Inspire)

JNIS, 2018

Ischemic Stroke

ORIGINAL RESEARCH

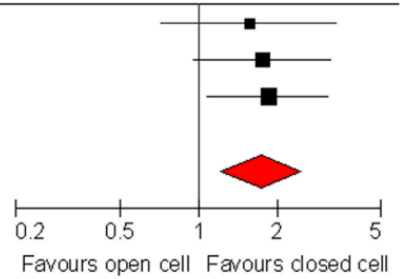
Influence of stent design and use of protection devices on outcome of carotid artery stenting: a pooled analysis of individual patient data

Fritz Wodarg,[1] Elisabeth L Turner,[2] Joanna Dobson,[2] Peter A Ringleb,[3] Willem P Mali,[4] Gustav Fraedrich,[5] Gilles Chatellier,[6] Jean-Pierre Bequemin,[7] Martin M Brown,[8] Ale Algra,[9] Jean-Louis Mas,[10] Olav Jansen,[1] Leo H Bonati,[8,11] On behalf of the Carotid Stenosis Trialists' Collaboration

	Open cell		Closed cell		Risk Ratio	Risk Ratio
Study	Events	Total	Events	Total	95% CI	95% CI
EVA-3S	12 (11.9)	101	11 (7.6)	145	1.57 (0.72-3.41)	
SPACE	14 (11.0)	127	28 (6.3)	446	1.76 (0.95-3.23)	
ICSS	35 (9.5)	367	19 (5.1)	371	1.86 (1.09-3.19)	
Total	**61 (10.3)**	**595**	**58 (6.0)**	**962**	**1.76 (1.23-2.52)**	

Heterogeneity: interaction p=0.938

Test for overall effect: p=0.002

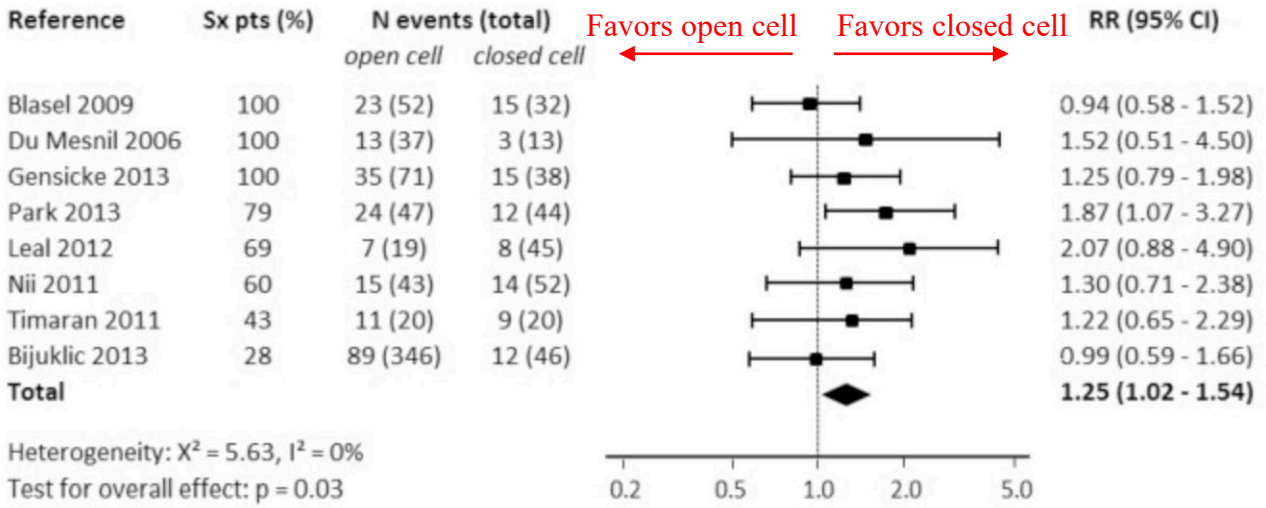


Greater risk of procedural stroke/death with open cell stents

J Vasc Surg, 2018

A meta-analysis of the effect of stent design on clinical and radiologic outcomes of carotid artery stenting

Evelien E. de Vries, MD,[a] Armelle J. A. Meershoek, MD,[a] Evert J. Vonken, MD, PhD,[b] Hester M. den Ruijter, PhD,[c] Jos C. van den Berg, MD, PhD,[d,e] *and* Gert J. de Borst, MD, PhD,[a] on behalf of the ENDORSE Study Group,* *Utrecht, The Netherlands; and Lugano and Bern, Switzerland*

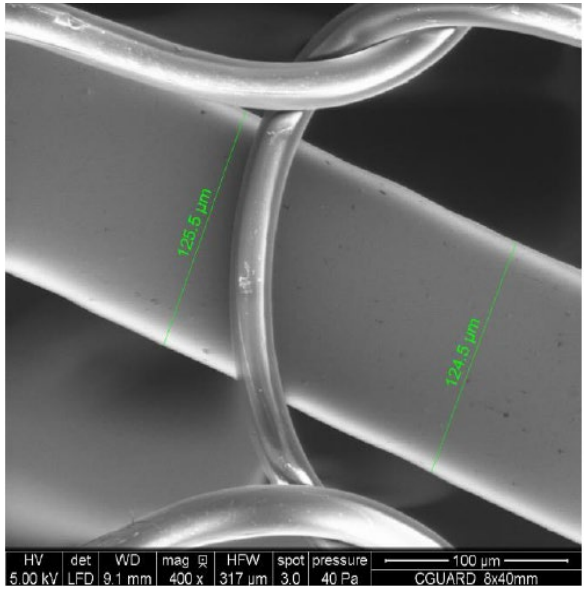


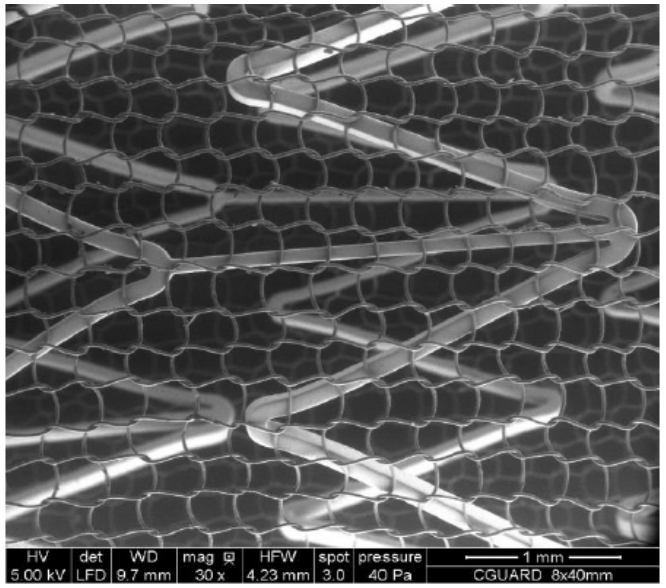
Greater risk of any new MRI-DWI hits with open-cell stents

PROBLEM: Approximately 2/3 of neurovascular events (stroke, TIA) occur after the carotid surgery procedure takes place[2]. How to preserve the flexibility of an open-celled stent while building in embolic protection?

SOLUTION: The CGuard EPS

The only stent platform available with our patented MicroNet mesh technology

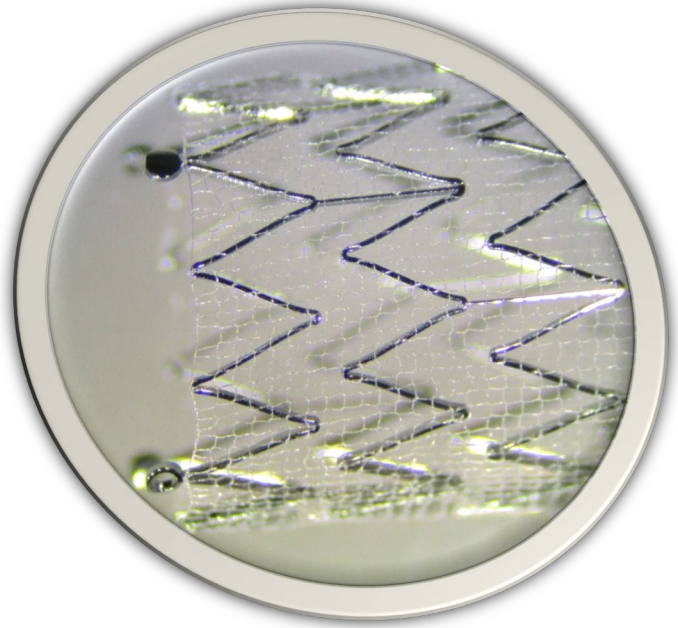


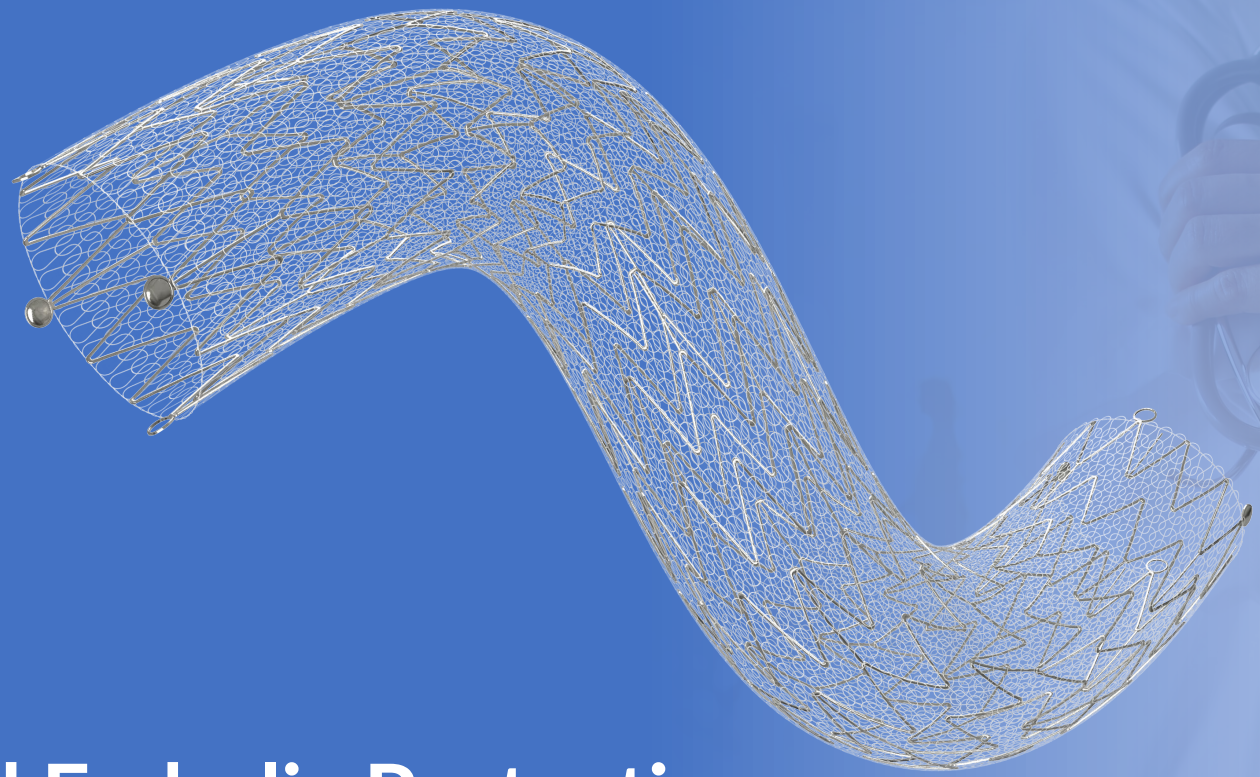


Interior Component:
Open-Cell Nitinol stent
(92 µm and 125 µm)

Exterior Component :
Closed-cell PET
(Polyethylene terephthalate)
25 µm

Cell size: **165 µm**





Sustained Embolic Protection

INSPIREMD

NSPR on NASDAQ

Based in Tel Aviv, with offices being established in Miami

Global Operations / Commercial success in 30 Countries (CE)

UBNS Neurosurgery UNIVERSITY AT BUFFALO

Buffalo General Medical Center
Gates Vascular Institute
A Kaleida Health Facility

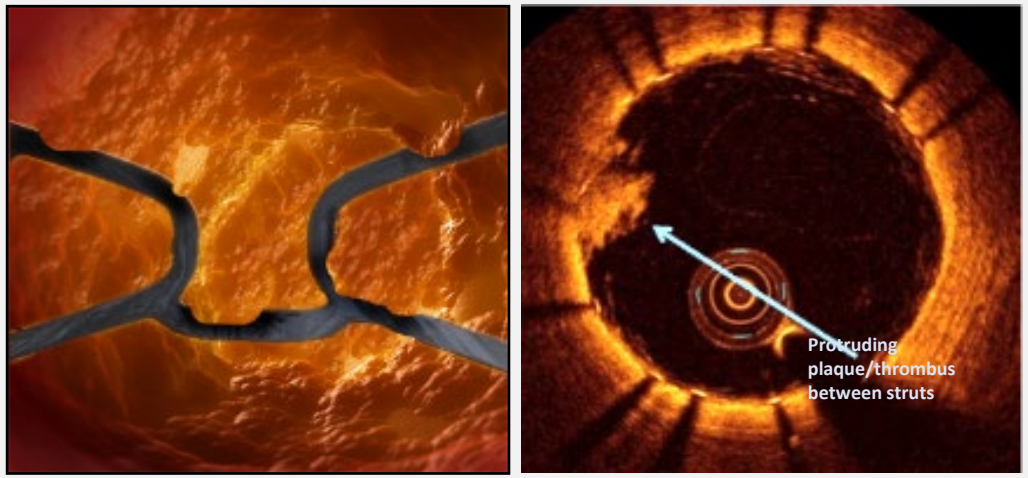
CANON STROKE & VASCULAR RESEARCH CENTER UNIVERSITY AT BUFFALO

Jacobs School of Medicine and Biomedical Sciences
University at Buffalo

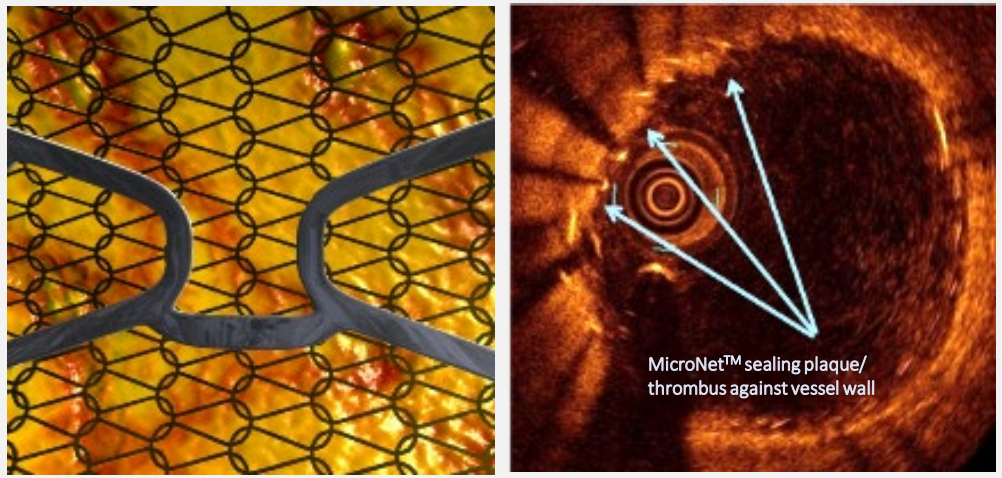
JACOBS INSTITUTE

SOLUTION: Proprietary MicroNet™ Technology[1]

New mesh covered stent offers superior plaque coverage when compared to conventional stent approaches



VS.



Conventional Open Cell Stent (1St GEN):

Bare or dual layer approach, with plaque protrusion risk

CGuard Stent System (3rd GEN):

Stents are covered in MicroNet

An Embolic Prevention System (EPS) for Ultimate Thrombus Protection

MicroNet captures and locks thrombus & plaque materials against the arterial wall, deterring debris from entering the bloodstream while also acting as a mechanical barrier to prevent plaque protrusion

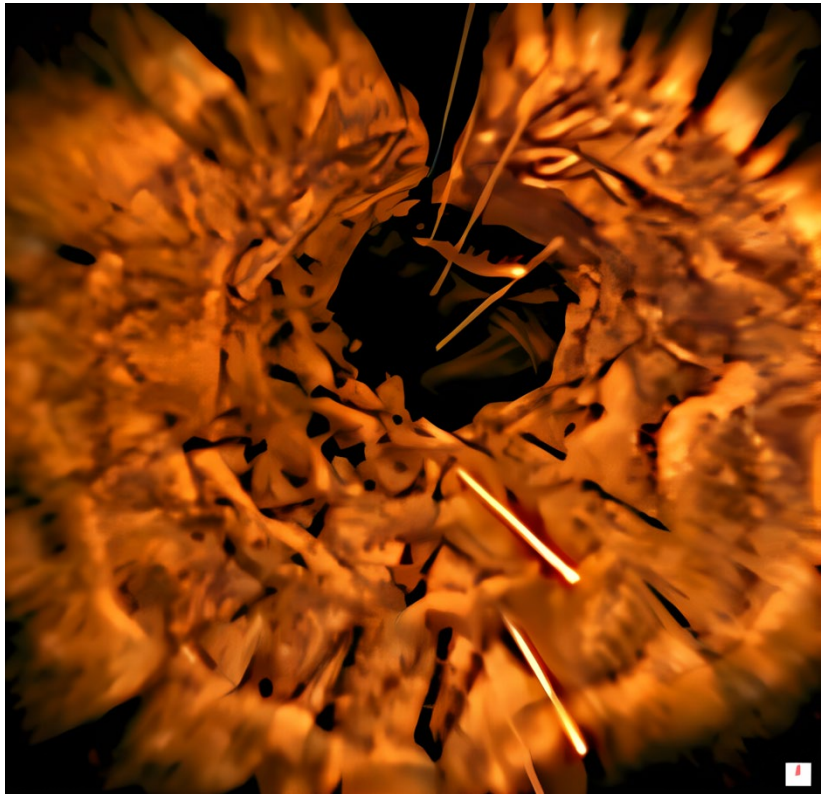
[1] Tomoyuki Umemoto, MD. Optical coherence tomography assessment of new generation mesh-covered stents after carotid stenting. Eurointerventional 2017;1348-1355 (published online)

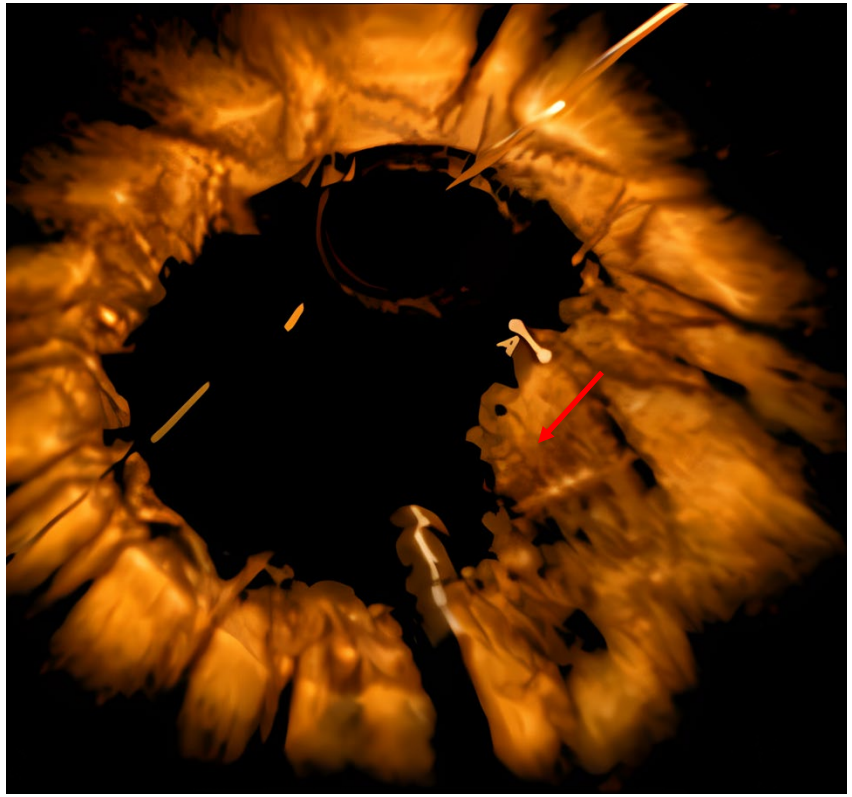
Image: Prof. Valdés Chávarri

Plaque Protrusion Is the Main Risk, Cell Area Is Key

Low plaque coverage leads to plaque protrusion or prolapse and plaque passing into the vessel lumen

66% of strokes occur after removal of the cerebral protection device because of plaque prolapse through stent struts





As CEA excludes the plaque, the ideal stent should do so as well

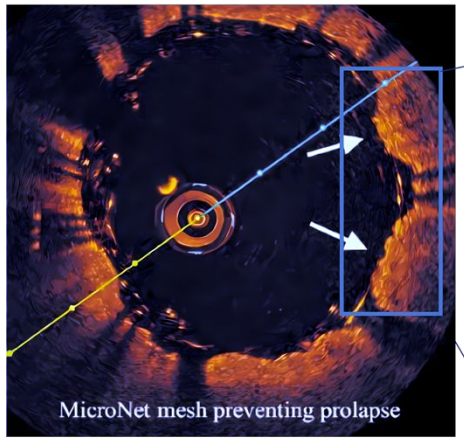
Amor, M. et al. Pre-Clinical and first clinical experiences with the Micromesh Carotid stent Roadsaver, LINC 2014

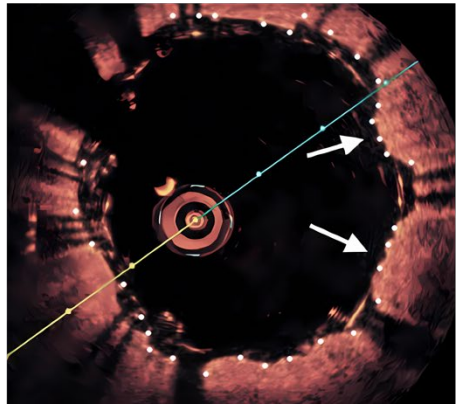
Stabile E, Tesorio T, Esposito G.
The Modern Approach to Endovascular Carotid Revascularisation.
EuroIntervention 2016;12:e538–40

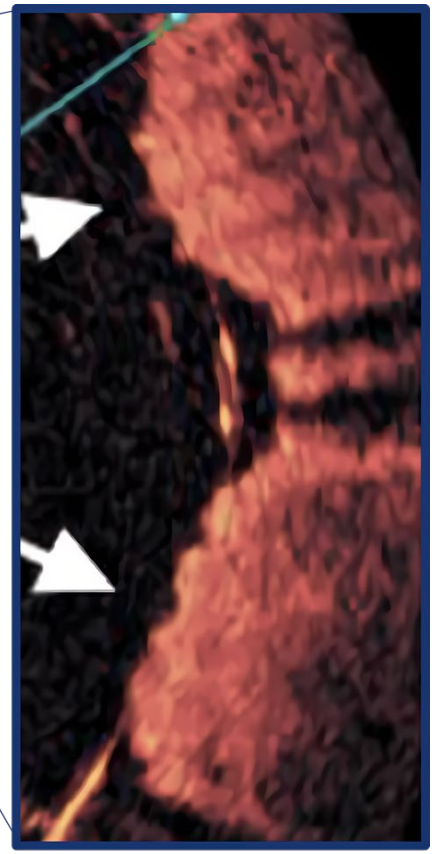
Case reports courtesy of Dr. Gianmarco de Donato,
Department of Medicine Surgery and Neuroscience
Universita degli studi di Siena, Italy

Image(s) courtesy of Dr. Setacci,
Run 5&6 pt#17

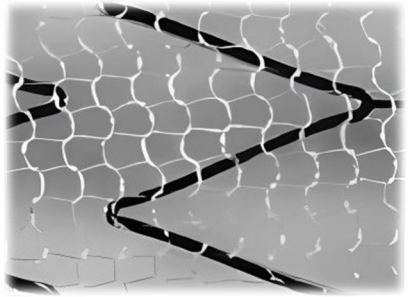
Plaque Prolapse Retained by Micronet™



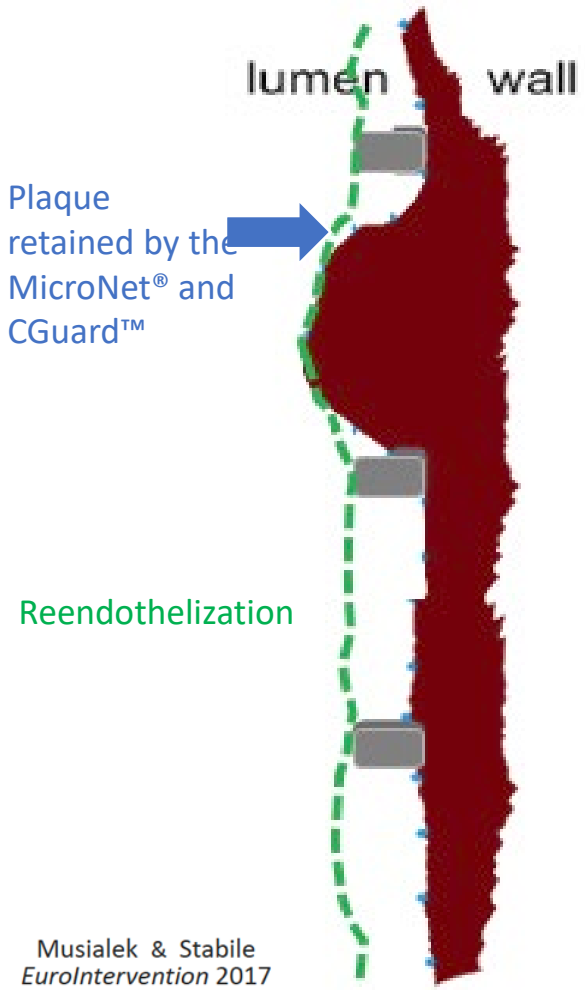




Tomyuki Umemoto et al.
EuroIntervention 2017

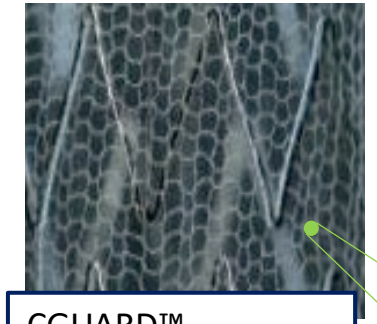



Residual plaque prolapse with novel dual-layer carotid stents: is it mesh-covered or not?



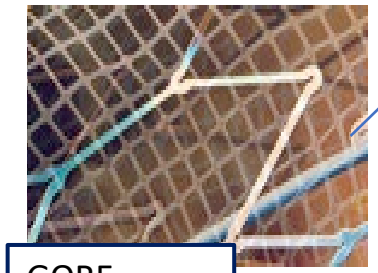
Musialek & Stabile
EuroIntervention 2017

Pore Size



CGUARD™

TERUMO



GORE

65µ 375µ 500µ 1050µ 1900µ

Closed cell stent

Open cell stent

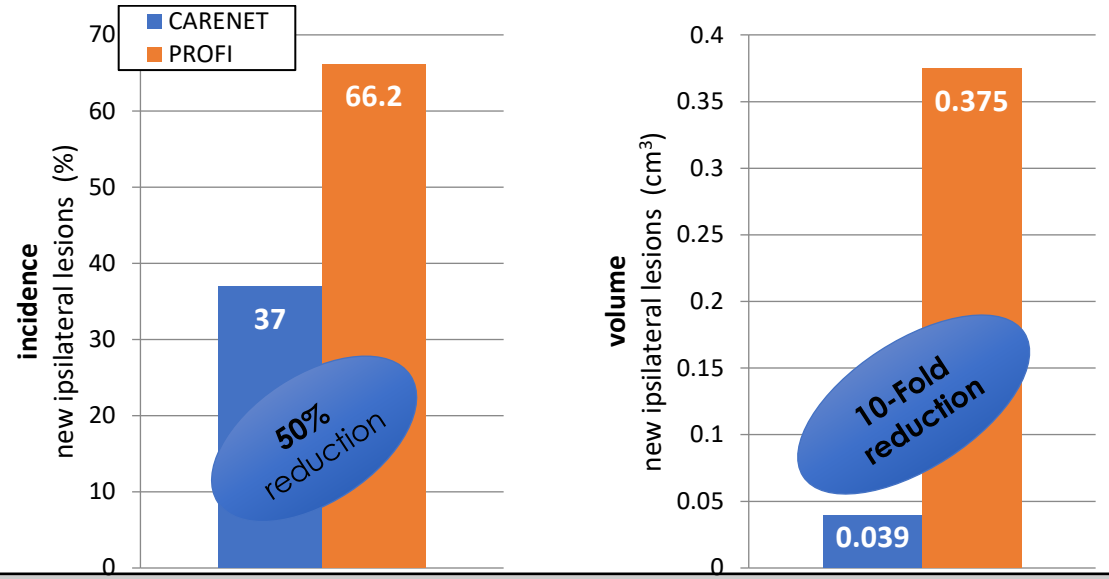
* Averag

CARENET

DW-MRI Analysis

Bijuklic et al. *JACC*, 2012;59

DW-MRI analysis @ 48 hours, n=27*	



Incidence of new ipsilateral lesions at 48 hours was reduced by almost half compared to published data, and volume was reduced almost 10-fold.

All but one lesion had resolved completely by 30 days.

DW-MRI analysis @ 30 days, n=25**	
Incidence of new ipsilateral lesions	4.0%
Average lesion volume (cm^3)	0.08 ± 0.00
Permanent lesions at 30 days	1

1 year Outcomes of the C-GUARDIANS Pivotal IDE Trial of the C-GUARD MicroNet Stent

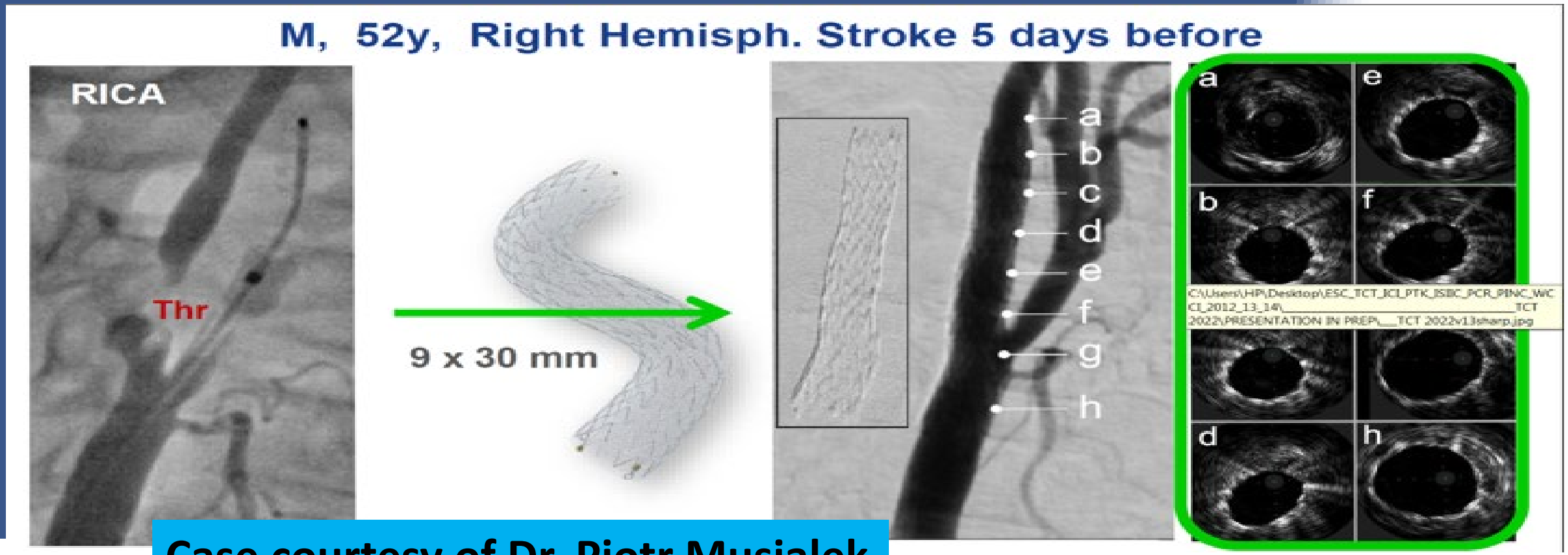
D. Chris Metzger, MD

OhioHealth Riverside Methodist Hospital

Columbus, Ohio, USA

On Behalf of the C-GUARDIANS Investigators

The CGuard Stent Combines the Conformability of Open Cell Design with the High Plaque Coverage of MicroNet™



Case courtesy of Dr. Piotr Musialek

dural Angio

IVUS

Designed to minimize plaque protrusion *during and after* the procedure

Clinical Data Supporting CGuard *Peri-procedural* Safety

CGuard commercially available in Europe since 2015 (CE Mark)

Study	Year	N	DS 30-day % (n)	DSMI 30-day % (n)
CARENET	2015	30	0.0% (0)	0.0% (0)
PARADIGM	2016	101	0.0% (0)	0.0% (0)
CASANA	2017	82	1.22% (1)	1.22% (1)
WISSGOTT I	2017	30	0.0% (0)	0.0% (0)
IRONGUARD I	2018	200	2.50% (5)	2.50% (5)
WISSGOTT II	2019	30	0.0% (0)	0.0% (0)
IRONGUARD 2	2020	733	0.05% (4)	1.09% (8)
GREEK Study	2021	103	0.0% (0)	0.0% (0)
SIBERIA	2021	50	0.0% (0)	0.0% (0)
TOTAL		***1359***	***0.80% (11)***	***1.03% (14)***

1. Schofer, J. et al. JACC Cardiovasc. Interv. 2015.
2. Casana, R. et al. Eur. J. Vasc. Endovasc. 2017.
3. Musialek, P. et al. Interv. Cardiol. 2016
4. Wissgott, C. et al. Int. Soc. Endovasc. Spec. 2017
5. Speziale, F. et al. EuroIntervention 2018
6. Wissgott, C. et al. J Endovasc Ther. 2019
7. Sirignano, P et al. Cardiovascular Interventions 2020
8. Tigkiropoulos, K. et al. Journal of EndoTherapy 2021
9. Karpenko, A. et al JACC Cardiovasc. Interv. 2021

1359

0.80%

1.03%

C-GUARDIANS Trial Design

Design

Prospective, multicenter, international, single-arm clinical trial comparing the primary endpoint to a performance goal derived from literature

Trial Objective

Evaluate the safety and efficacy of the CGuard Prime™ Carotid Stent System in the treatment of carotid artery stenosis in symptomatic and asymptomatic patients ***at high risk for CEA*** undergoing carotid artery stenting (CAS)

Principal Investigators

Dr. Chris Metzger, MD
OhioHealth Riverside Methodist Hospital. Columbus, Ohio, USA

Dr. Piotr Musialek, MD, PhD
Jagiellonian University, John Paul II Hospital, Kraków, Poland

Sample Size & Population

316 subjects

24 US and EU sites

Symptomatic with ≥ 50% stenosis or asymptomatic with ≥ 80% stenosis

≤ 80 years of age at high risk for CEA
Pre-specified 25% symptomatic

Primary Endpoint

Incidence of death (all-cause mortality), all stroke, and myocardial infarction (DSMI) through 30-days post-index procedure or Ipsilateral stroke from 31 to 365 days

UBNS Neurosurgery University at Buffalo

Buffalo General Medical Center
Gates Vascular Institute
A Kaleida Health Facility

Canon Stroke & Vascular Research Center
University at Buffalo

Jacobs School of Medicine and Biomedical Sciences
University at Buffalo

Jacobs Institute

C-GUARDIANS: Other Trial Features

Secondary Endpoints	• Technical success and treatment success • Death, stroke, minor stroke, major stroke, MI through 30-day • Ipsilateral stroke through 30 days, 1-, 2-, 3-year follow-up • TLR through 1-, 2-, 3-year follow-up
Embolic Protection	Distal EPD (NAV6), Proximal Protection (MoMA), or both
Medications	DAPT required for 30-days post-procedure
Trial Conduct	• Physician screening committee • Independent CEC for MAE adjudication • Independent DSMB • Independent CoreLab by Syntropic

Patient Demographics

Characteristic	ITT (N=316)
Age (mean SD)	69.0 ± 6.6
% Symptomatic	24.3%
% Male	63.9%
Diabetes Mellitus	41.8%
Hypertension	92.6%
Dyslipidemia	90.0%
CAD	52.1%
COPD	23.8%
Current Smoker	26.4%
PVD	28.6%

Lesions Characteristics

Characteristic	ITT (N=316)
Stenosis	
Pre-procedure	89.9%
Post-procedure	7.3%
Calcification	
None/mild	64.8%
Moderate	20.3%
Severe	14.8%
Lesion length (mm)	18.7

Core lab adjudicated

Procedural Data

Characteristic	ITT (N=316)
Pre-dilatation	93.0%
Post-dilatation	96.8%
Embolic protection utilized	
Emboshield NAV 6	261
MoMA	78
Both (Nav6 and MoMA)	24
Other EPD	1

C-GUARDIANS: 30-Day Major Adverse Events (LBCT VIVA 2023)

Event rate in % (n)	ITT (N=316)	Per Protocol^
Death, Stroke or MI*	0.95% (3)	0.63% (2)
Death#	0.32% (1)	0.00% (0)
Any stroke#	0.95% (3)	0.63% (2)
Major Stroke#	0.63% (1)	0.32% (1)
Minor Stroke#	0.32% (2)	0.32% (1)
MI#	0.00% (0)	0.00% (0)
Death or any stroke*	0.95% (3)	0.63% (2)
Death or major stroke*	0.63% (2)	0.32% (1)

30-day S/D/MI

** Hierarchical: patient count (each patient first occurrence of the most serious event). # Non-hierarchical: event count (multiple events in each patient are counted individually).*

^ Per Protocol Analysis excludes 1 patient (did not take dual antiplatelet therapy; had a major stroke and died).

The CEC independently adjudicated all neurological, cardiac events:

- 1 major fatal stroke on post procedural day 10 after all DAPT stopped contrary to protocol requirements.
- 1 minor stroke. (NIHSS 2, post procedure). NIHSS 1, CDU patent 30 days, NIHSS 0 at 6 and 12 months
- 1 retinal infarct in a patient presenting with amaurosis fugax, adjudicated as a minor stroke. (NIHSS 1). NIHSS 0, CDU patent 30 days

C-GUARDIANS Trial 1-Year Primary Endpoint Results

Event*	ITT	Per Protocol**
30-day DSMI + Ipsilateral stroke between 31 and 365 days	1.95 % (6)	1.70% (5)
30-day DSMI	0.95% (3)	0.63% (2)
Ipsilateral stroke between 31 and 365 days	1.00% (3)	1.04% (3)
TLR	0.98% (3)	1.01% (3)

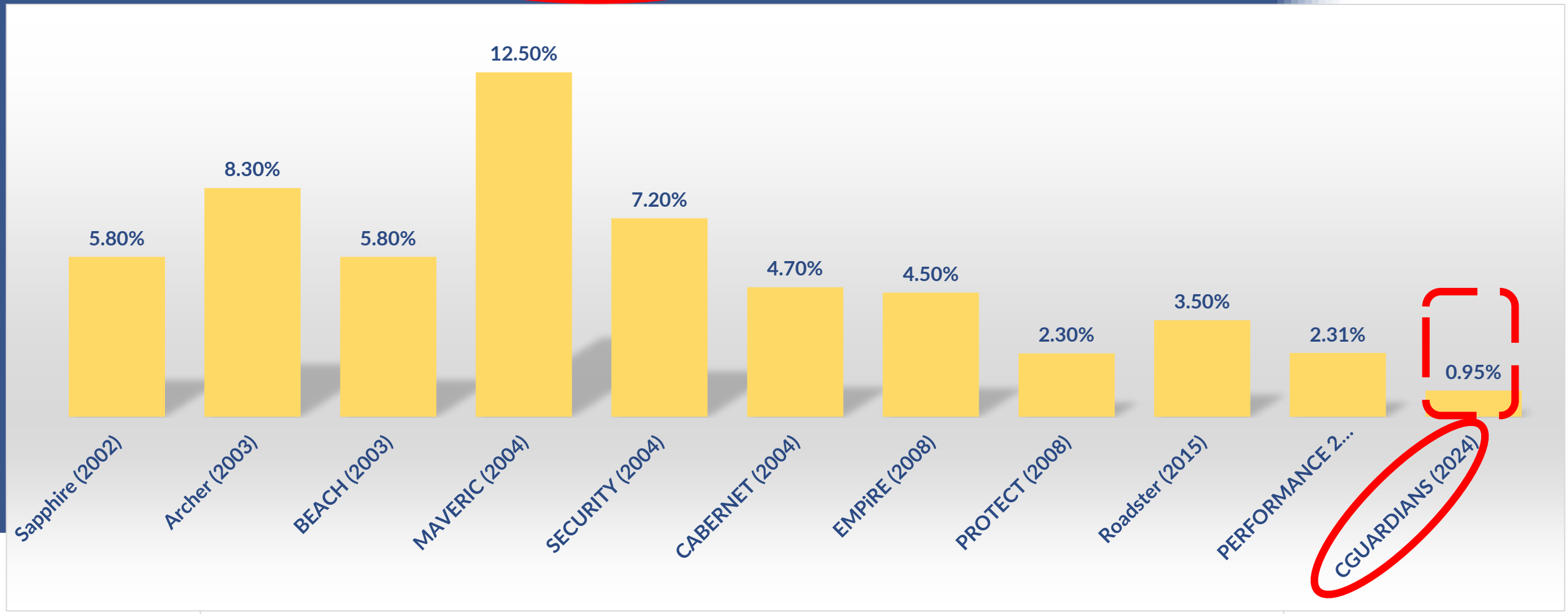
** Kaplan-Meier estimate for all 1-year endpoints*

*** Per Protocol Analysis excludes 15 patients with Major Protocol Deviations*

The CEC independently adjudicated all neurological, cardiac events:

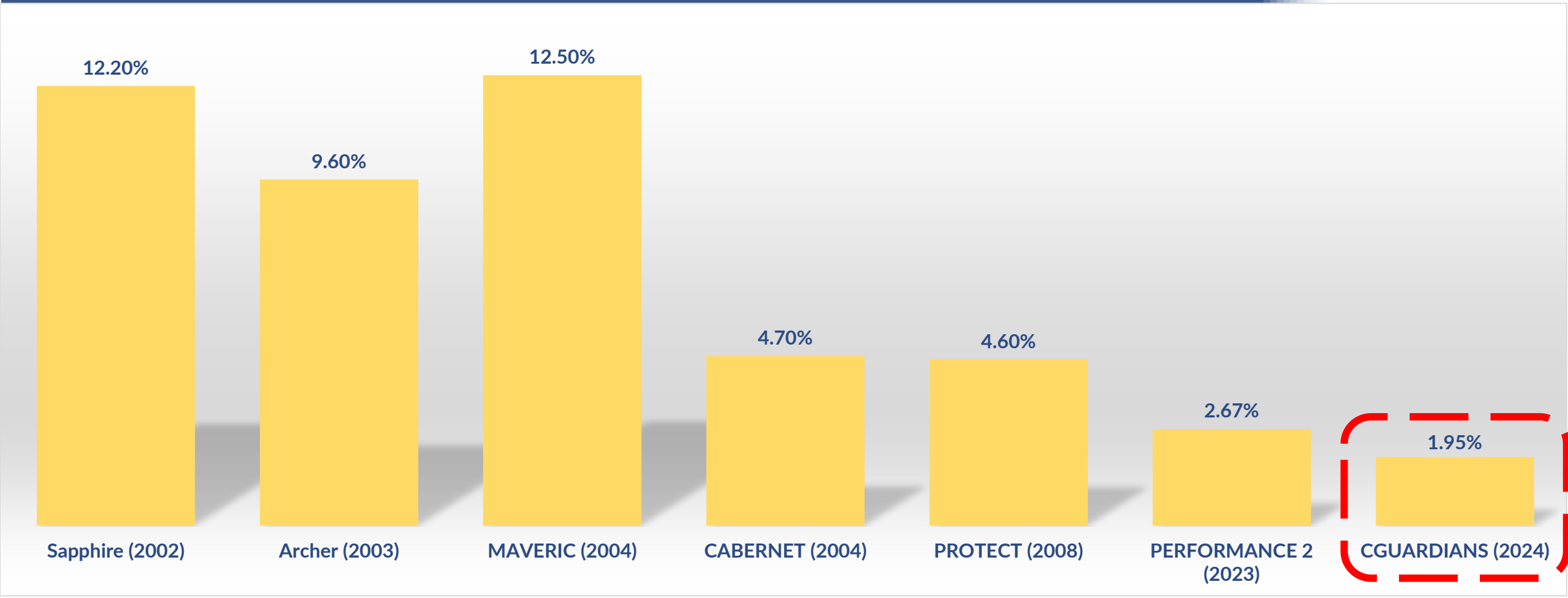
- *1 minor stroke (retinal) on POD 189.*
- *1 major stroke on POD 280: Prostatectomy (Antiplatelet therapy stopped).*
- *1 major stroke on POD 307: Stent patent; A Fib discovered.*

C-GUARDIANS: 30-Day DSMI in Context of CAS, TCAR Trials



C-GUARDIANS: 1-Year Outcomes in Context

(D/S/MI @ 30 days and ipsilateral stroke to 1 year)



Summary of C-GUARDIANS 1 Year Outcomes

- **30-Day Outcomes**
  * DSMI: **ITT 0.95%, PP 0.63%**
  * No MI, No contralateral stroke

- **1-Year Outcomes**

  Follow up compliance rate at 1-year: 97%

  30-day DSMI or ipsilateral stroke between 31 and 365 days:
  * **ITT 1.95%, PP 1.7%**
  * **TLR (any target revascularization up to 365 days): 1% (3)**

Conclusions

- The C-GUARDIANS Pivotal IDE results demonstrate extremely low event rates for 30 – day stroke/death/MI (0.95%) and 1 -year S/D/MI at 30 dates plus ipsilateral strokes (1.95%), representing the lowest event rates in published trials of CAS, TCAR, and CEA
- These data are consistent with previously published European data
- These results appear to confirm the proposed “neuro-protective” benefits of this stent design.
- The results support consideration of CAS with this stent as a front-line therapeutic option for appropriate patients being considered for carotid revascularization

Tandem Stroke

MR CLEAN

ASPECTS — median (interquartile range)¶	9 (7–10)	9 (8–10)
Intracranial arterial occlusion — no./total no. (%)‖		
Intracranial ICA	1/233 (0.4)	3/266 (1.1)
ICA with involvement of the M1 middle cerebral artery segment	59/233 (25.3)	75/266 (28.2)
M1 middle cerebral artery segment	154/233 (66.1)	165/266 (62.0)
M2 middle cerebral artery segment	18/233 (7.7)	21/266 (7.9)
A1 or A2 anterior cerebral artery segment	1/233 (0.4)	2/266 (0.8)
Extracranial ICA occlusion — no./total no. (%)‖**	75/233 (32.2)	70/266 (26.3)

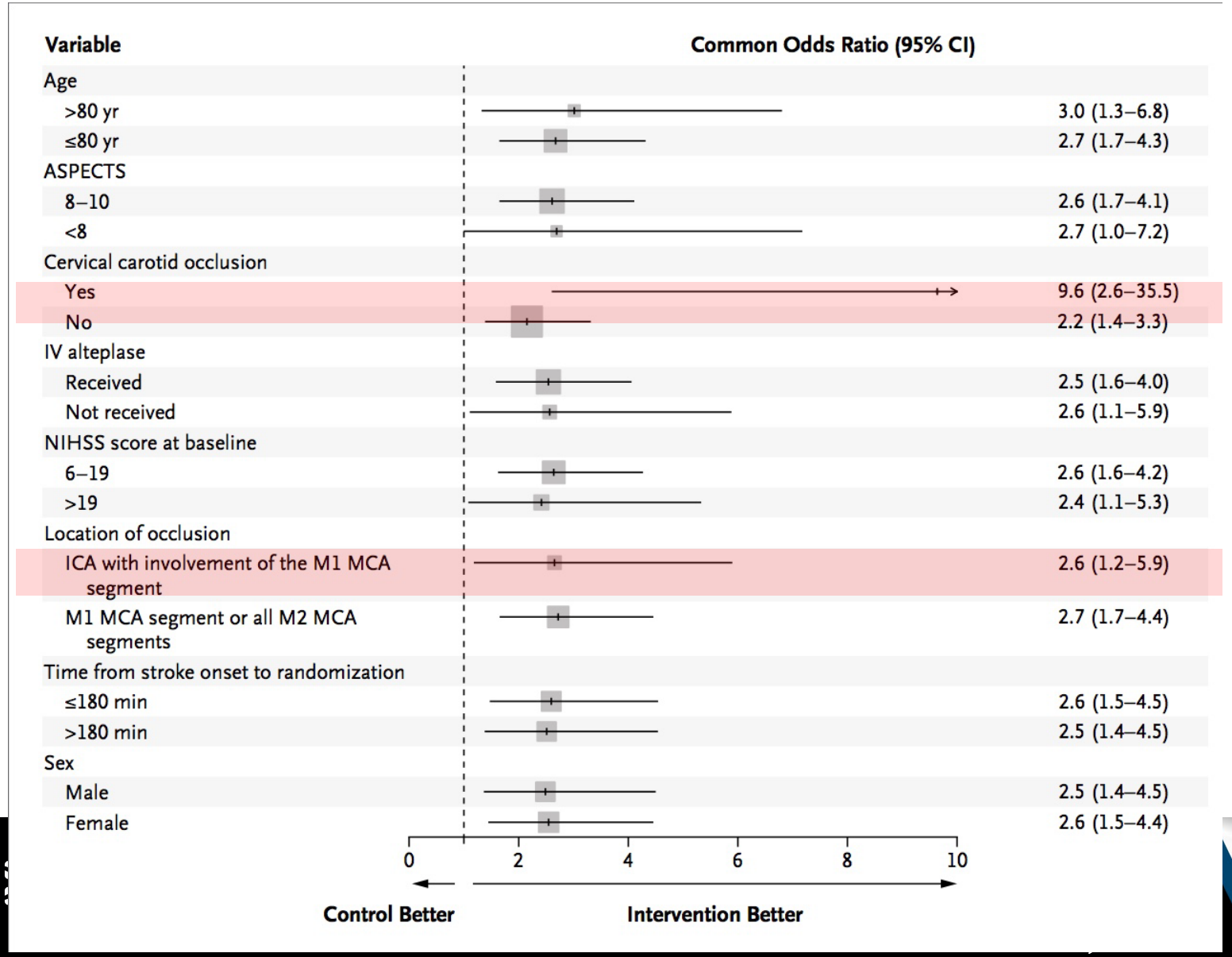
ESCAPE

Imaging characteristics		
ASPECTS on CT — median (interquartile range)¶	9 (8–10)	9 (8–10)
Location of occlusion on CTA — no./total no. (%)‖		
ICA with involvement of the M1 middle-cerebral-artery segment	45/163 (27.6)	39/147 (26.5)
M1 or all M2 middle-cerebral-artery segments	111/163 (68.1)	105/147 (71.4)
Single M2 middle-cerebral-artery segment	6/163 (3.7)	3/147 (2.0)
Ipsilateral cervical carotid occlusion — no. (%)	21 (12.7)	19 (12.7)

REVASCAT

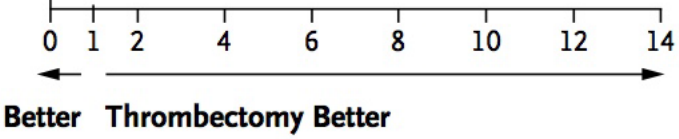
Imaging characteristics		
Median ASPECTS value (IQR)§	7.0 (6.0–9.0)	8.0 (6.0–9.0)
Location of intracranial occlusion on CTA or MRA — no./total no. (%)¶		
Intracranial internal carotid artery without involvement of M1	0	1/101 (1.0)
Terminal internal carotid artery with involvement of M1	26/102 (25.5)	27/101 (26.7)
M1	66/102 (64.7)	65/101 (64.4)
Single M2	10/102 (9.8)	8/101 (7.9)
Ipsilateral cervical carotid occlusion — no. (%)‖	19/102 (18.6)	13/101 (12.9)

ESCAPE


Variable
Common Odds Ratio (95% CI)
Age
>80 yr
3.0 (1.3–6.8)
≤80 yr
2.7 (1.7–4.3)
ASPECTS
8–10
2.6 (1.7–4.1)
<8
2.7 (1.0–7.2)
Cervical carotid occlusion
Yes
9.6 (2.6–35.5)
No
2.2 (1.4–3.3)
IV alteplase
Received
2.5 (1.6–4.0)
Not received
2.6 (1.1–5.9)
NIHSS score at baseline
6–19
2.6 (1.6–4.2)
>19
2.4 (1.1–5.3)
Location of occlusion
ICA with involvement of the M1 MCA segment
2.6 (1.2–5.9)
M1 MCA segment or all M2 MCA segments
2.7 (1.7–4.4)
Time from stroke onset to randomization
≤180 min
2.6 (1.5–4.5)
>180 min
2.5 (1.4–4.5)
Sex
Male
2.5 (1.4–4.5)
Female
2.6 (1.5–4.4)
0
2
4
6
8
10
Control Better
Intervention Better

REVASCAT

Subgroup	No. of Patients	Odds Ratio (95% CI)	P Value for Interaction
Age			0.19
<70 yr	121	2.5 (1.3–4.6)	
≥70 yr	85	0.9 (0.4–2.0)	
Baseline NIHSS			0.34
6–16	92	1.5 (0.7–3.1)	
≥17	114	2.0 (1.0–4.0)	
Site of occlusion			0.82
Intracranial ICA	26		
M1	135	1.2 (0.7–2.2)	
Both cervical ICA and TICA or M1 occlusion	45	4.3 (1.5–12.5)	
Time to randomization			0.09
≤4.5 hr	135	1.8 (1.0–3.4)	
>4.5 hr	71	1.4 (0.6–3.3)	
Alteplase			0.75
Yes	150	1.4 (0.8–2.6)	
No	56	2.7 (1.0–7.1)	
ASPECTS score			0.76
<8	101	1.4 (0.7–2.9)	
≥8	105	2.2 (1.1–4.4)	



HERMES

	n	cOR (95% CI)
Age (years) ($p_{interaction}$ = 0·07)		
18–49	158	1·36 (0·75–2·46)
50–59	218	2·85 (1·72–4·72)
60–69	333	2·58 (1·49–4·48)
70–79	371	2·41 (1·55–3·74)
18–79	1080	2·44 (1·70–3·50)
≥80	198	3·68 (1·95–6·92)
ASPECTS ($p_{interaction}$ = 0·29)		
0–5	121	1·24 (0·62–2·49)
6–8	475	2·34 (1·68–3·26)
9–10	682	2·66 (1·61–4·40)
Alteplase ($p_{interaction}$ = 0·43)		
Yes	1090	2·45 (1·68–3·57)
No	188	2·43 (1·30–4·55)
Stroke location ($p_{interaction}$ = 0·17)		
ICA	274	3·96 (1·65–9·48)
M1	887	2·29 (1·73–3·04)
M2	94	1·28 (0·51–3·21)
NIHSS score ($p_{interaction}$ = 0·45)		
≤10	177	1·67 (0·80–3·50)
11–15	307	2·68 (1·39–5·19)
16–20	473	2·81 (1·80–4·38)
≥21	321	2·52 (1·40–4·54)
Onset to randomisation ($p_{interaction}$ = 0·10)		
≤300 min	1070	2·66 (1·83–3·87)
>300 min	208	1·76 (1·05–2·97)
Sex ($p_{interaction}$ = 0·34)		
Male	676	2·54 (1·92–3·36)
Female	601	2·38 (1·46–3·88)
Tandem lesion ($p_{interaction}$ = 0·17)		
Yes	122	2·95 (1·38–6·32)
No	1132	2·35 (1·68–3·28)
Total	**1278**	**2·49 (1·76–3·53)**

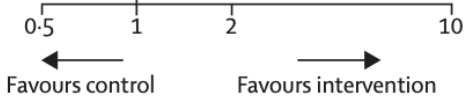


***Figure 2*: Forest plot showing adjusted treatment effect for mRS at 90 days in prespecified subgroups with p values for heterogeneity across subgroups**

- MR CLEAN
  - 75/145 tandem lesions underwent thrombectomy
  - 30 patients underwent CAS
- REVASCAT
  - 9/103 underwent CAS
- HERMES
  - 122 patients with TO
  - Intervention significantly improved outcomes

Several studies have shown worse presentation and outcomes for Tandem stroke patients vs. isolated intracranial occlusion

frontiers in Neurology

Endovascular Treatment of Atherosclerotic Tandem Occlusions in Anterior Circulation Stroke: Technical Aspects and Complications Compared to Isolated Intracranial Occlusions

Journal of NeuroInterventional Surgery

Ischemic stroke
Original research

Acute ischemic stroke with tandem lesions: technical endovascular management and clinical outcomes from the ESCAPE trial

Lower final TICI score in Tandem group

	Tandem intracranial-extracranial occlusions ($N = 121$)	Isolated intracranial occlusions ($N = 456$)	P
BASELINE			
Age (years)	72 (61–79)	70 (63–78)	0.544
Sex, female	25.6% (31/121)	50.4% (230/456)	<0.001
Admission NIHSS	17 (IQR 12–20)	16 (IQR 13–21)	0.474
IVT	52.1% (63/121)	53.9% (246/456)	0.759
Intracranial occlusion site			0.003
- M1	67.8% (82/121)	80.9% (369/456)	
- ICA	32.2% (39/121)	19.1% (87/456)	
Symptom-onset to groin puncture (mins)	262 (IQR 194–356)	241 (IQR 190–315)	0.093
Atrial fibrillation	30.0% (36/120)	45.2% (192/425)	0.003
Diabetes	20.7% (25/121)	13.6% (62/455)	0.063
Arterial hypertension	62.8% (76/121)	65.2% (296/454)	0.669
Dyslipidemia	51.3% (61/119)	45.9% (208/453)	0.304
Smoking	45.8% (54/118)	24.2% (102/421)	<0.001
INTERVENTIONAL			
Procedure time	57 (IQR 87–115)	33 (IQR 49–89)	<0.001
Number of maneuvers	1 (IQR 1–3)	1 (IQR 1–3)	0.495
Final TICI 2b/3	70.2% (85/121)	83.6% (381/456)	0.002
Complications			0.122
- None	- 89.3% (108/121)	- 93.2% (425/456)	
- Dissection	- 7.4% (9/121)	- 5.7% (26/456)	
- Perforation	- 2.5% (3/121)	- 0.4% (2/456)	
- Other	- 0.8% (1/121)	- 0.7% (3/456)	
Infarct in previously unaffected territories	7.4% (9/121)	8.6% (39/456)	0.853
OUTCOME			
sICH	10.7% (13/121)	6.9% (31/452)	0.177
aICH	29.8% (36/121)	17.09% (77/452)	0.003
90-day mRS	3 (IQR 1–4)	3 (IQR 1–4)	0.142
90-day mRS ≤ 2	42.4% (50/118)	49.6% (212/427)	0.177
90-day mortality	19.5% (23/118)	15.7% (67/427)	0.329

Largest series from the German Stroke Registry

Stroke
Volume 52, Issue 4, April 2021; Pages 1265-1275
https://doi.org/10.1161/STROKEAHA.120.031797

American Heart Association.

CLINICAL AND POPULATION SCIENCES

Tandem Lesions in Anterior Circulation Stroke

Analysis of the German Stroke Registry–Endovascular Treatment

Tandem lesions Anterior circulation
(06/2015-12/2019)
GSR-ET

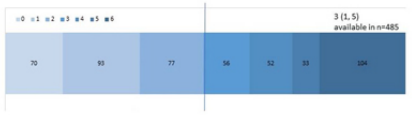
n=874 out of 6635

69.0.1±12.2 years,
33.6% female
pmRS 0 (0, 1)*
NIHSS 15 (10, 18)*

Internal carotid artery Acute treatment

n=607 (69.5%)

73.3±13.0 years, 51.8% female
pmRS 0 (0, 1)*
NIHSS 15 (10, 18)*
Outcome



Internal carotid artery No acute treatment

n=188 (21.5%)

71.2±12.8 years, 39.9% female
pmRS 0 (0, 1)*
NIHSS 15 (11, 18)*
Outcome

Extracranial-first approach

n=267 (44.0%)

69.3±11.9 years, 31.1% female
pmRS 0 (0, 0)*
NIHSS 14 (9, 18)*
Outcome

Intracranial-first approach

n=226 (37.4%)

67.5±11.2 years, 28.2% female
pmRS 0 (0, 0)*
NIHSS 14 (10, 18)*
Outcome

Conclusion:
In tandem lesions in the anterior circulation, acute treatment of the extracranial ICA-lesion is associated with better clinical outcome and lower mortality. The intracranial-first approach might provide advantages.

Table 3. Logistic Regression for Successful Reperfusion (mTICI2b-3) (Table view)

	OR	95% CI	*P* value
Age	0.980	0.962–0.999	0.035
Sex	0.895	0.579–10.384	0.618
pmRS	10.042	0.844–10.286	0.705
NIHSS at admission	0.988	0.956–10.022	0.494
IVT treatment	10.576	10.039–20.393	0.033
Acute extracranial ICA treatment	40.629	30.035–70.060	0.000

Significantly better outcomes with Acute Extracranial Stenting

Stenting for Tandem Occlusions

JAMA Network Open

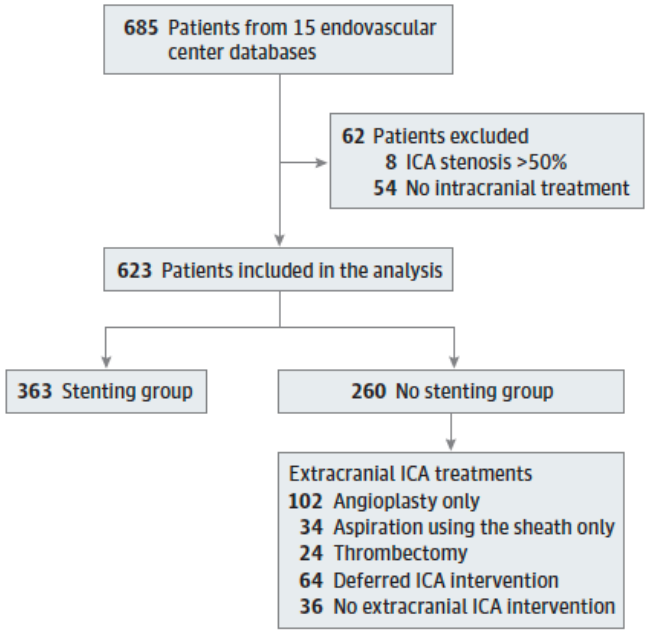
Original Investigation | Neurology

Functional and Safety Outcomes of Carotid Artery Stenting and Mechanical Thrombectomy for Large Vessel Occlusion Ischemic Stroke With Tandem Lesions

Mudassir Farooqui, MD, MPH; Osama O. Zaidat, MD, MS; Ameer E. Hassan, DO; Darko Quispe-Orozco, MD; Nils Petersen, MD; Afshin A. Divani, PhD; Marc Ribo, MD, PhD; Michael Abraham, MD; Johanna Fifi, MD; Waldo R. Guerrero, MD; Amer M. Malik, MD, MBA; James E. Siegler, MD; Thanh N. Nguyen, MD; Sunil Sheth, MD; Albert J. Yoo, MD, PhD; Guillermo Linares, MD; Nazli Janjua, MD; Milagros Galecio-Castillo, MD; Wondewossen G. Tekle, MD; Victor M. Ringheanu, BA; Marion Oliver, MD; Giana Dawod, MD; Jessica Kobsa, BA; Ayush Prasad, BA; Asad Ikram, MD; Eugene Lin, MD; Kristine Below, BA; Cynthia B. Zevallos, MD; Marta Olivé Gadea, MD; Abid Qureshi, MD; Andres Dajles, MS; Stavros Matsoukas, MD; Ameena Rana, MD; Mohamad Abdalkader, MD; Sergio Salazar-Marioni, MD; Jazba Soomro, MD; Weston Gordon, MD; Juan Vivanco-Suarez, MD; Charoskhon Turabova, MD; Maxim Mokin, MD; Dileep R. Yavagal, MD; Mouhammad A. Jumaa, MD; Santiago Ortega-Gutierrez, MD, MSc

- Retrospective, observational registry from 17 hospitals (16 US, 1 Spain) from 2015-2020
- All received EVT
- 2 groups: CAS and no CAS
- Primary outcomes: 90d mRS 0-2 and symptomatic ICH

Stenting for Tandem Occlusions



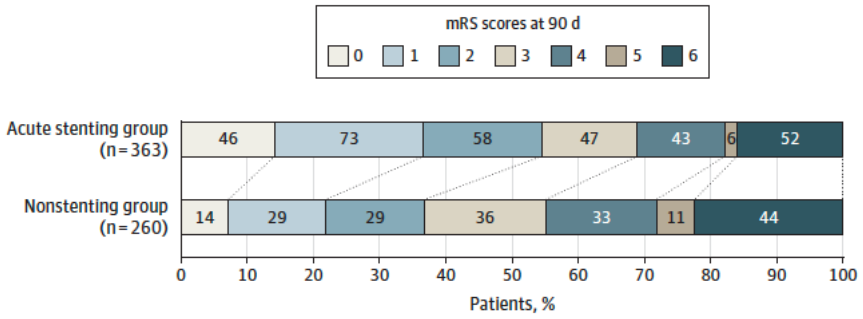


Table 1. Baseline and Procedural Characteristics and Stroke Time Metrics Among Patients With Carotid Artery Stenting and Nonstenting[a] (continued)

Characteristic	Total (N = 623)	Carotid artery stenting group (n = 363)	Nonstenting group (n = 260)	*P* value
Time metrics, median (IQR), min				
Time from LKW to arterial puncture (n = 588)	351 (215-706)	350 (213-749)	352 (219-637)	.52
Door to arterial puncture (n = 605)	65 (28-109)	65 (31-109)	65 (26-109)	.89
Arterial puncture to reperfusion (n = 599)	56 (37-87)	58 (38-88)	54 (33-87)	.14

Table 2. Clinical and Radiographic Outcomes Among Patients With Carotid Artery Stenting and Nonstenting Groups

Outcome	Sample size	No. (%) of patients			Unadjusted		Adjusted	
		Total	Carotid artery stenting group	Nonstenting group	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Primary outcomes								
90-d mRS score 0-2[a]	554	249 (47.8)	177 (54.5)	72 (36.7)	1.96 (1.39-2.77)	<.001	1.67 (1.2-2.4)	.007
Symptomatic ICH[b]	538	28 (5.2)	18 (5.5)	10 (4.8)	1.02 (0.5-2.1)	.96	0.9 (0.46-1.94)	.87
Secondary outcomes								
mTICI score ≥2b[c]	548	477 (86.7)	306 (90.5)	171 (80.7)	2.3 (1.4-3.7)	.001	1.7 (1.02-3.6)	.002
Discharge mRS score 0-2[d]	443	114 (25.7)	74 (28.9)	40 (21.4)	1.6 (1.08-2.28)	.02	1.2 (0.8-1.8)	.41
Mortality at 90 d[e]	521	99 (18.4)	52 (16.0)	44 (22.4)	0.64 (0.42-0.97)	.03	0.78 (0.5-1.2)	.27
Periprocedural hemodynamic impairment[f]	NA	56 (15.4)	43 (11.8)	13 (5.0)	NA	.01	NA	NA
Intracranial and extracranial complications at time of treatment[g]	NA	34 (6.2)	18 (6.1)	13 (6.4)	NA	.92	NA	NA

Antero- vs Retrograde Stenting

Anterograde

- Address the primary/causative lesion
- Prevent distal emboli
- Improve collateral restoration

Retrograde

- Shorter angiographic times
- ??? Better outcomes in short series

Antero- vs Retrograde Stenting

Neurosurg Focus, 2017

Management of acute ischemic stroke due to tandem occlusion: should endovascular recanalization of the extracranial or intracranial occlusive lesion be done first?

Leonardo Rangel-Castilla, MD,[1,5,6] Gary B. Rajah, MD,[6] Hakeem J. Shakir, MD,[1,5] Hussain Shallwani, MD,[1,5] Sirin Gandhi, MD,[4,5] Jason M. Davies, MD, PhD,[1,2,5] Kenneth V. Snyder, MD, PhD,[1,4,5,7] Elad I. Levy, MD, MBA,[1,3,5,7] and Adnan H. Siddiqui, MD, PhD,[1,3,5,7,8]

Departments of [1]Neurosurgery, [2]Biomedical Informatics, [3]Radiology, and [4]Neurology, Jacobs School of Medicine and Biomedical Sciences, and [7]Toshiba Stroke and Vascular Research Center, University at Buffalo, State University of New York; [5]Department of Neurosurgery, Gates Vascular Institute at Kaleida Health; [8]Jacobs Institute, Buffalo, New York; and [6]Department of Neurosurgery, Wayne State School of Medicine, Wayne State University, Detroit, Michigan

Noted that proximal stenting followed by distal thrombectomy compares favorably to other series in terms of outcomes and angiographic times

Antero- vs Retrograde Stenting

JNIS, 2018

Ischemic Stroke

REVIEW

Management of tandem occlusions in acute ischemic stroke – intracranial versus extracranial first and extracranial stenting versus angioplasty alone: a systematic review and meta-analysis

Mitchell P Wilson,[1] Mohammad H Murad,[2] Timo Krings,[3] Vitor M Pereira,[3] Cian O'Kelly,[4] Jeremy Rempel,[1] Christopher A Hilditch,[3] Waleed Brinjikji[3,5]

findings persist in larger pooled analysis. Our meta-analysis does demonstrate a slight trend toward an improved safety profile with an extracranial first approach including a 90-day mortality rate (8% [95% CI 3% to 15%] vs 15% [95% CI 3% to 32%]) and procedure-related complications (8% (1–20%)%] vs 20% (9–39%)%]), though these differences were not significant and

Balloon Guide for Carotid Stenting

Justin M. Cappuzzo, MD [‡§*]
Andre Monteiro, MD[‡§*]
Muhammad Waqas, MBBS[‡§]
Ammad A. Baig, MD[‡§]
Daniel O. Popoola, PhD[‖]
Faisal Almayman, MD[‡§]
Wasiq I. Khawar, BA[‡]
Zoe G. Farkash[§]
Jason M. Davies, MD, PhD[‡§¶#**]
Adnan H. Siddiqui, MD, PhD[‡§#**††]
Elad I. Levy, MD, MBA [‡§#**††]
Kenneth V. Snyder, MD, PhD[‡§#**]

CASE SERIES

Carotid Artery Stenting Using the Walrus Balloon Guide Catheter With Flow Reversal for Proximal Embolic Protection: Technical Description and Single-Center Case Series

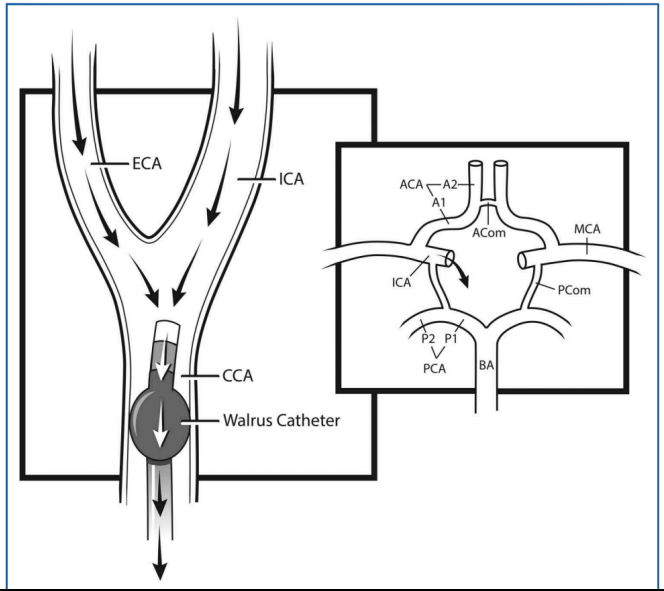


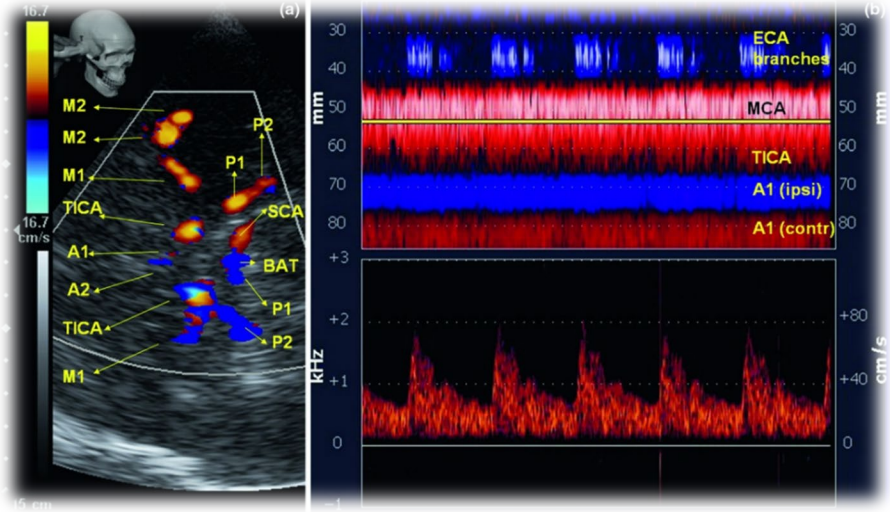
TABLE. Baseline Clinical and Procedural Characteristics

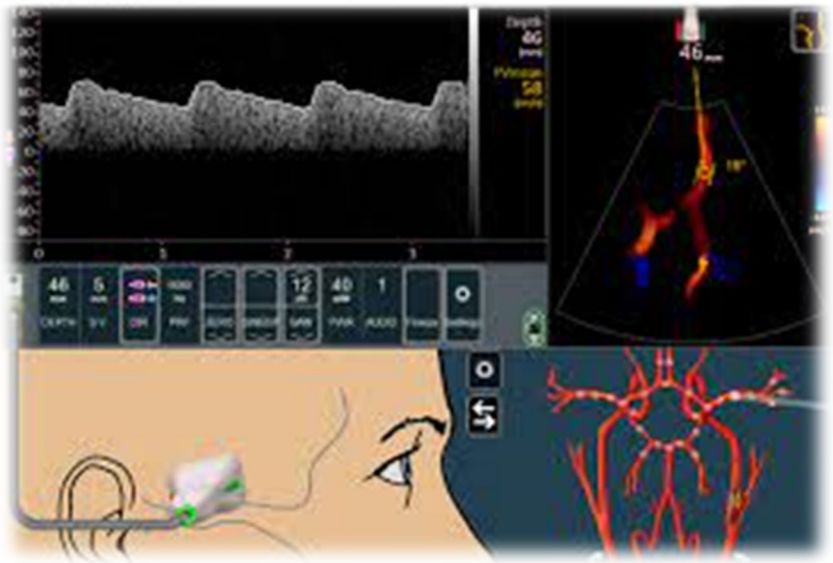
Variable	Value (N=105)[a]
Age, y; mean (SD)	69.8 (9.4)
Women	36 (34.3)
Comorbidities	
Hypertension	60 (57.1)
Diabetes	38 (36.2)
Hyperlipidemia	80 (76.2)
Atrial fibrillation	19 (18.1)
Smoking status	
Active smoker	37 (35.2)
Former smoker	28 (26.7)
Never a smoker	41 (39)
Reason for stenting	
High anatomic location of plaque	68 (64.8)
Previous neck surgery or radiation	16 (15.2)
High surgical risk	37 (35.2)
Symptomatic patients	59 (56.2)
Stenosis severity, %	
≥70	99 (94.3)
50-69	6 (5.7)
<50	1 (1)
Contralateral stenosis ≥50%	44 (41.9)
Anesthesia	
Moderate sedation	103 (98.1)
General anesthesia	2 (1.9)
Angioplasty	
Prestenting	44 (41.9)
Poststenting	37 (35.2)
Prestenting and poststenting	4 (3.8)
Not performed	20 (19.1)
Distal embolic protection device	90 (85.7)
Periprocedural complications	
Access site hematoma	2 (1.9)
Vasospasm	3 (2.8)
Stroke at 30 d[b]	2 (1.9)
Mortality at 30 d[b]	1 (1)

UBNS Neurosurgery UNIVERSITY AT BUFFALO
Buffalo General Medical Center
Gates Vascular Institute
A Kaleida Health Facility
CANON STROKE & VASCULAR RESEARCH CENTER UNIVERSITY AT BUFFALO
Jacobs School of and Biomedical University at Buffalo

Transcranial Doppler Ultrasound - Background

Detects motion using the difference in frequency between emitted ultrasonic waves and the returning echoes





Flow waveform demonstrates peak systolic and end diastolic velocities

Robotic Transcranial Doppler Study

- Balloon Guide Catheter used in all for flow arrest/reversal
- Terminal Internal Carotid Artery (TICA) signal plotted
- All cases demonstrated reversal of intracranial flow with BGC inflation and back bleeding through guide

Balloon Guide for Tandem Occlusions

In revision, JNIS

A Propensity Score-Matched Comparative Study of Balloon Guide Catheters versus Conventional Guide Catheters for Concurrent Mechanical Thrombectomy with Carotid Stenting in Tandem Strokes: Comparison of First-pass Effect, Symptomatic Intracranial Hemorrhage, and 90-day Functional Outcomes

Authors

Ammad A Baig MD[1, 2]; Muhammad Waqas MD[1, 2]; Ryan C Turner MD PhD[1, 2]; Cathleen C Kuo BS[3]; Brianna M Donnelly BS[1, 2]; Pui Man Rosalind[*First name*] Lai [*Last name*] MD[1, 2]; Kunal P. Raygor MD[1, 2]; Mehdi Bouslama MD[1, 2]; Jaims Lim MD[1, 2]; Jenna Neumaier BS[3]; Justin M Cappuzzo MD[1,2]; Jason M Davies MD PhD[1,2,4-6]; Kenneth V Snyder MD PhD[1,2,5,6]; Adnan H Siddiqui MD PhD[1,2, 5-7]; Elad I Levy MD MBA[1,2,5-7]

Use of BGC in Tandem Strokes

Total sample size – **125 patients**

MT & CAS with BGC for Tandem Strokes – **85 (40 after PSM)**

MT without BGC for Tandem Strokes – **40 (40 after PSM)**

BGC vs. no BGC for Tandem Stroke

Better 1st Pass Effect w BGC

Lower Discharge NIHSS w BGC

Better 90-day outcome (mRS 0-2) w BGC

	No-BGC	BGC	OR	p-value
First-pass effect (mTICI 2B or 3)	**22 (55.0)**	**27 (67.5)**	**1.15 (1.14, 1.46)**	**0.013**
Final mTICI				
• 0 – 2A	7 (17.5)	7 (17.5)	Reference	
• 2B - 3	33 (82.5)	33 (82.5)	0.85 (0.33, 3.06)	1
Total number of passes (Mean ± SD)	1.7 ± 1.1	1.4 ± 0.8	0.93 (0.83, 1.05)	0.287
Intraoperative Complications				
• Thromboembolism	2 (5.0)	3 (7.5)	1.45 (0.23, 9.29)	0.691
• Dissection	2 (5.0)	1 (2.5)	0.31 (0.07, 4.66)	0.555
• Vasospasm	0 (0.0)	2 (5.0)	1.88 (0.22, 104.96)	0.170
Symptomatic ICH (Type II PH)	5 (12.5)	2 (5.0)	0.37 (0.07, 2.02)	0.235
NIHSS at discharge	**11.0 ± 7.1**	**8.0 ± 6.1**	**0.987 (0.974, 0.999)**	**0.042**
Outcome measure				
• Good outcome (mRS 0-2)	11 (27.5)	21 (52.3)	Reference	
• Poor outcome (mRS 3-6)	**29 (72.5)**	**19 (47.5)**	**0.34 (0.14, 0.87)**	**0.040**
In-hospital mortality	12 (30.0)	7 (17.5)	0.49 (0.17, 1.43)	0.189

BGC group had significantly lower procedure duration (61.5% vs. 77.9% (OR=0.996;P=0.006)), On multivariate regression analysis, BGC group had significantly higher rate of first-pass effect (mTICI 2B-3) (OR=0.660, 95% CI=0.480-0.908;P=0.013), and a lower periprocedural sICH rate (OR=0.615, 95% CI=0.406-0.932;P=0.025). No difference in in-hospital mortality was observed (OR=1.591; 95% CI=0.976-2.593;P=0.067) (Table 3).

Revascularization of tandem left ICA and M1 occlusion

Adnan Siddiqui, MD PhD

Kunal Raygor, MD

Rosalind Lai, MD

UBNS Neurosurgery
UNIVERSITY AT BUFFALO

JACC: CARDIOVASCULAR INTERVENTIONS VOL. 11, NO. 13, 2018

PUBLISHED BY ELSEVIER

Carotid Stenting With Antithrombotic Agents and Intracranial Thrombectomy Leads to the Highest Recanalization Rate in Patients With Acute Stroke With Tandem Lesions

Panagiotis Papanagiotou, MD, PhD,[a] Diogo C. Haussen, MD,[b] Francis Turjman, MD, PhD,[c] Julien Labreuche, BST,[d] Michel Piotin, MD, PhD,[e] Andreas Kastrup, MD, PhD,[f] Henrik Steglich-Arnholm, MD,[g] Markus Holtmannspötter, MD,[h] Christian Taschner, MD, PhD,[i] Sebastian Eiden, MD,[i] Raul G. Nogueira, MD,[b] Maria Boutchakova, MD,[a] Adnan Siddiqui, MD, PhD,[j] Bertrand Lapergue, MD, PhD,[k] Franziska Dorn, MD,[l] Christophe Cognard, MD, PhD,[m] Monika Killer, MD,[n] Salvatore Mangiafico, MD,[o] Marc R[illegible] Alejandro Spiotta, MD,[r] Marc Antoine Labeyrie, MD,[s] A[illegible] Sébastien Richard, MD, PhD,[u] René Anxionnat, MD, PhD, on behalf of the TITAN Investigators

TABLE 2 Efficacy and Safety Outcomes According to Therapeutic Group

	Thrombectomy and						
	Cervical ICA Stenting With Antithrombotic Agents (Group 1) (n = 256)	Cervical ICA Stenting Without Antithrombotic Agents (Group 2) (n = 66)	Cervical ICA Angioplasty (Group 3) (n = 52)	Thrombectomy Alone (Group 4) (n = 108)	p Value*	p Value†	p Value‡
Recanalization	213 (83)	48 (73)	36 (69)	65 (60)	<0.001	0.129	0.349
90-day favorable outcome	148 (58)	29 (44)	21 (40)	45 (42)	0.007	0.892	1
90-day mortality	24 (9)	12 (18)	6 (12)	18 (17)	0.07	0.96	0.539
Symptomatic hemorrhagic complications	14 (5)	6 (9)	0 (0)	5 (5)	0.944	0.336	0.175

Values are n (%). Recanalization was defined as mTICI grade 2B or 3 at the end of thrombectomy. Favorable outcome was defined as an mRS score of 2 or less. Symptomatic hemorrhagic complications were defined as any parenchymal hematoma, subarachnoid hemorrhage, or intraventricular hemorrhage associated with worsening of NIHSS score of 4 points or more according to ECASS-2 criteria. *Group 4 versus group 1. †Group 4 versus group 2. ‡Group 4 versus group 3.

ECASS = European Cooperative Acute Stroke Study; mRS, modified Rankin Scale; other abbreviations as in Table 1.

UBNS Neurosurgery UNIVERSITY AT BUFFALO

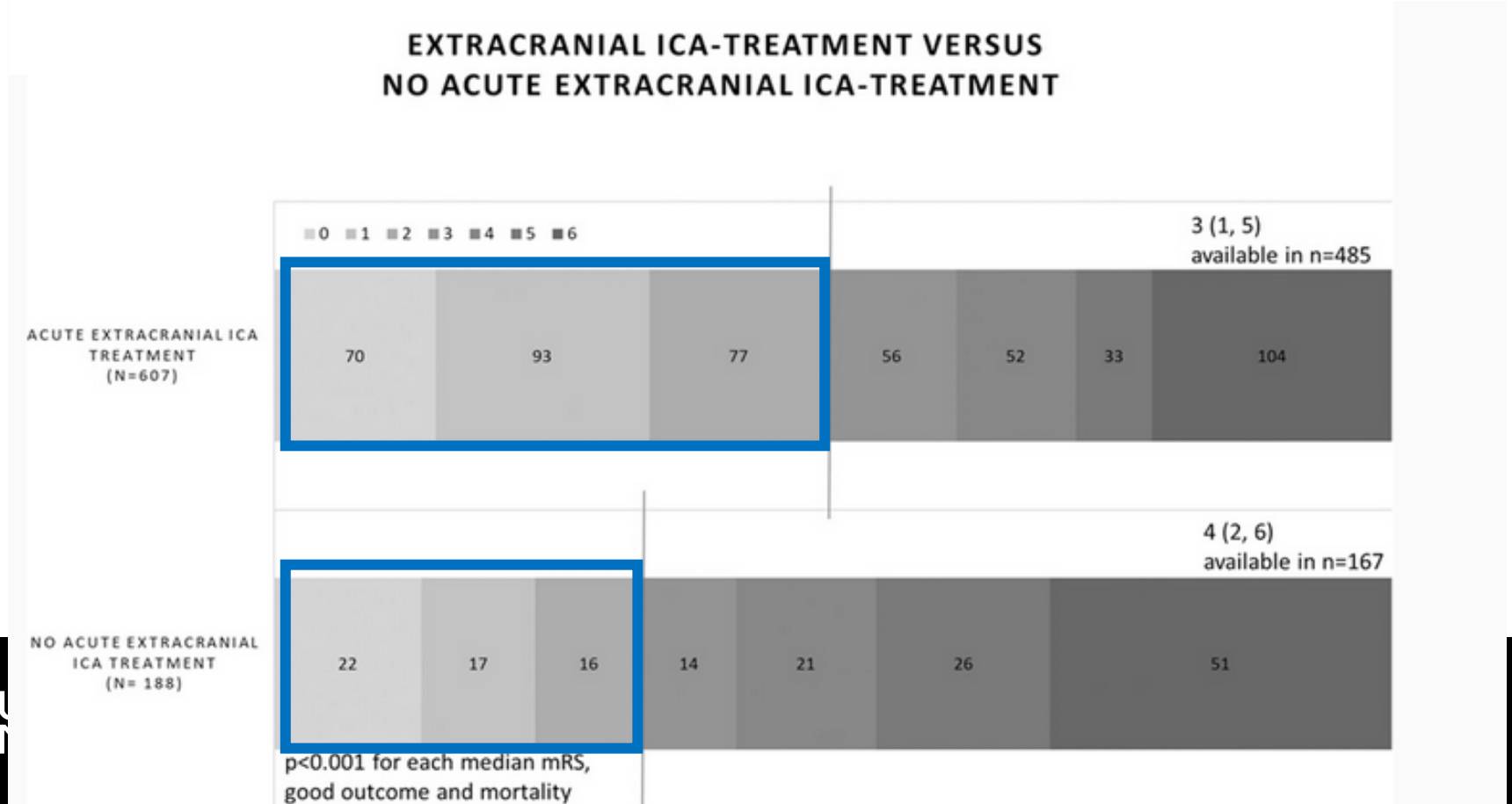
Pooled data from TITAN and ETIS

- Good clinical outcome @90d more frequent after ICA stenting (603 tandem occlusion, 341 with acute stenting)
- Hemorrhage more often after stenting

13 05.
(13):1290-9.

Data from the German Stroke Registry

- 874 patients with Tandem Occlusions, 69.5% underwent Stenting
- TICI 2b/3 more often after stenting (39.5% versus 29.3%, p<0.001)



ke. 2021;52(4):1265-75.

Extracranial first

- ✓ Creates a stable access
- ✓ Passage of the lesion without problems if multiple intracranial passes are necessary
- ✓ Potential embolic thrombi are being blocked by the intracranial occlusion

Extracranial first

- ✓ Creates a stable access
- ✓ Passage of the lesion without problems if multiple intracranial passes are necessary
- ✓ Potential embolic thrombi are being blocked by the intracranial occlusion

„Blind“ positioning of the stent without understanding the lesion

SAFEGUARD-STROKE: Multi-centric, multi-specialty study

COURSE LINC 2023

Lukasz Tekieli[1-3], Andrey Afanasiev[4], Maciej Mazgaj[5], Vladimir Borodetsky[6], Kolja Sievert[7], Magdalena Knapik[1,2,8], Audrius Širvinskas[3], Adam Mazurek[1,2], Karolina Dzierwa[9], Thomas Sanczuk[10], Valerija Mosenko[11], Mariusz Trystula[12], Piotr Paluszek[12], Justyna Stefaniak[13], Piotr Pieniazek[2,3,12], Inga Slautaitė[14], Artūras Mackevičius[15], Michael Teitcher[16], Horst Sievert[7], Iris Q Grunwald[17,18], Piotr Musialek[1,2]

[1]John Paul II Hospital in Krakow Thrombectomy-Capable Stroke Centre, **Krakow, Poland**
[2]Jagiellonian University Department of Cardiac and Vascular Diseases, John Paul II Hospital Krakow, Poland
[3]Jagiellonian University Department of Interventional Cardiology, John Paul II Hospital Krakow, Poland
[4]Department of Interventional Radiology, Republican Vilnius University Hospital, **Vilnius, Lithuania**
[5]Department of Diagnostic and Interventional Radiology, Stephan Cardinal Wyszynski Regional Hospital, **Lublin, Poland**
[6]Department of Interventional Radiology, Share Zedek Medical Center and Faculty of Medicine, The Hebrew University of Jerusalem, **Jerusalem, Israel**
[7]CardioVascular Center Frankfurt (CVC), Sankt Katharinen Hospital, **Frankfurt, Germany**
[8]Department of Radiology, Podhalanski Multispecialty Hospital, **Nowy Targ, Poland**
[9]Cardiovascular Imaging Laboratory John Paul II Hospital, Krakow, Poland
[10]Department of Neurology, Stephan Cardinal Wyszynski Regional Hospital, Lublin, Poland
[11]Santaros Klinikos, Vilnius University Hospital, Vilnius, Lithuania
[12] Department of Vascular and Endovascular Surgery, John Paul II Hospital, Krakow, Poland
[13]Department of Bioinformatics and Telemedicine, Jagiellonian University Medical College, Krakow, Poland
[14]Department of Neurology, Republican Vilnius University Hospital, Vilnius, Lithuania
[15]Department of Vascular Surgery, Republican Vilnius University Hospital, Vilnius, Lithuania
[16]Department of Neurology, Share Zedek Medical Center and Faculty of Medicine, The Hebrew University of Jerusalem, Jerusalem, Israel
[17]Division of Imaging Science and Technology, School of Medicine, University of Dundee, Dundee, **Scotland, United Kingdom**
[18]University of Dundee Chair of Neuroradiology and Department of Radiology, Ninewells Hospital, Dundee, Scotland, United Kingdom

Aim

To evaluate **clinical outcomes and stent patency** using the Micronet-covered stent in **consecutive** patients with carotid artery bifurcation origin **stroke** **eligible for emergency recanalization**

LEIPZIG INTERVENTIONAL COURSE
LINC 2023

Clinical characteristics, n=75

Age, years; range	67 [61-74]; 40 - 89
Gender, woman	21 (28.0)
ASPECTS on admission; range	9 [9-10]; 6 - 10
NIHSS on admission	14 [12-19]
mRS before admission	0 [0-1]
Time from symptom onset to presentation in Stroke Centre, h	3 [2-6]
Type of stroke (mechanism) Hemodynamic+Embolic* Hemodynamic# Embolic**	 20 (26.7) 37 (49.3) 18 (24.0)
Type of stroke (clinical) Hyperacute Crescendo TIA/stroke-in-evolution Stuttering/aggravating	 65 (86.7) 6 (8.0) 4 (5.3)
Side, right	38 (50.7)
ICA lesion type Atherothrombus Dissection Atherothrombus + dissection	 69 (92.0) 5 (6.7) 1 (1.3)

Clinical characteristics, cont'd

ICA thrombus†	42 (56.0)
ICA heavy calcifications‡	24 (32.0)
Tandem lesion	38 (50.1)
Smoking history No Current Ex-smoker	 33 (44.0) 26 (34.7) 16 (21.3)
Diabetes	25 (33.3)
Hypertension	67 (89.3)
Hypercholesterolemia or hypolipidemic therapy prior to stroke	62 (82.7)
Stroke in history TIA in history	7 (9.3) 17 (22.7)
Coronary artery disease	26 (34.4)
Atrial fibrillation	10 (13.3)
Symptomatic PAD	8 (10.7)
History of neck/chest radiotherapy	3 (4.0)

Procedural data (1)

Vascular access (n=75)	
Femoral	67 (89.3)
Radial	5 (6.7)
Transcarotid	3 (4.0)
Extra/intracranial thrombectomy* (n=75)	
• Extracranial	23 (30.7)
Aspiration	20 (26.7)
Large-bore ST	3 (4.0)
• Intracranial	36 (48.1)
Aspiration	21 (28.0)
Aspiration plus ST	12 (16.0)
ST	3 (4.0)

Procedural data (2)

Intracranial Mechanical Thrombectomy (n=36, in n=5 > 1 level)	
ICA	8 (22.2)
M1	21 (58.3)
M2	12 (33.3)
Number of passages during intracranial MT	2 [1-4]
range	1-9
Extracranial lesion strategy	
Predilation	46 (61.3)
'Direct' stenting	29 (38.7)
Carotid stent strategy in tandem lesions	
Antegrade	11 (28.9)
Retrograde	27 (71.1)

Procedural data (4)

Final mTICI	
0/1	3 (4.0)
2a	5 (6.7)
2b/c	17 (22.7)
3	50 (66.7)
Procedure time	70 [49-90]
Range	33-170
Intraprocedural heparin use	75 (100)
Intraprocedural heparin regimen	
Limited to catheter(s) flush drip	6 (8.0)
Additional heparin dose	69 (92.0)
<3000 IU	11 (14.7)
3000-5000 IU	21 (28.0)
ACT-adjusted dosing (≥ 250 sec)	37 (49.3)

Procedural data (5)

Periprocedural antiplatelet administered	75 (100.0)
iv. ASA	7 (9.3)
oral/nasogastric tube ASA	68 (90.7)
IIb/IIIa inhibitor use (ia/iv)	16 (21.3)
ia. bolus only	4 (5.3)
ia. bolus + iv infusion	12 (16.0)
Postprocedural antiplatelets	
One drug	4 (5.3)
Two drugs	71 (94.7)
Timing of second antiplatelet agent administration (n=71)	
≤24h	38 (53.5)
>24h	33 (46.5)
If delayed - when given, hours	28 [26-31]
range	24-48
Recommended DAPT (SAPT) duration, months	3 [3-3]
range	1-12

Key in-hospital outcomes

In-hospital (by discharge) outcomes	
Any intracranial hemorrhage	12 (16)
asICH	8 (10.7)
sICH	4 (5.3)
In-hospital death	7 (9.3)
NIHSS on discharge	4 [2-8]
range	0-23
mRS at discharge	1 [1-3]
range	0-6
Stent patent[#] by discharge	66 (94.3)

Key 90-day outcomes

90-day outcomes[†]	n=66
New stroke by 90-days, any ipsilateral contralateral posterior circulation	2 (3) 1 (1.5) 0 1 (1.5)
90-day death (total[*])	9 (12.0)
NIHSS at 90 days	3 [2-5]
mRS[‡] at 90 days	1 [1-2]
Stent patent[¥] by 90 days	59 (92.2)
DUS PSV/EDV (cm/s) [Q1-Q3]	64/24 [55-84]/[21-30]

Tandem occlusions - our experience

Franziska Dorn

Uniklinikum Bonn

franziska.dorn@ukbonn.de

UBNS Neurosurgery UNIVERSITY AT BUFFALO

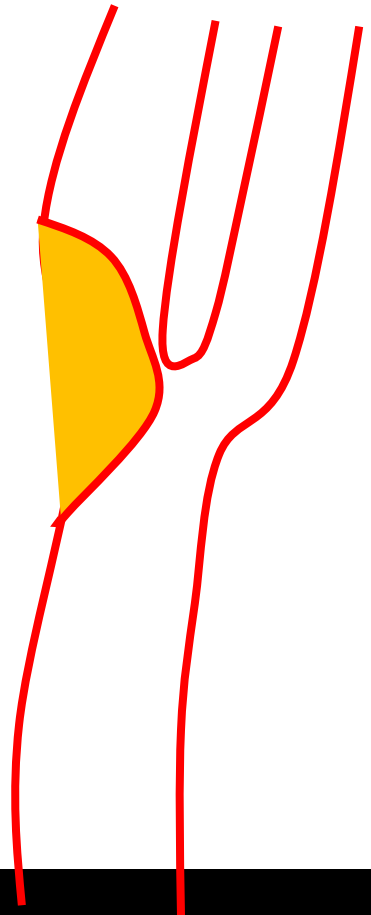
Buffalo General Medical Center
Gates Vascular Institute
A Kaleida Health Facility

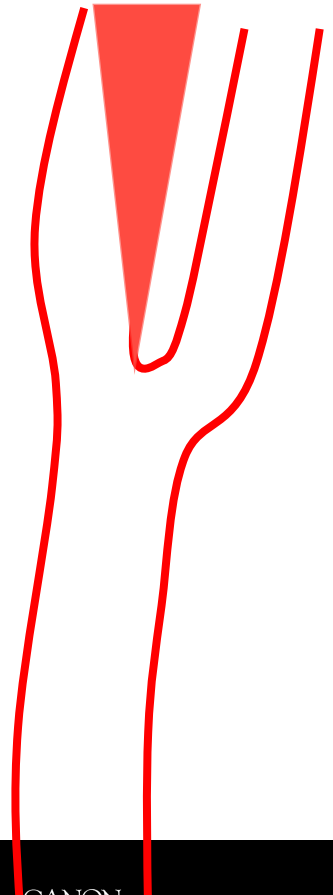
CANON STROKE & VASCULAR RESEARCH CENTER UNIVERSITY AT BUFFALO

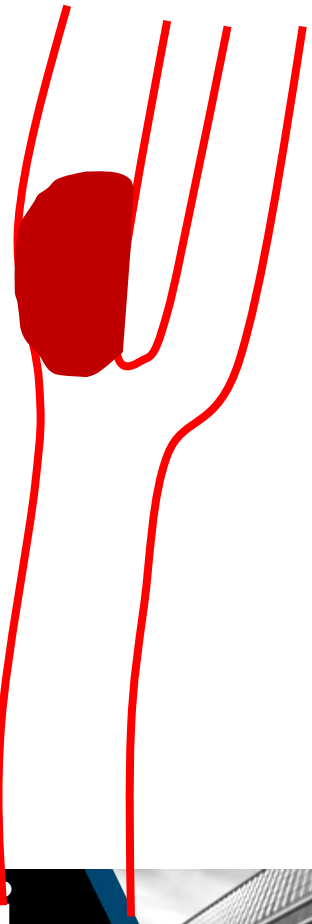
Jacobs School of Medicine and Biomedical Sciences
University at Buffalo

JACOBS INSTITUTE

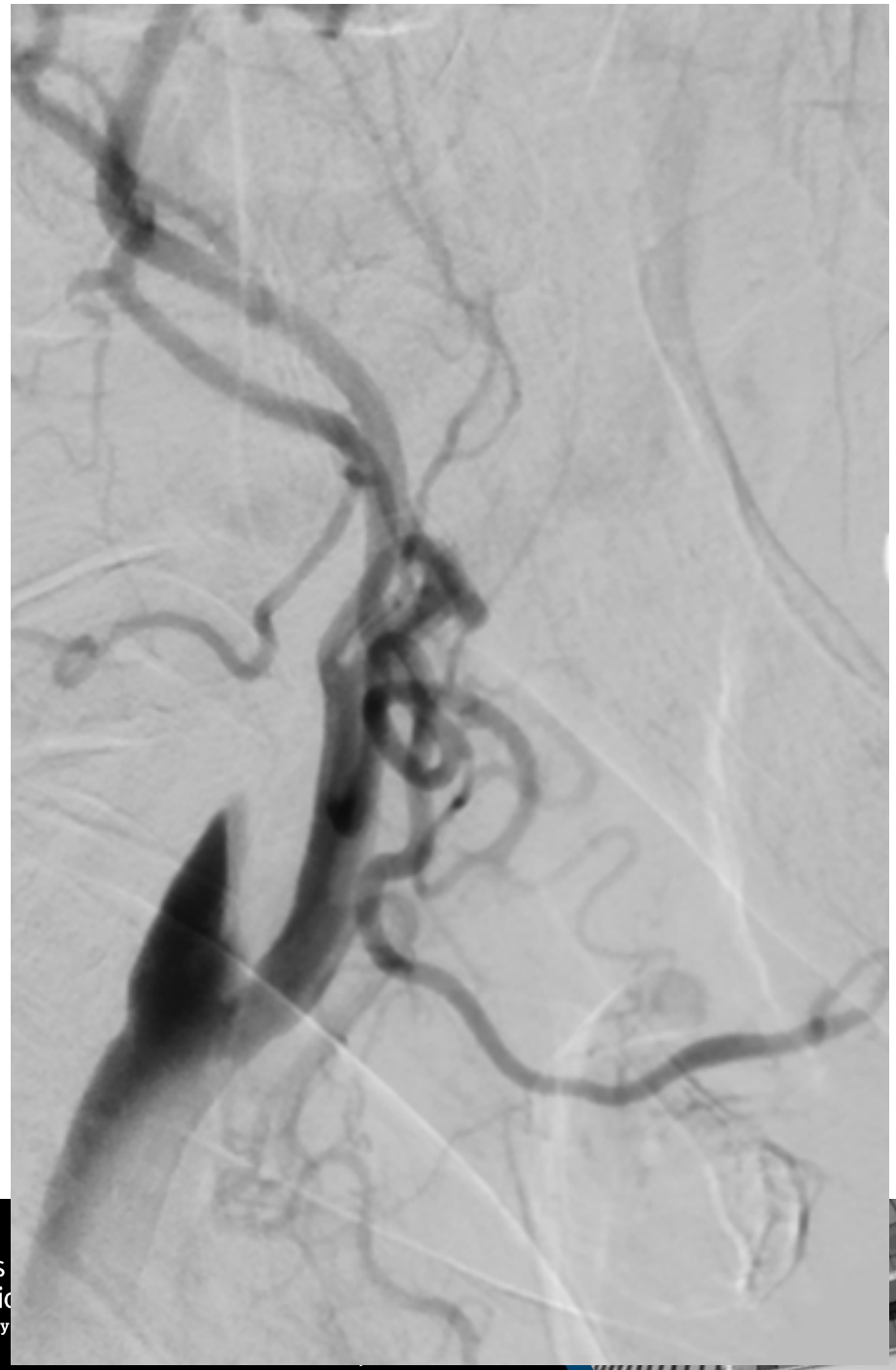
Different Tandem subtypes



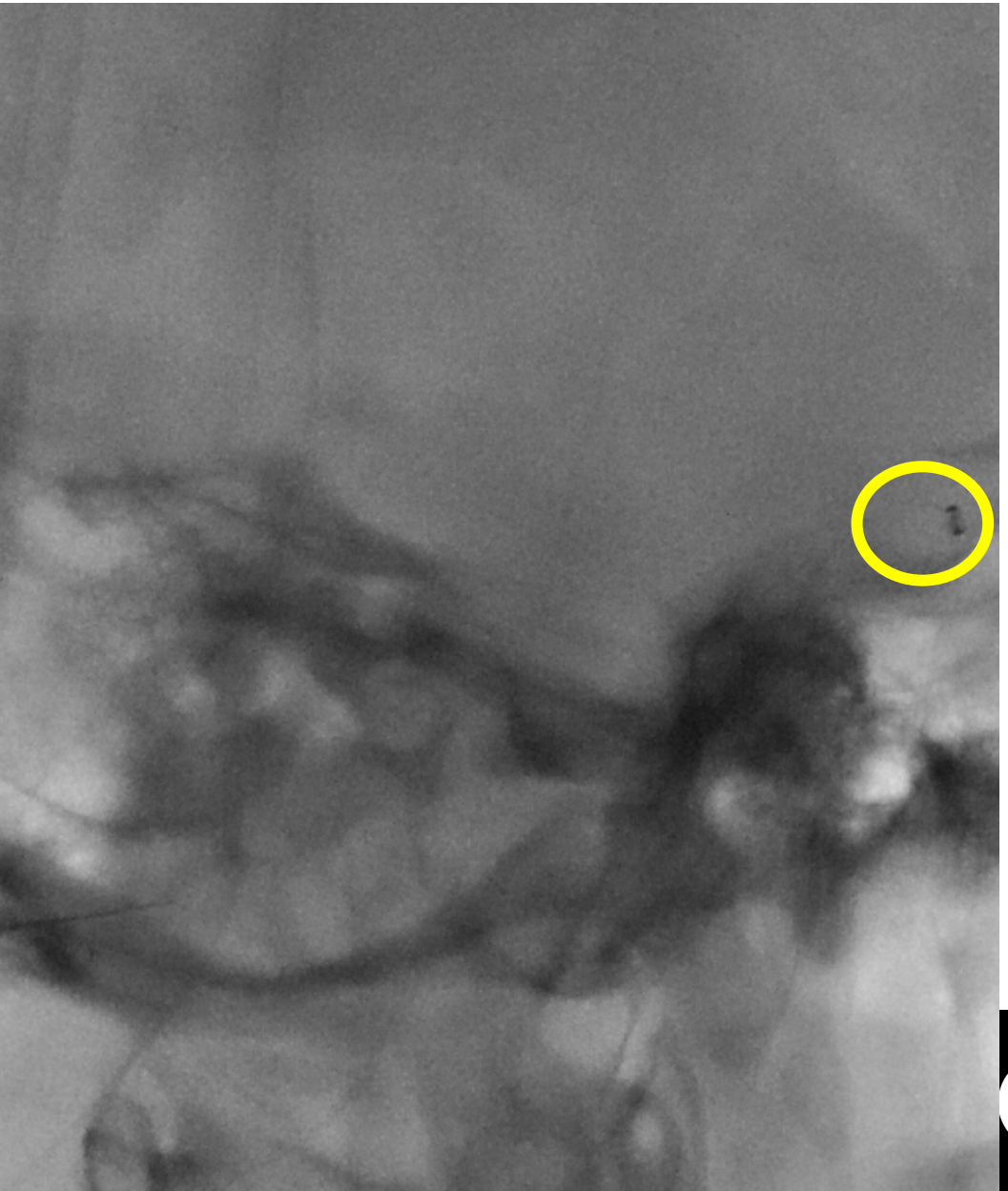


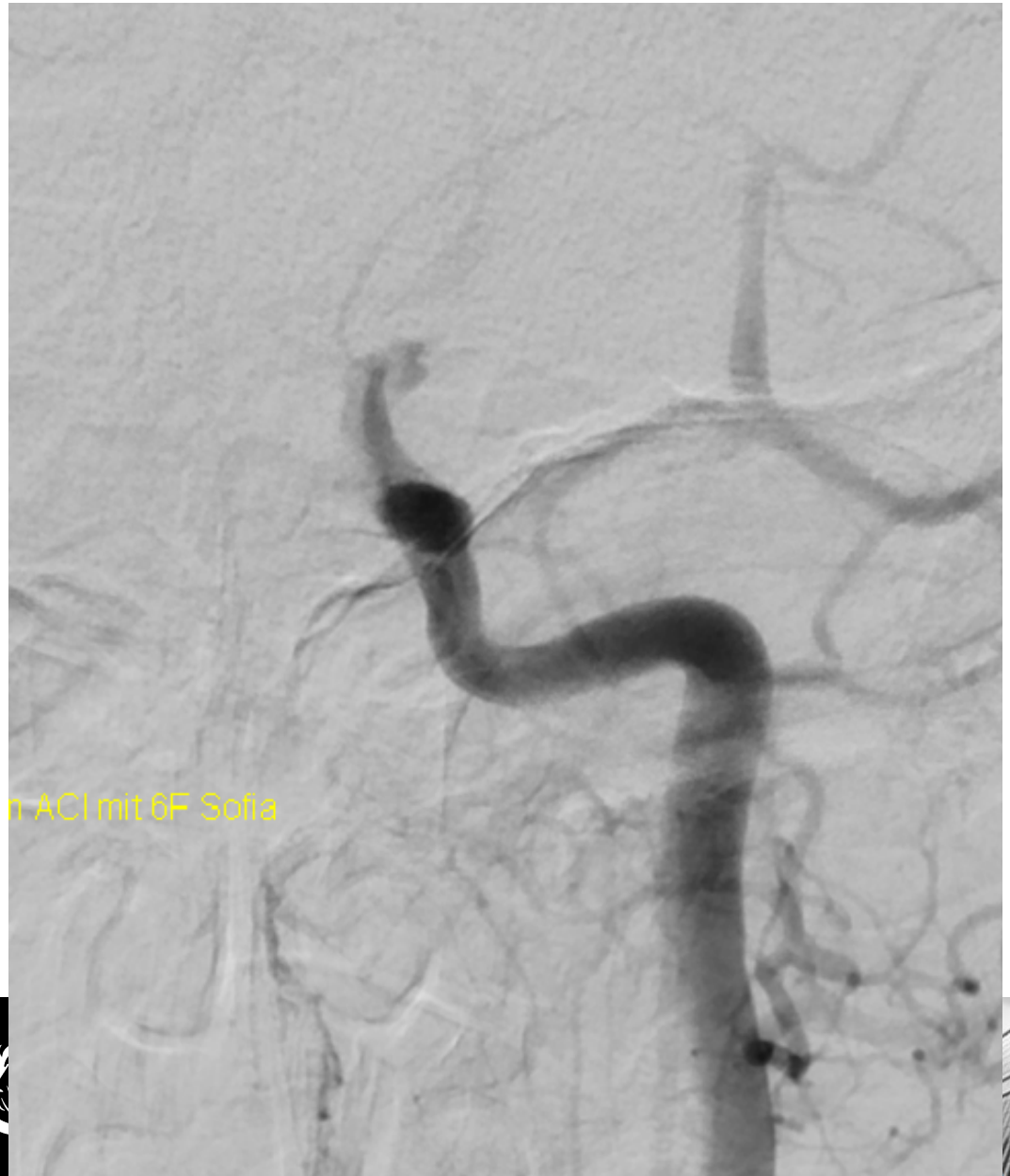


DISSECTION?

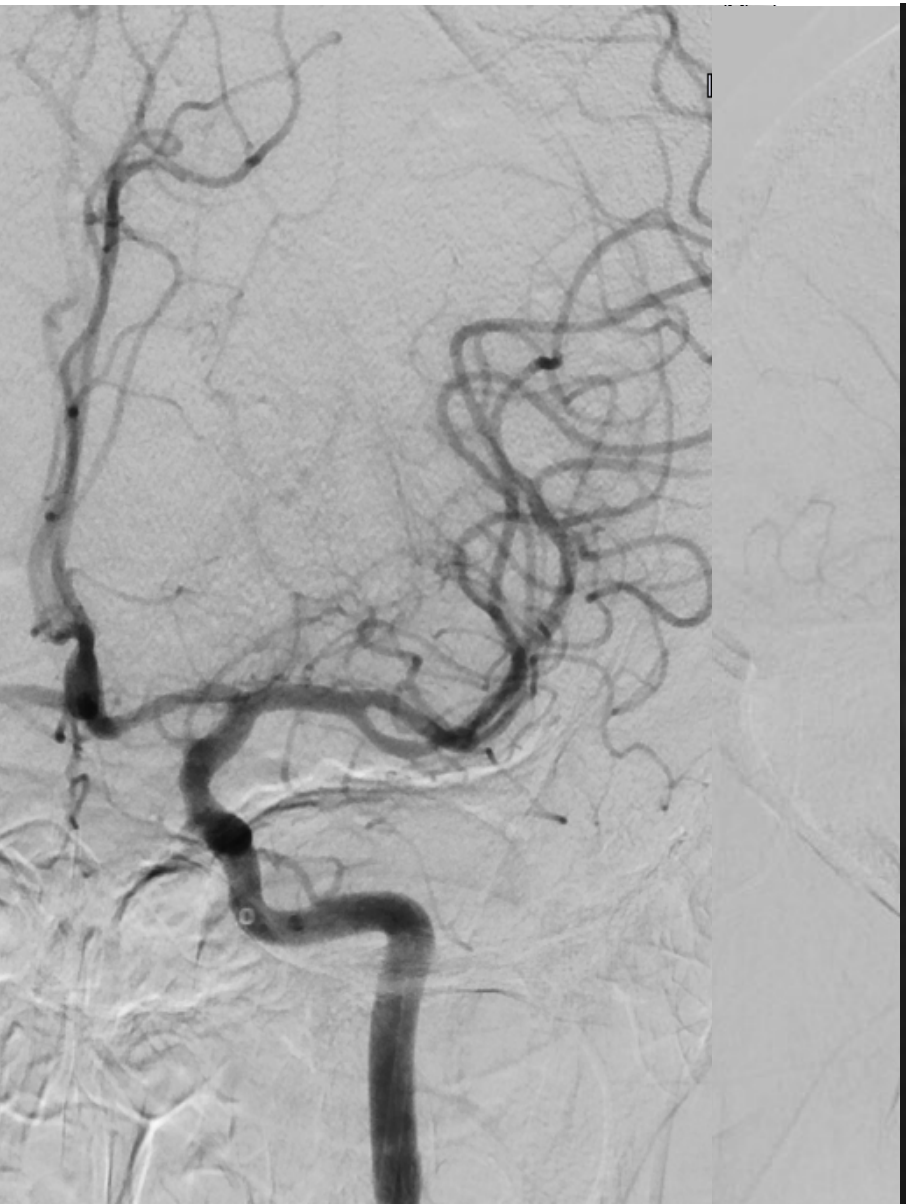


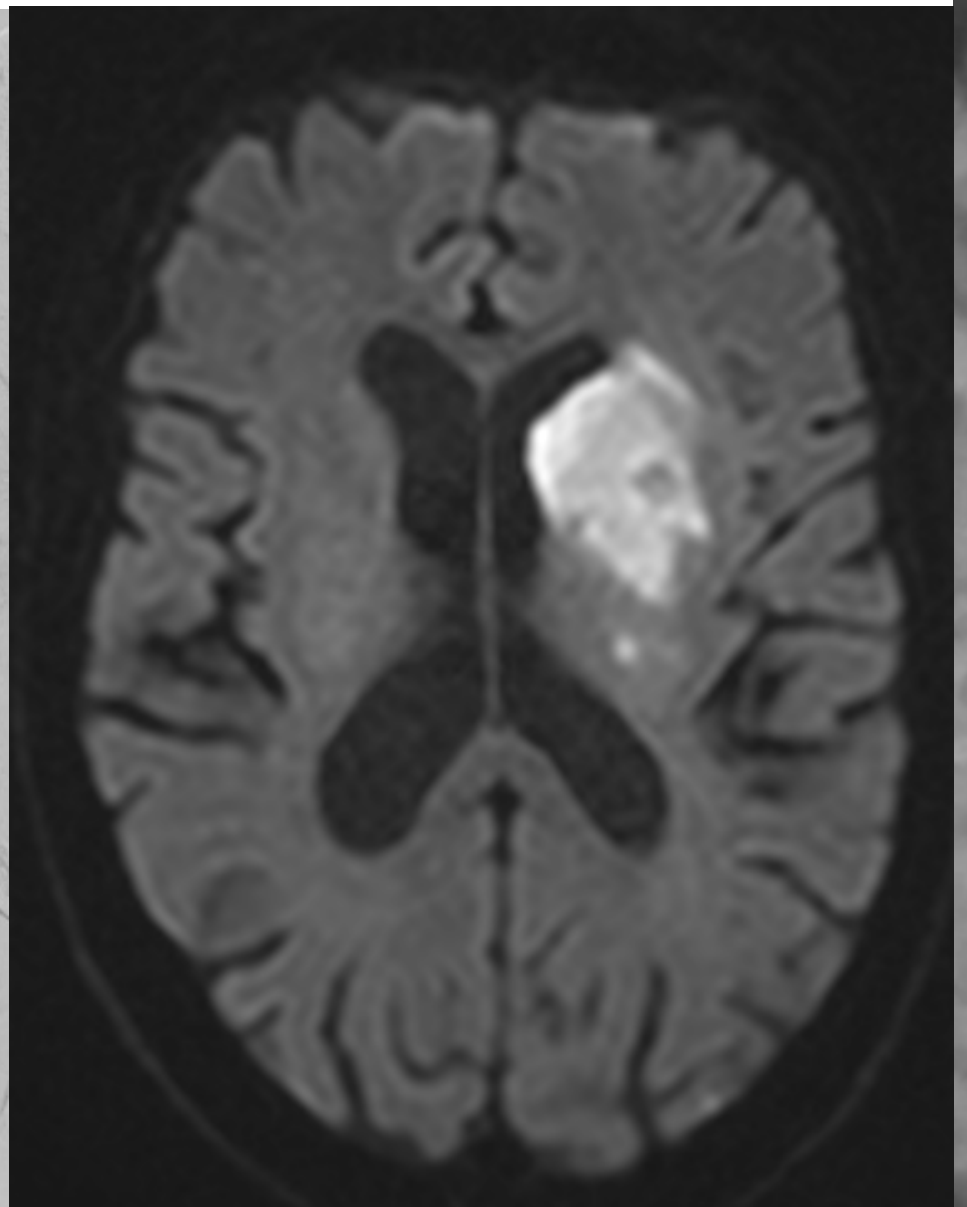
...easy to pass with 6F Sofia under continous aspiration

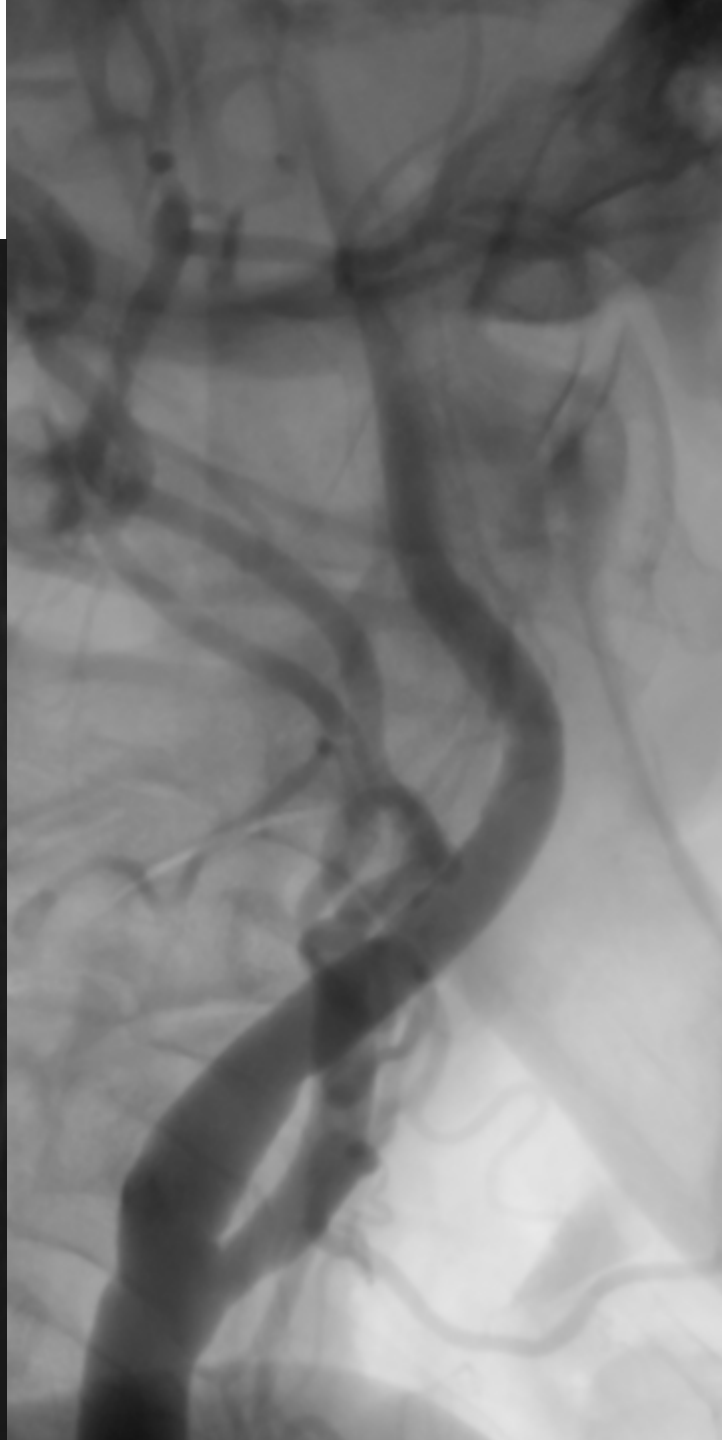




After aspiration

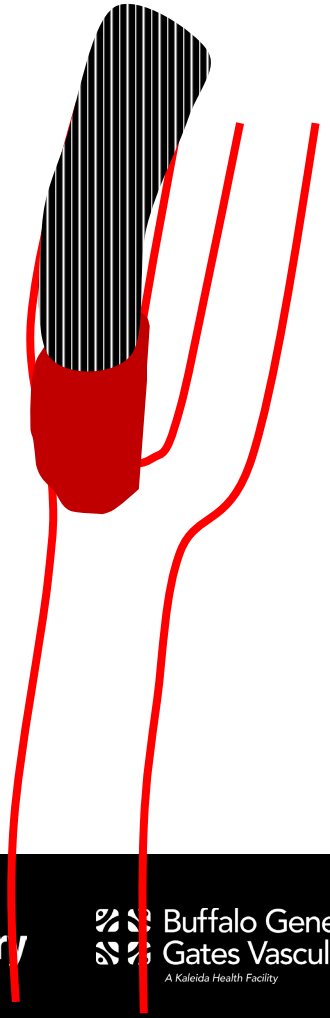




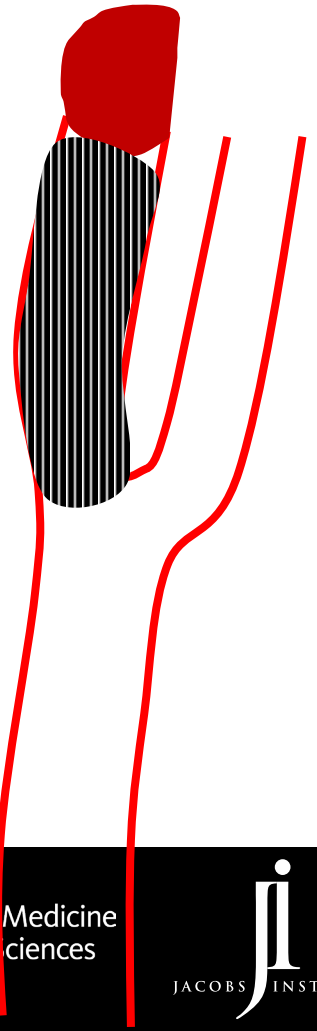


No TO

Embolic proximal occlusion



T-Occlusion AND proximal stasis



Intracranial first

- intracranial reperfusion faster if collaterals are present
- No potential interaction between the stent and the stentretriever

Neuroradiology (2015) 57:589–598
DOI 10.1007/s00234-014-1465-5

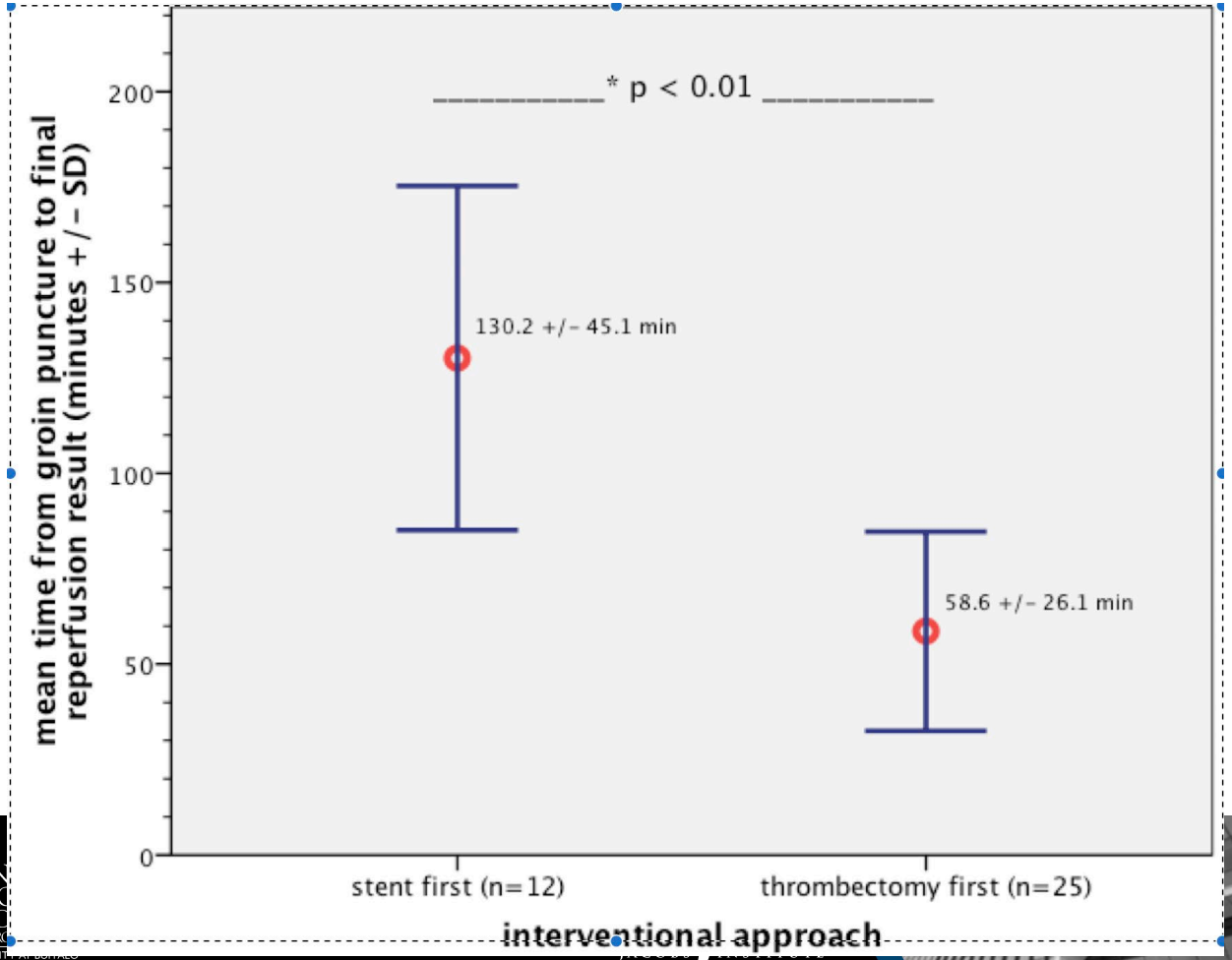
INTERVENTIONAL NEURORADIOLOGY

Mechanical thrombectomy in tandem occlusion: procedural considerations and clinical results

H. Lockau · T. Liebig · T. Henning · V. Neuschmelting · H. Stetefeld · C. Kabbasch · F. Dorn

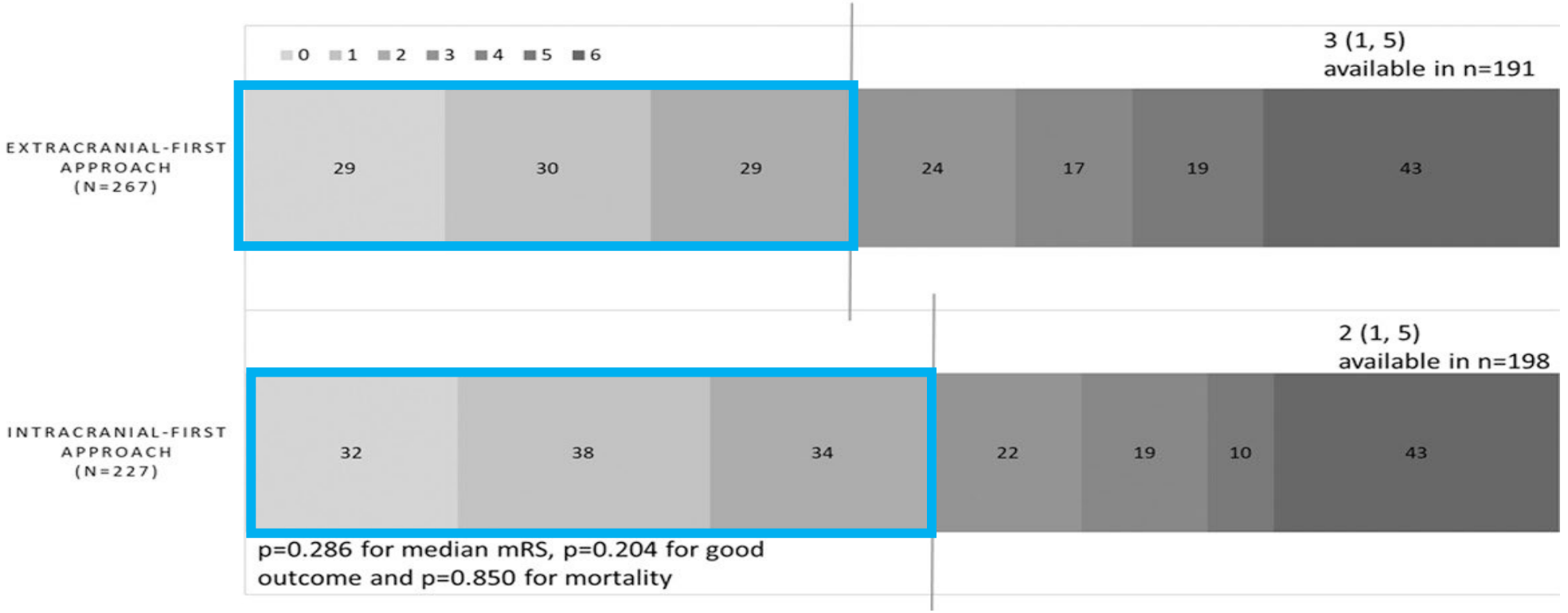
„Stent First“ versus „Thrombectomy First“

12/37 pts vs. 25/37 pts
TICI 2b/3 in 58.4% vs. 80%
3months mRS 0-2 in 33.3% vs. 52.0%



C

EXTRACRANIAL-FIRST VERSUS INTRACRANIAL-FIRST APPROACH IN ANTERIOR CIRCULATION STROKE PATIENTS WITH TANDEM LESIONS



Extracranial first

Intracranial first

ke. 2021;52(4):1265-75

Antiplatelets?

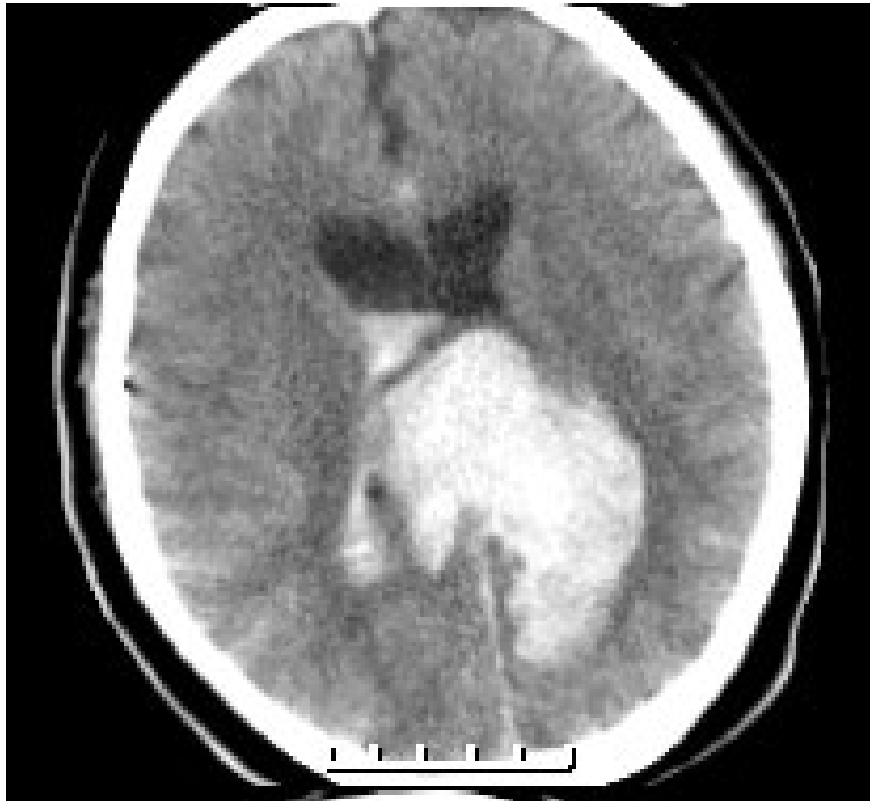
ICH after Tandem Occlusions

- *Rotem Sican-Hoffmann et al. :*

Metaanalysis of 11 studies, 237 pt., **sICH: 7%**

- *Gory et al. :* 4395 pt., **sICH 5.3%**
- *Lockau et al.* : **sICH 10.8 %**
- *Mpotsaris et al*: 63pt., **sICH 5%**
- Díaz-Pérez J. et al. : 153 pt., **sICH 8.5%**

- HERMES**: sICH 4.4%**



Periprocedural:

500mg Aspisol IV

CT /CTA after 12h

- Stent patency (if occluded, STOP)
- Hemorrhagic transformation/ infarct core volume

\+ Infarct Core volume? Hemorrahgic transformation? -

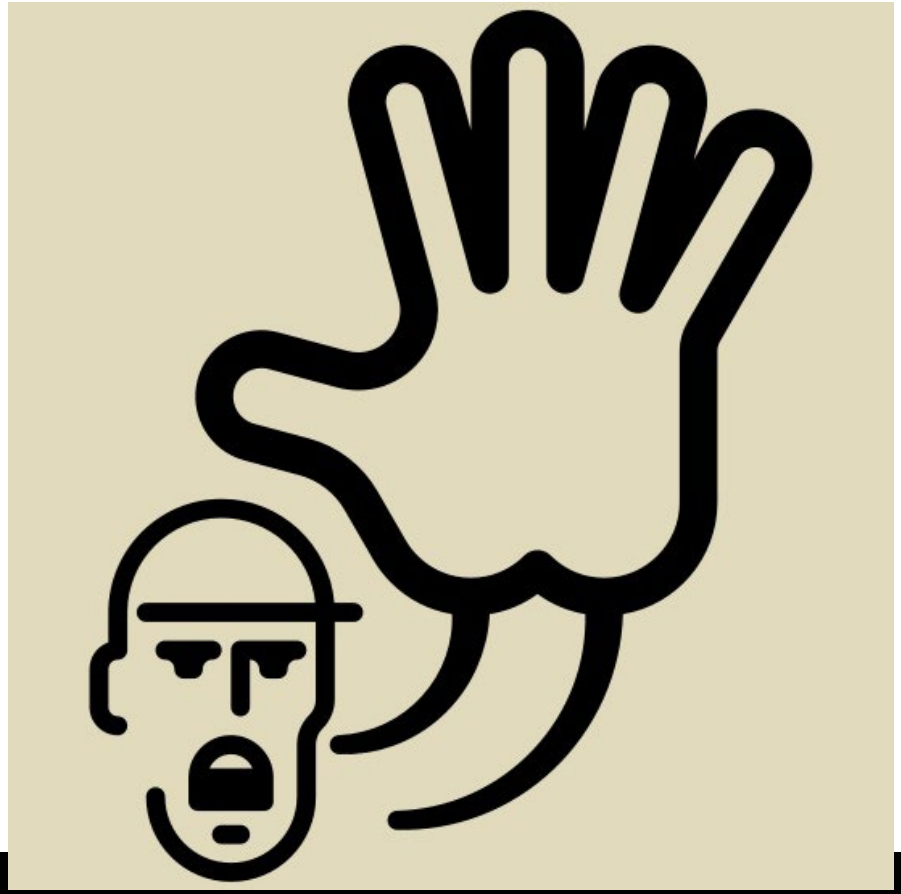
STOP

Continue ASA

Continue Aspisol
Start Ticragelor

Which stent
(….why I started to use the CGuard)

Don’t use Dual-layer stents in emergent CAS!



Acute Occlusions of Dual-Layer Carotid Stents After Endovascular Emergency Treatment of Tandem Lesions

Umut Yilmaz, MD; Heiko Körner, MD; Ruben Mühl-Benninghaus, MD; Andreas Simgen, MD; Catherine Kraus; Silke Walter, MD; Stefanie Behnke, MD; Klaus Faßbender, MD; Wolfgang Reith, MD; Marcus M. Unger, MD

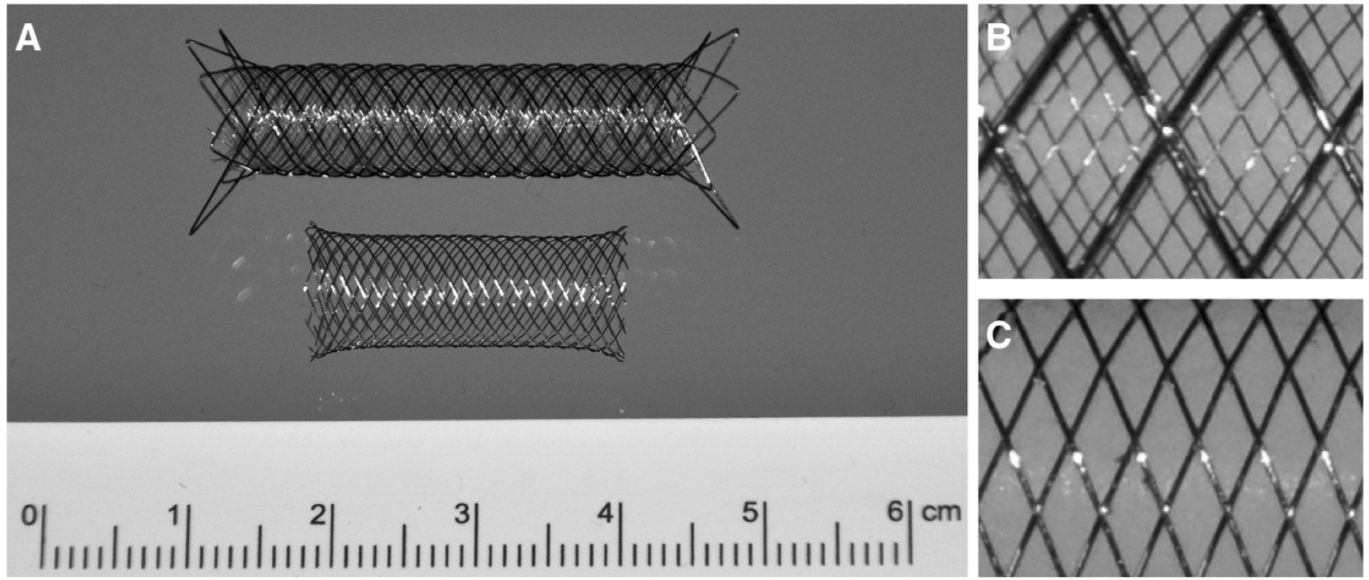
Background and Purpose—A new generation of carotid artery stents that uses a second micromesh layer to reduce embolic events during carotid artery stenting has recently been introduced. The purpose of this study was to compare acute occlusion rates of these new dual-layer stents with those of single-layer stents in the setting of emergency carotid artery stenting with intracranial mechanical thrombectomy in acute ischemic stroke.

Methods—Consecutive patients with acute tandem (intra- and extracranial) lesions of the anterior circulation who were endovascularly treated at our institution were identified from our registry of neuroendovascular interventions. Clinical, angiographic, and neuroimaging data were analyzed. End points included acute occlusions of the carotid stents (within 72 hours after stenting) and symptomatic intracerebral hemorrhage.

Results—Forty-seven patients were included. Dual-layer stents (n=20) had a significantly higher rate of acute occlusions than single-layer stents (n=27; 45% versus 3.7%; *P*=0.001; odds ratio, 21.3; 95% confidence interval, 2.4–188.4). There were no significant differences in the rates of patients who had any antiplatelet or dual antiplatelet medication before admission, in the rates of postinterventional symptomatic intracerebral hemorrhage, the mean National Institutes of Health Stroke Scale scores at admission, or the modified Rankin Scale scores at discharge.

Conclusions—The recently introduced dual-layer stents have a higher risk of acute occlusion compared with single-layer stents in the treatment of acute stroke. **(*Stroke*. 2017;48:2171-2175. DOI: 10.1161/STROKEAHA.116.015965.)**

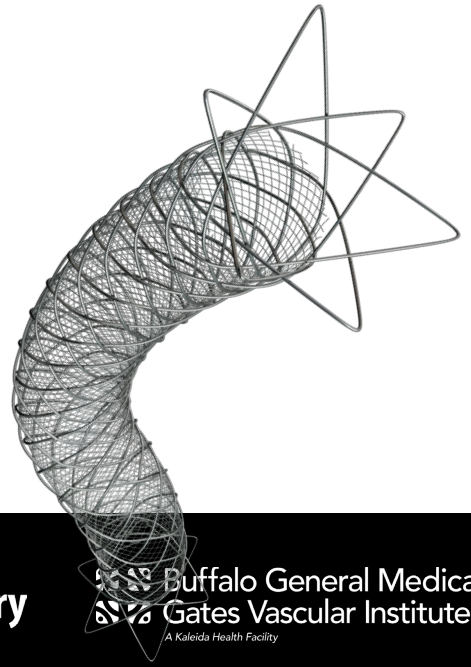
20 patients
....In-stent occlusion sign. higher with dual layer stents when compared to conventional stents (45% vs. 3.7%)



UBNS Neurosurgery UNIVERSITY AT BUFFALO
Buffalo General Medical Center
Gates Vascular Institute
A Kaleida Health Facility

Don’t use Dual-layer stents in emergent CAS!

- Yilmaz et al. **20 patients** (**45%** acute in-stent occlusions)
- Bartolini et al. **21 patients** (**52.4%** acute in-stent occlusions)
- Pfaff et al. 160 **patients** (**20.8%** acute in-stent occlusions)
- De Vries et al. **27 patients** (**18.5%** acute in-stent occlusions)

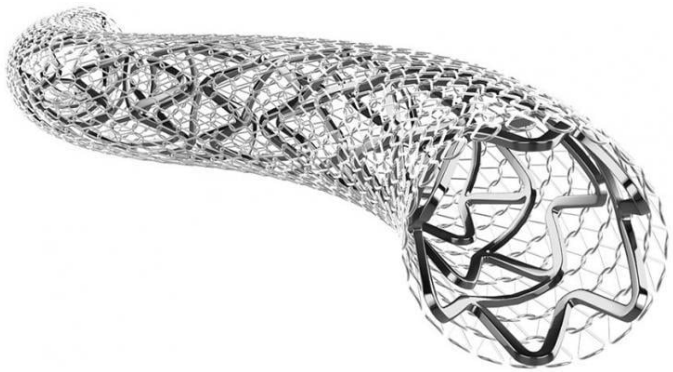


CASPER/ Roadsaver

Yilmaz U et al. Stroke. 2017 Aug;48(8):2171-2175.
Bartolini B et al. J Neurointerv Surg. 2019 Aug;11(8):772-774.
Pfaff JAR et al. J Neurointerv Surg. 2020 Jan;12(1):33-37.

CGuard: very limited data on TO

Single-center series including **33 patients** (**9%** acute occlusion rate)



diol. 2022:1-8.

Name	Terumo RoadSaver / Casper	CGuard™ Embolic Prevention System
Type & Material	close-cell/ Nitinol	open-cell/ Nitinol
Mesh Location	Inner mesh	Outer mesh
Mesh material	Nitinol	PET
Mesh structure	braided	single-fiber knitted
Pore size	375-500 µm	150 - 180 µm

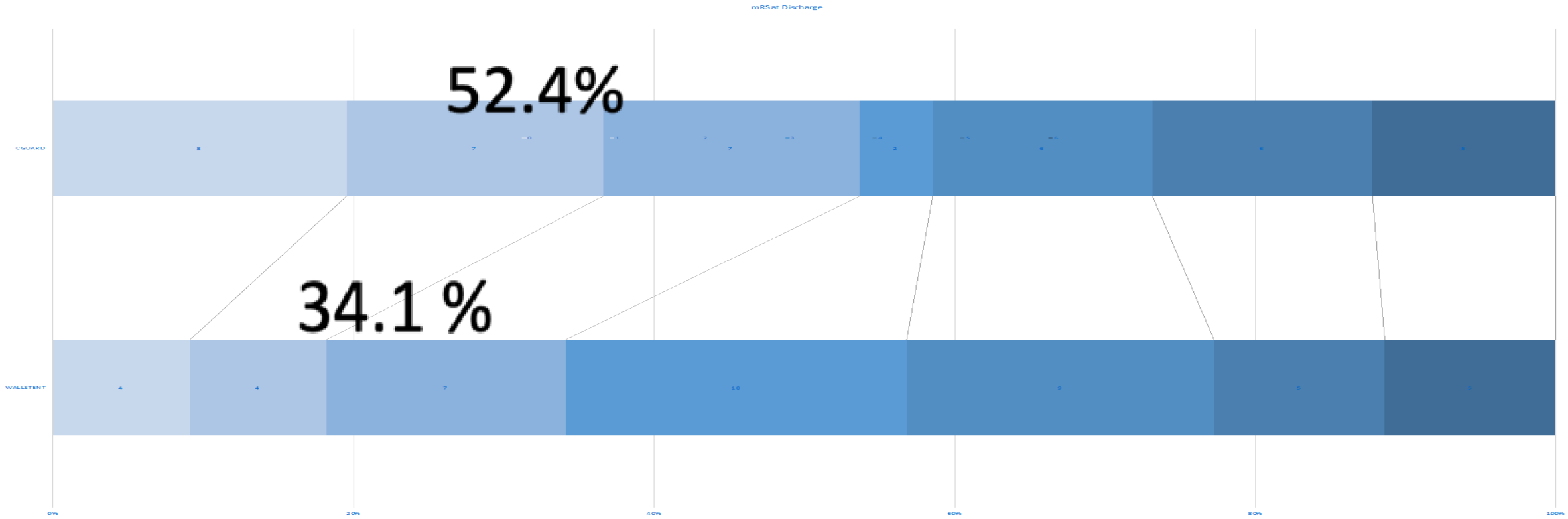
Wallstent vs. CGuard

- 86 TO patients (42 treated with CGuard, 44 with CWS)
- Acute in-stent occlusions (within 72 hours after stenting)

  - CGuard: 2/42 **(4.8%)**
  - Wallstent: 4/44 **(9.1%)** (p=0.615)

Zidan M et al., under review

mRS 0-2 at discharge more often after CGuard *(p=0.087)*



Zidan M et al., under review

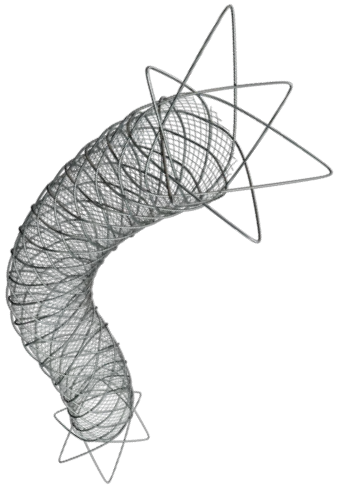
Multicentric experience

- 4 German Centers (Bonn, Solingen, Mainz, Frankfurt)
- 96 patients
- Technical succesful in all patients
- All stents were patent at the end of the procedure
- 5 **(5.2%)** Instent-occlusions within 72 hours (3 of them in dissections!)

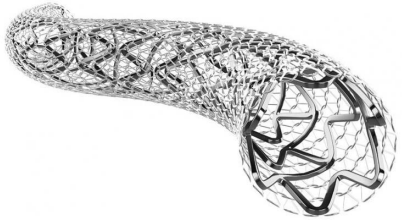
Zidan M et al., under review

Don’t use Dual-layer stents in emergent CAS?

- Yilmaz et al. **20 patients** (**45%** acute in-stent occlusions)
- Bartolini et al. **21 patients** (**52.4%** acute in-stent occlusions
- Pfaff et al. 160 **patients** (**20.8%** acute in-stent occlusions)
- De Vries et al. **27 patients** (**18.5%** acute in-stent occlusions)



- Klail et al. **33 patients** (**9%** acute in-stent occlusions)
- Zidan et al. **42 patients** (**4.8%** acute in-stent occlusions)
- Zidan et al. **96 patients** (**5.2%** acute in-stent occlusions)

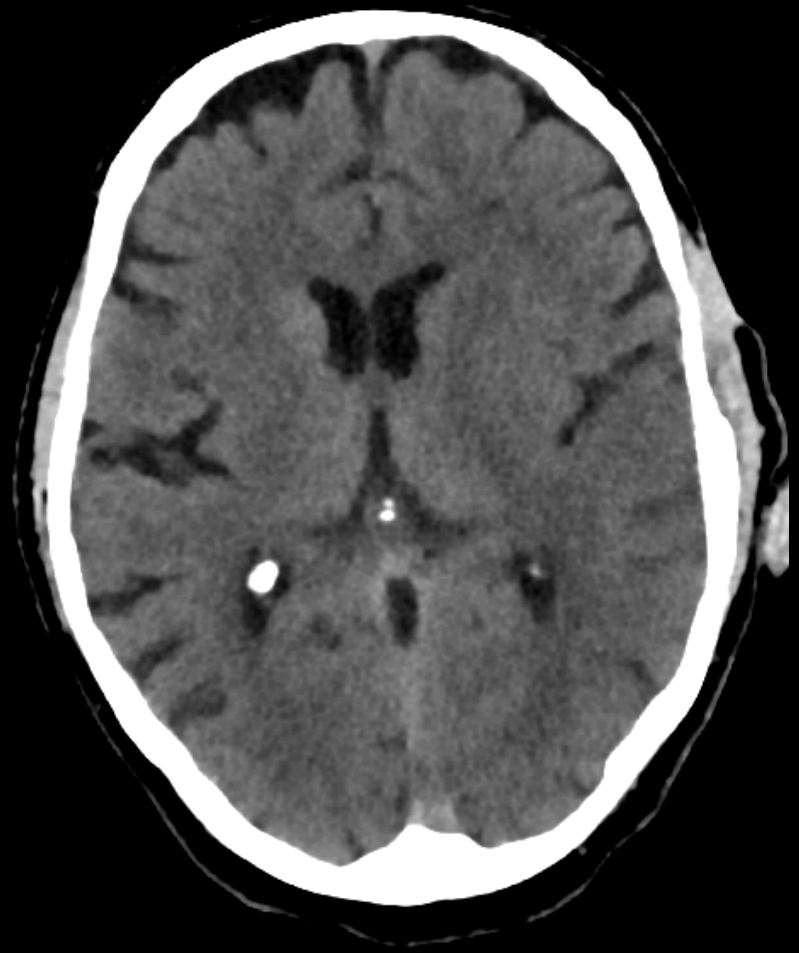


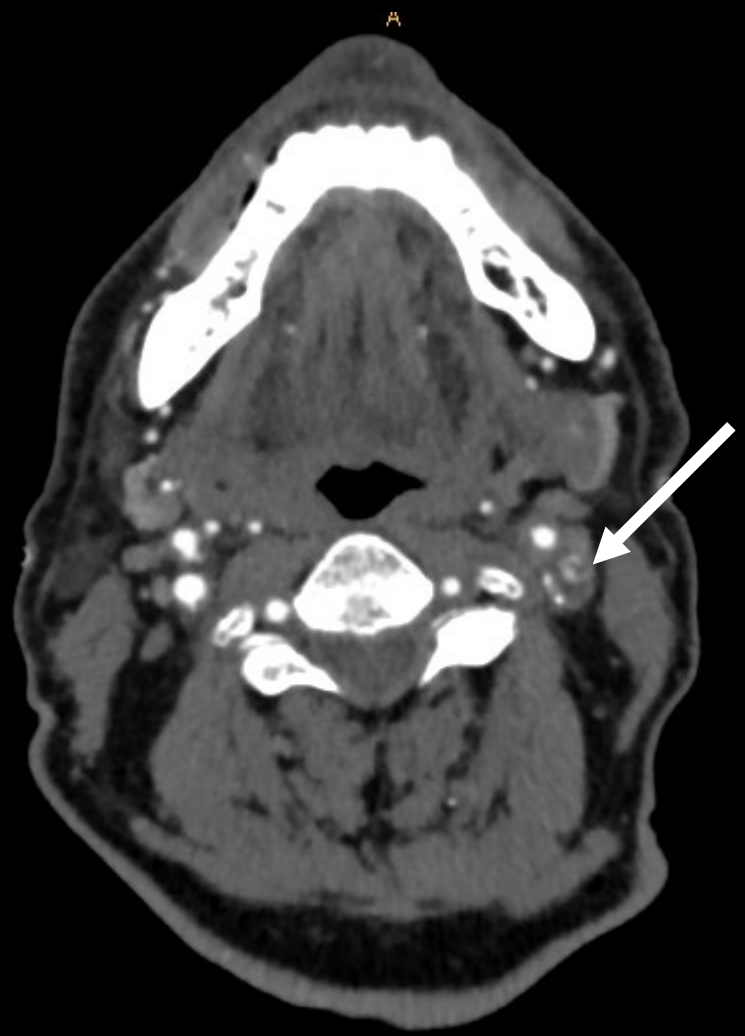
Yilmaz U et al. Stroke. 2017 Aug;48(8):2171-2175.
Bartolini B et al. J Neurointerv Surg. 2019 Aug;11(8):772-774.
Pfaff JAR et al. J Neurointerv Surg. 2020 Jan;12(1):33-37.
2:1-8.

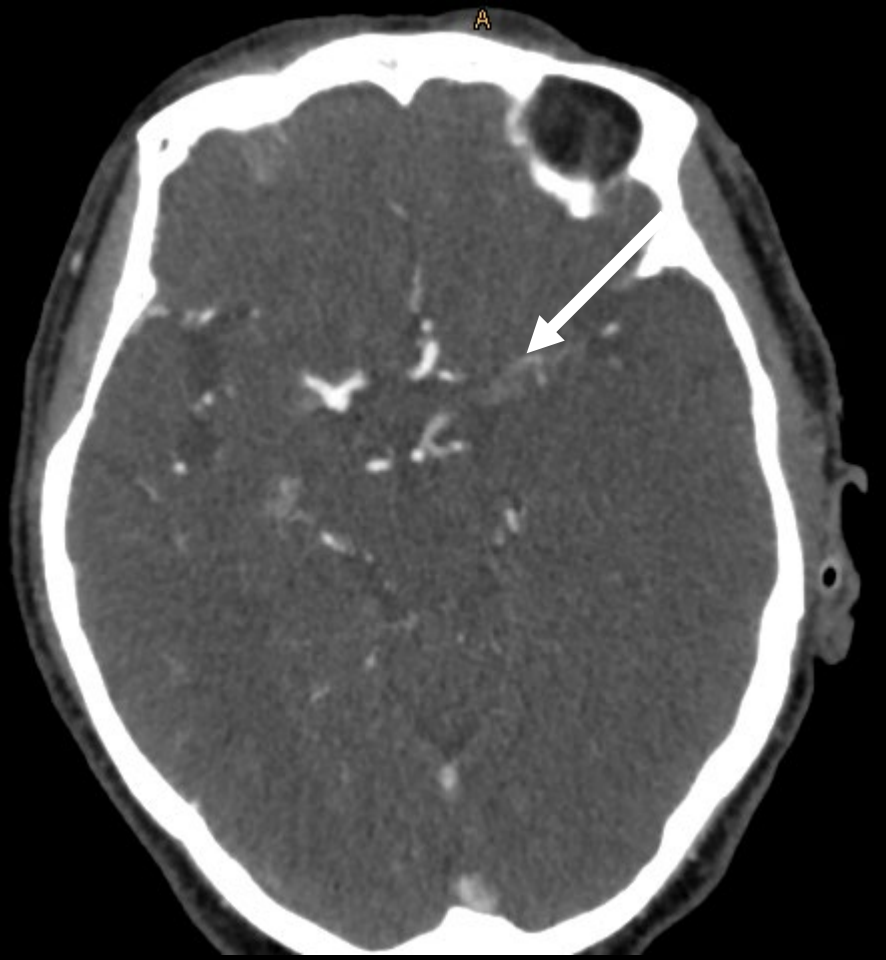
Conclusion

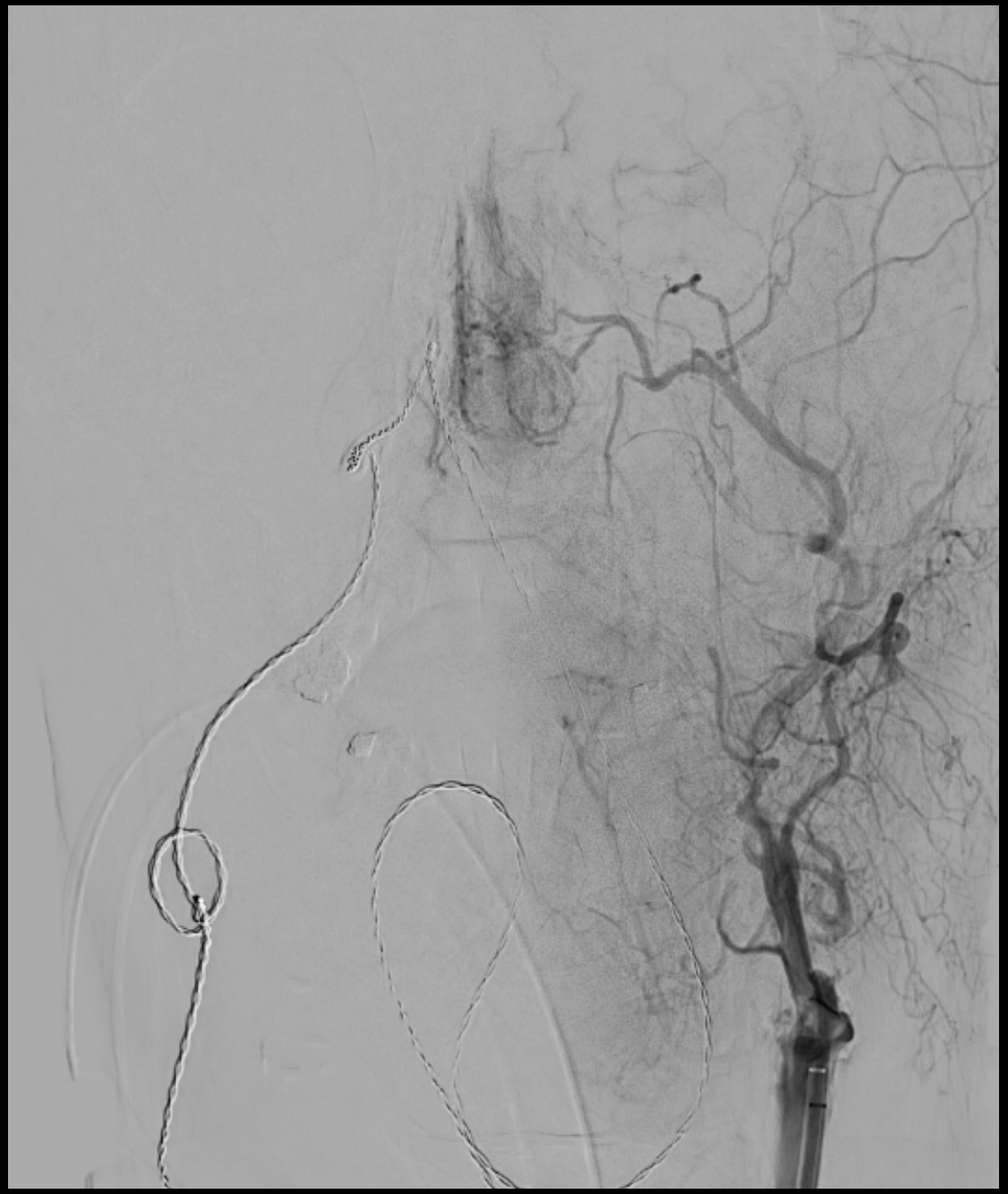
- TO: Stenting with antiaggregation beneficial
- Intracranial first beneficial
- CGuard seems safe for TO and should not be compared to Roadsaver/ Casper
- Further data needed!

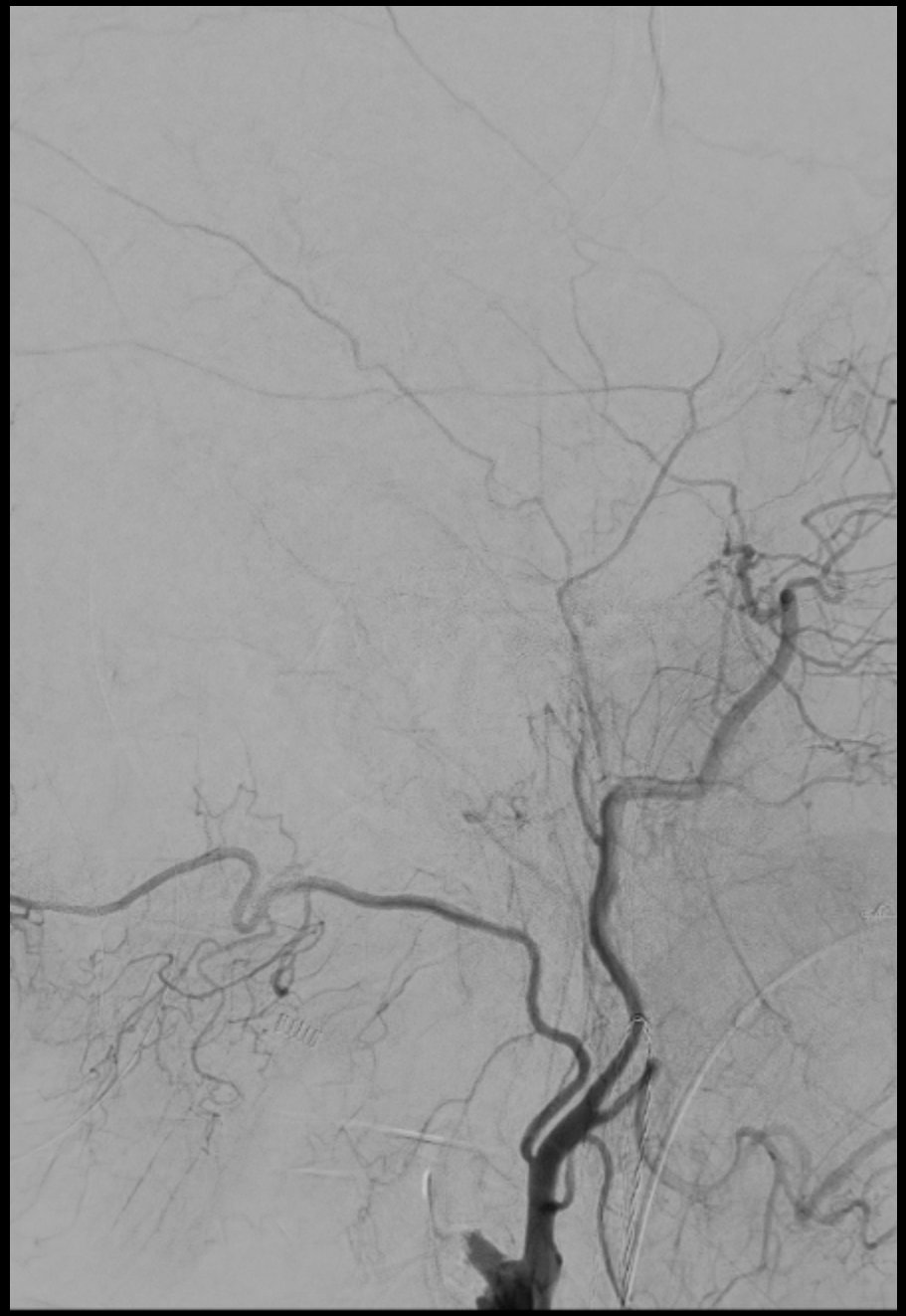
- ✓86 yo male
- ✓Wake up, NIHSS 17
- ✓ASPECTS 7



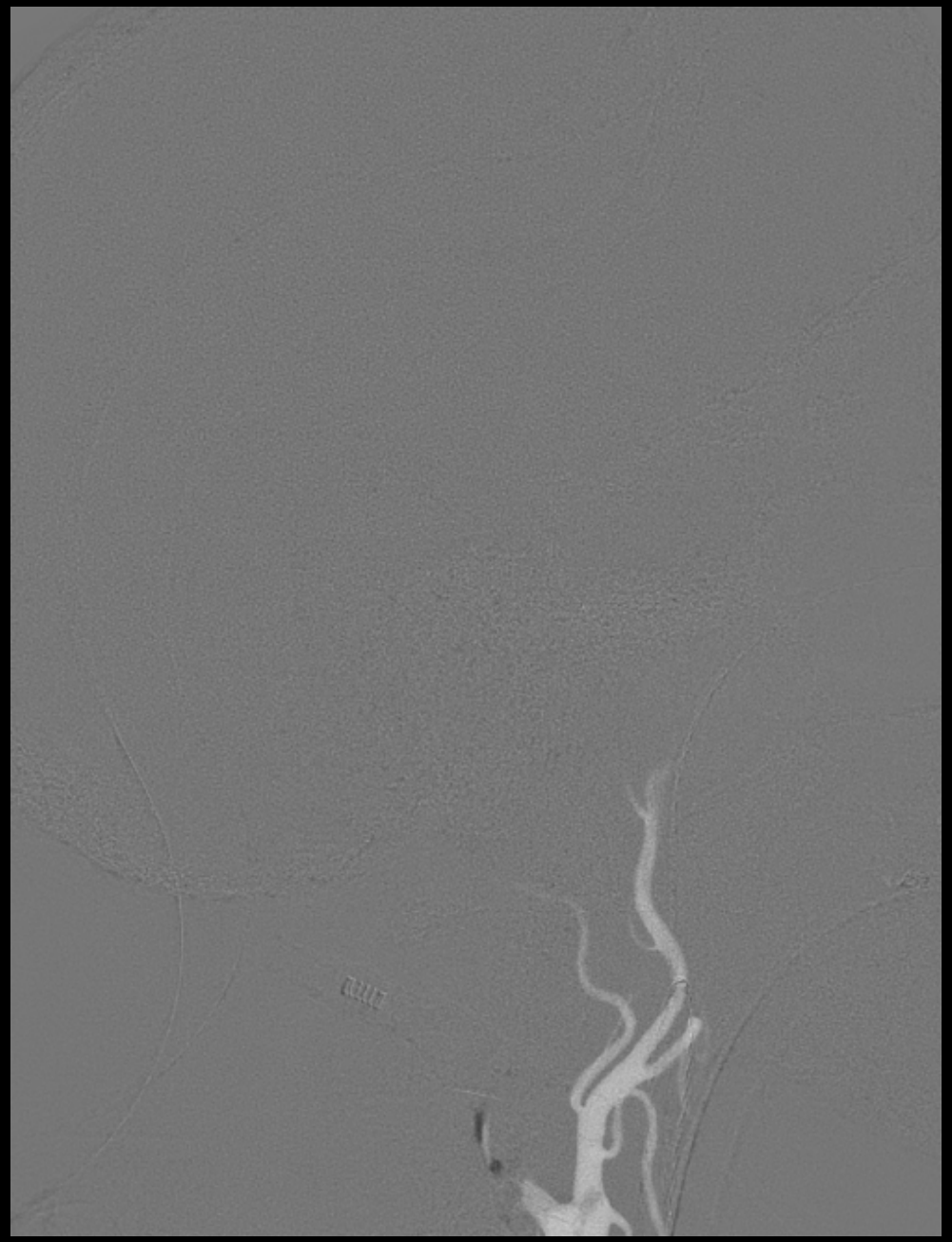


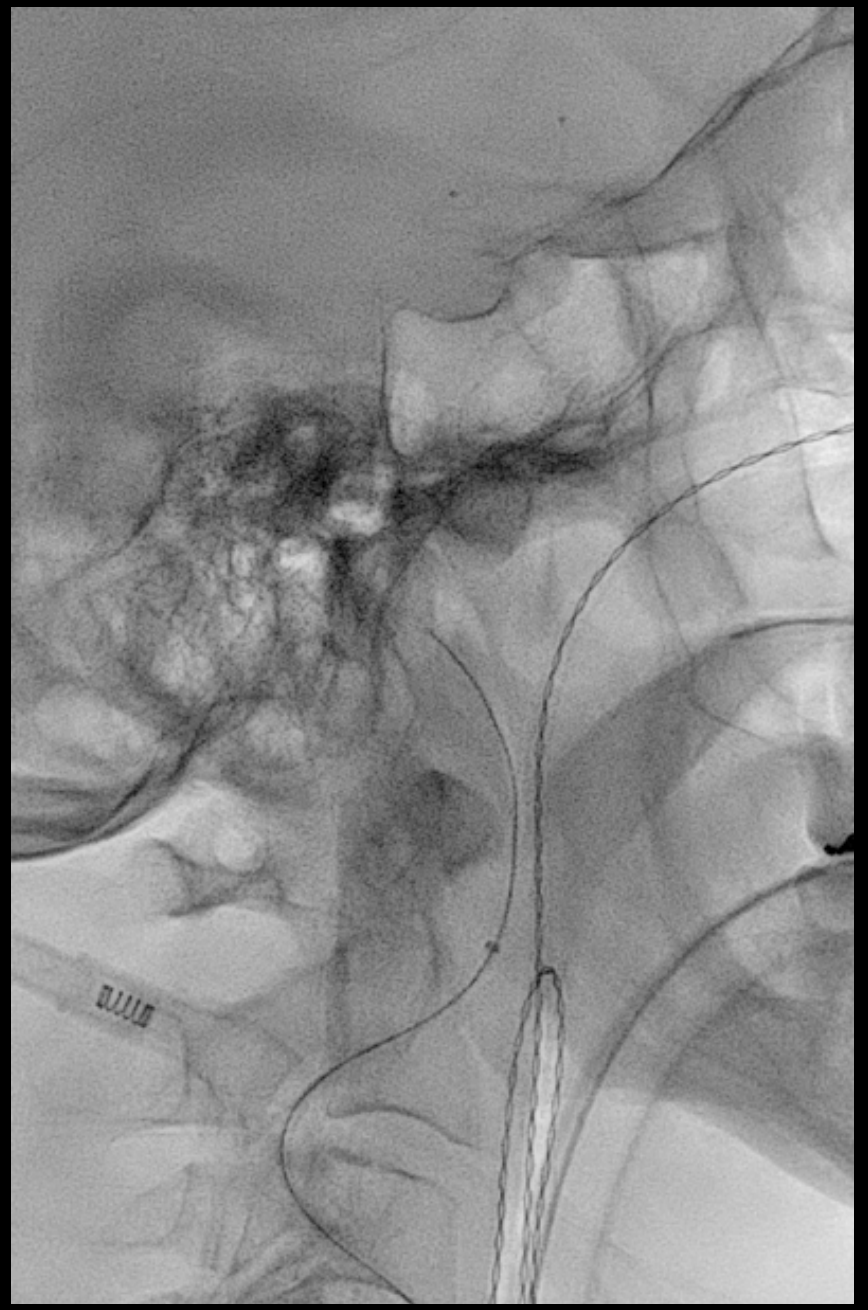


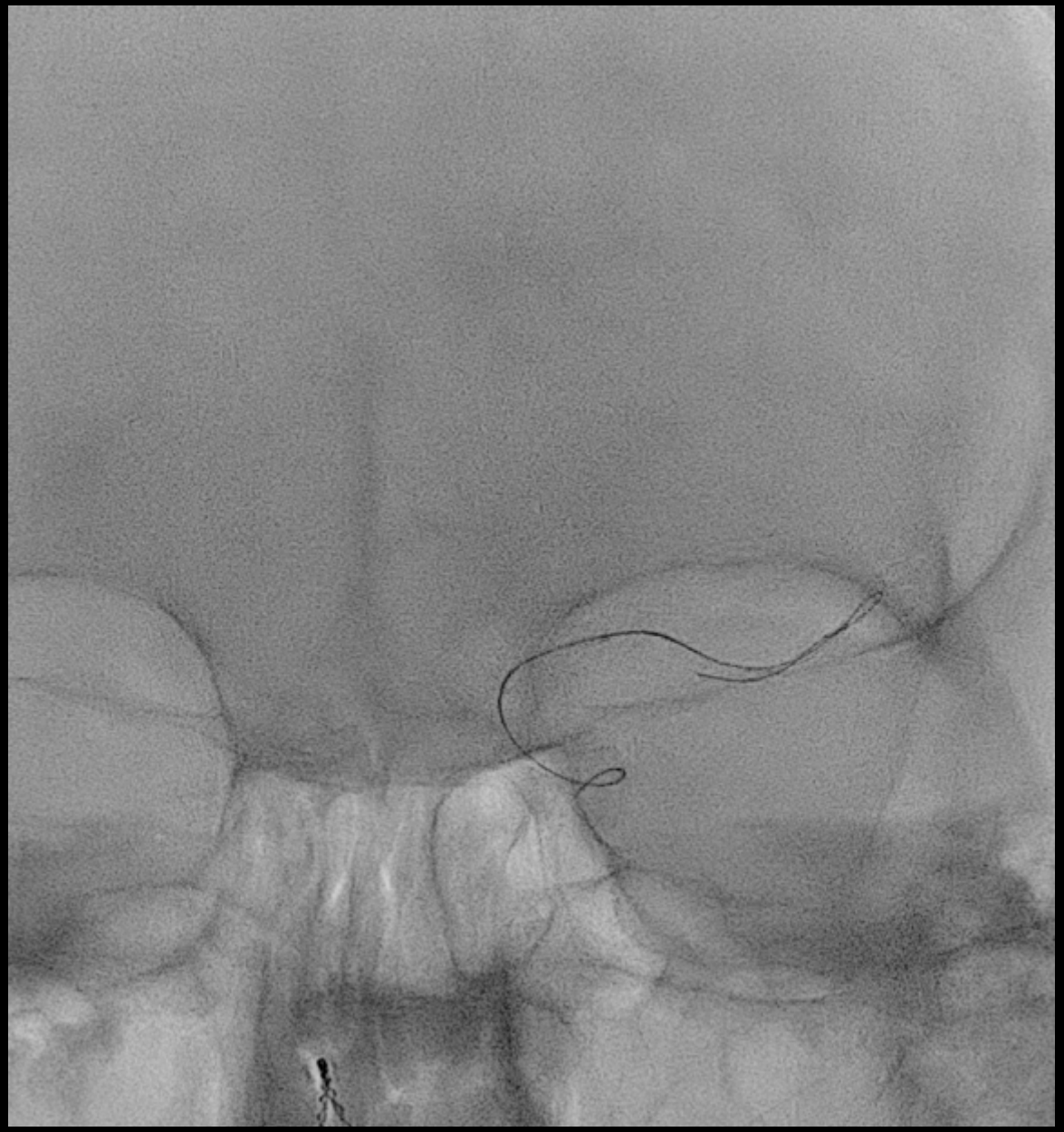


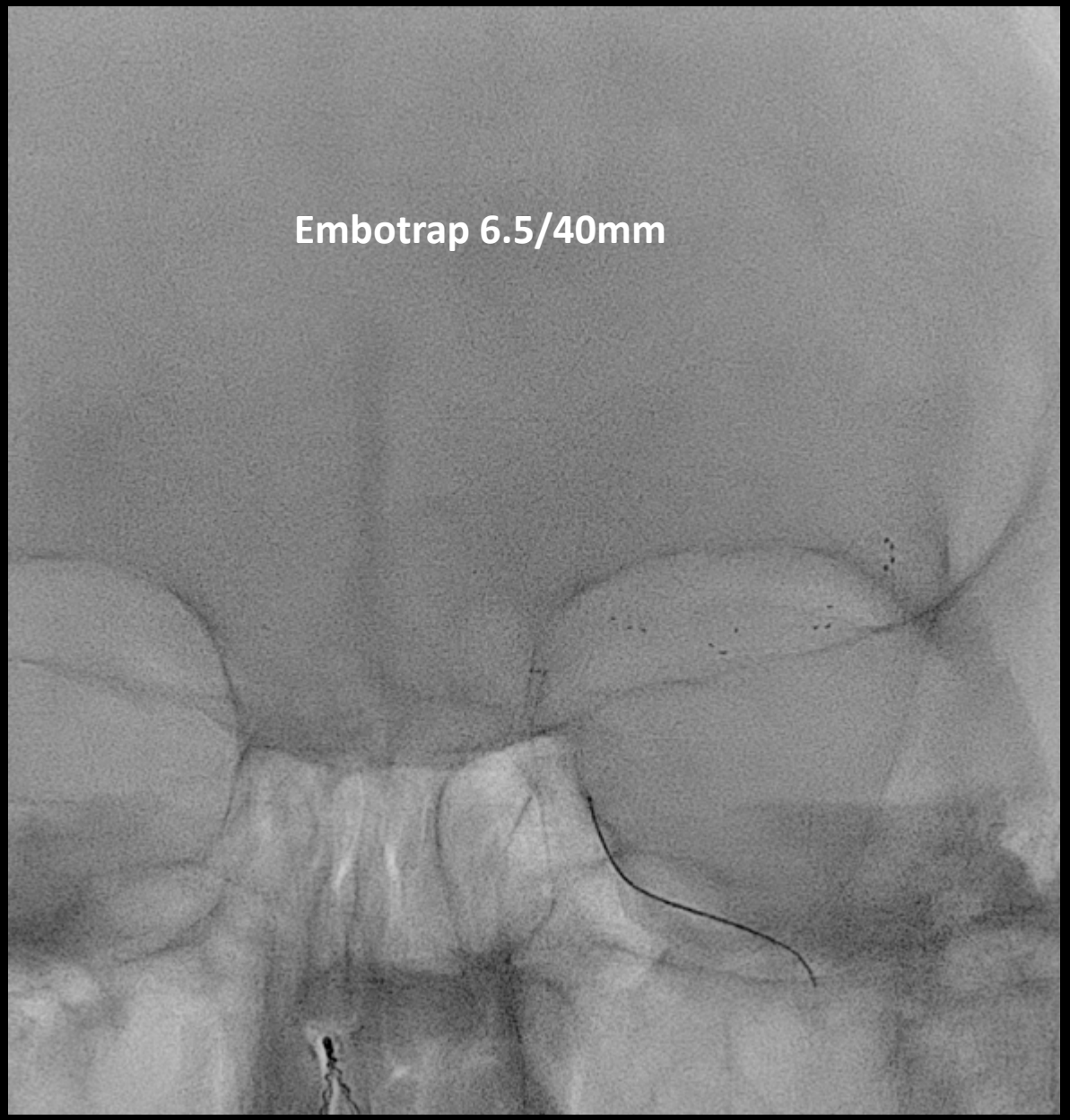


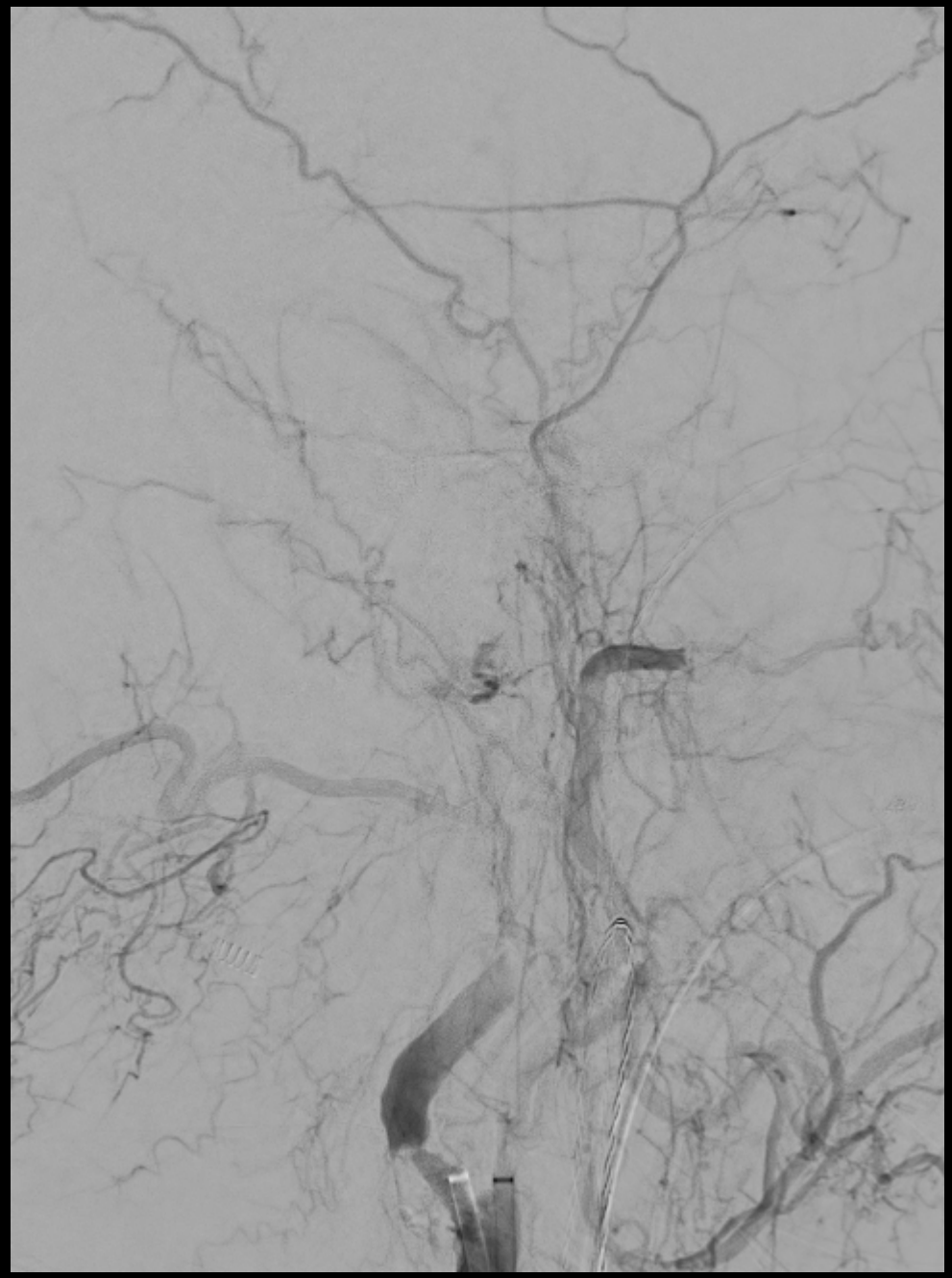
- ✓8F Vista Brite Tip
- ✓6F Sofia
- ✓Terumo
- ✓Synchro-14

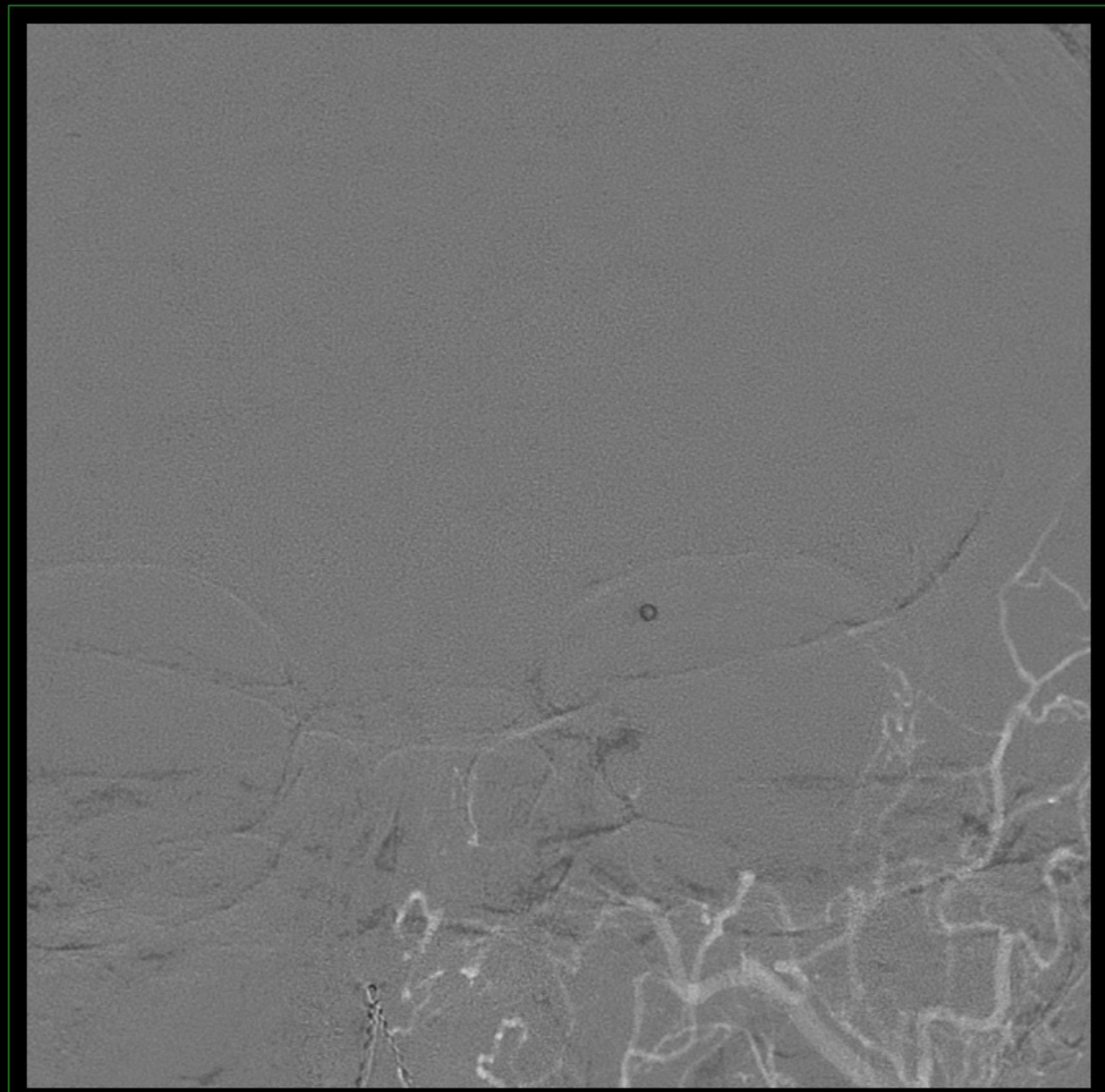


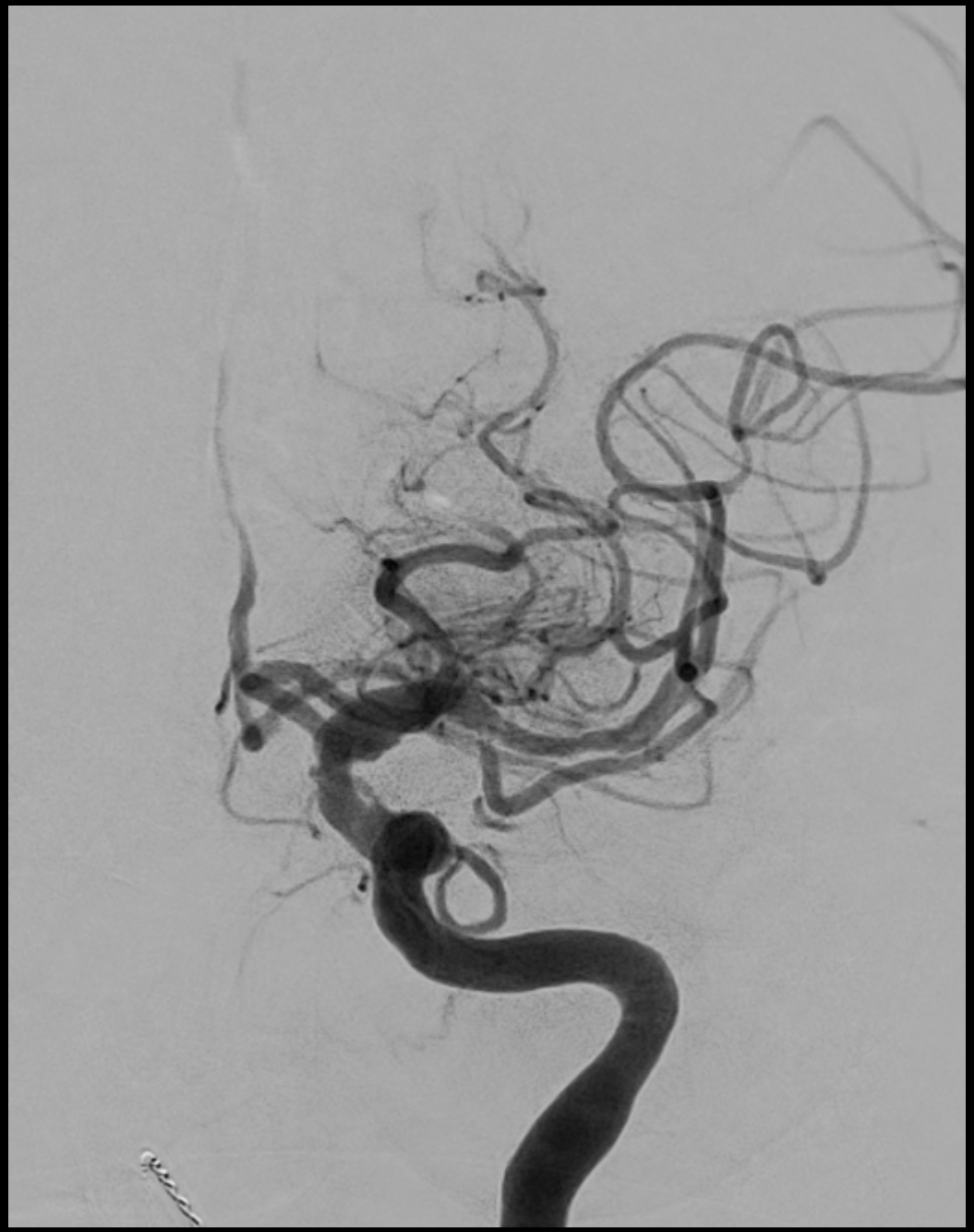


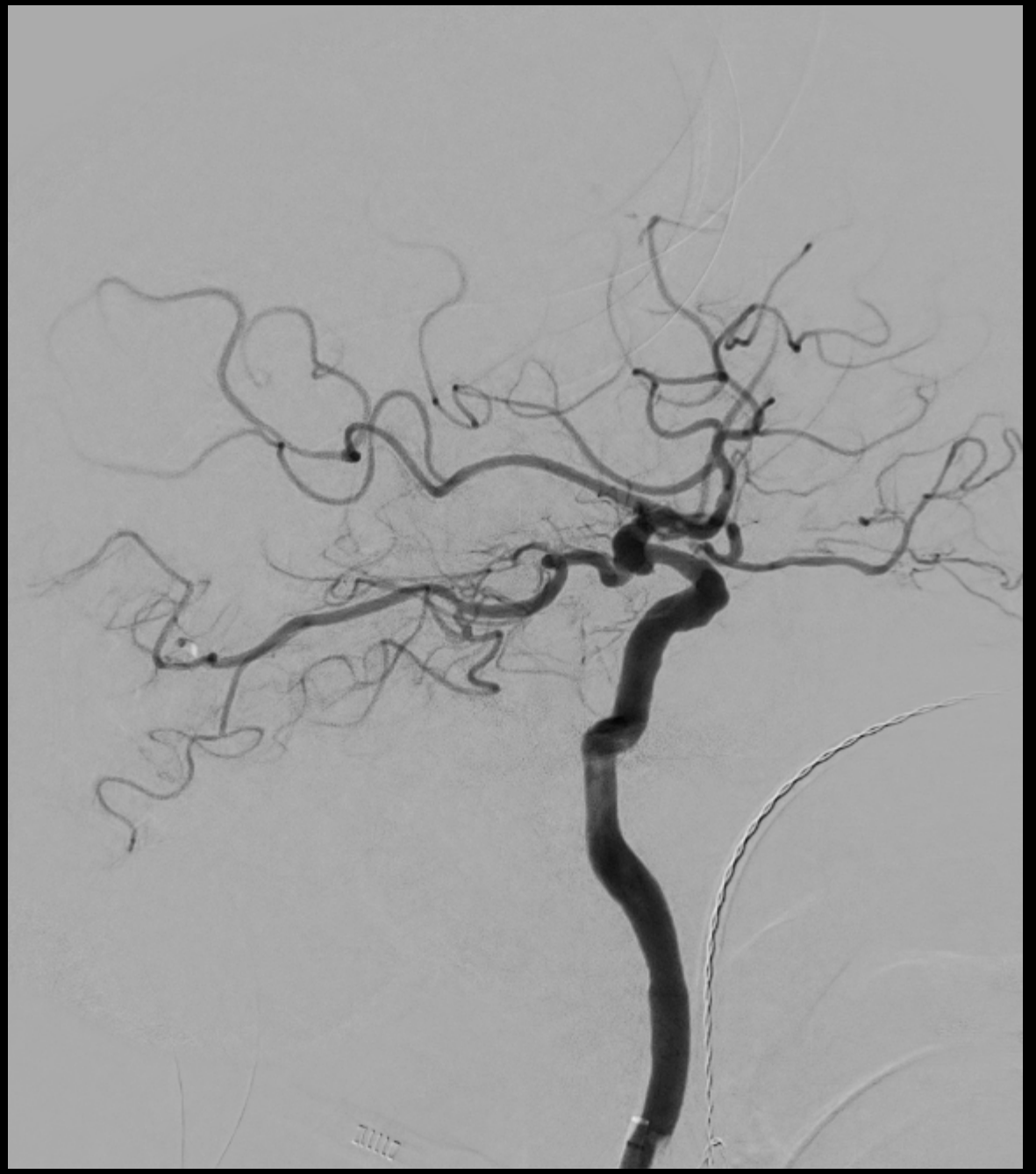


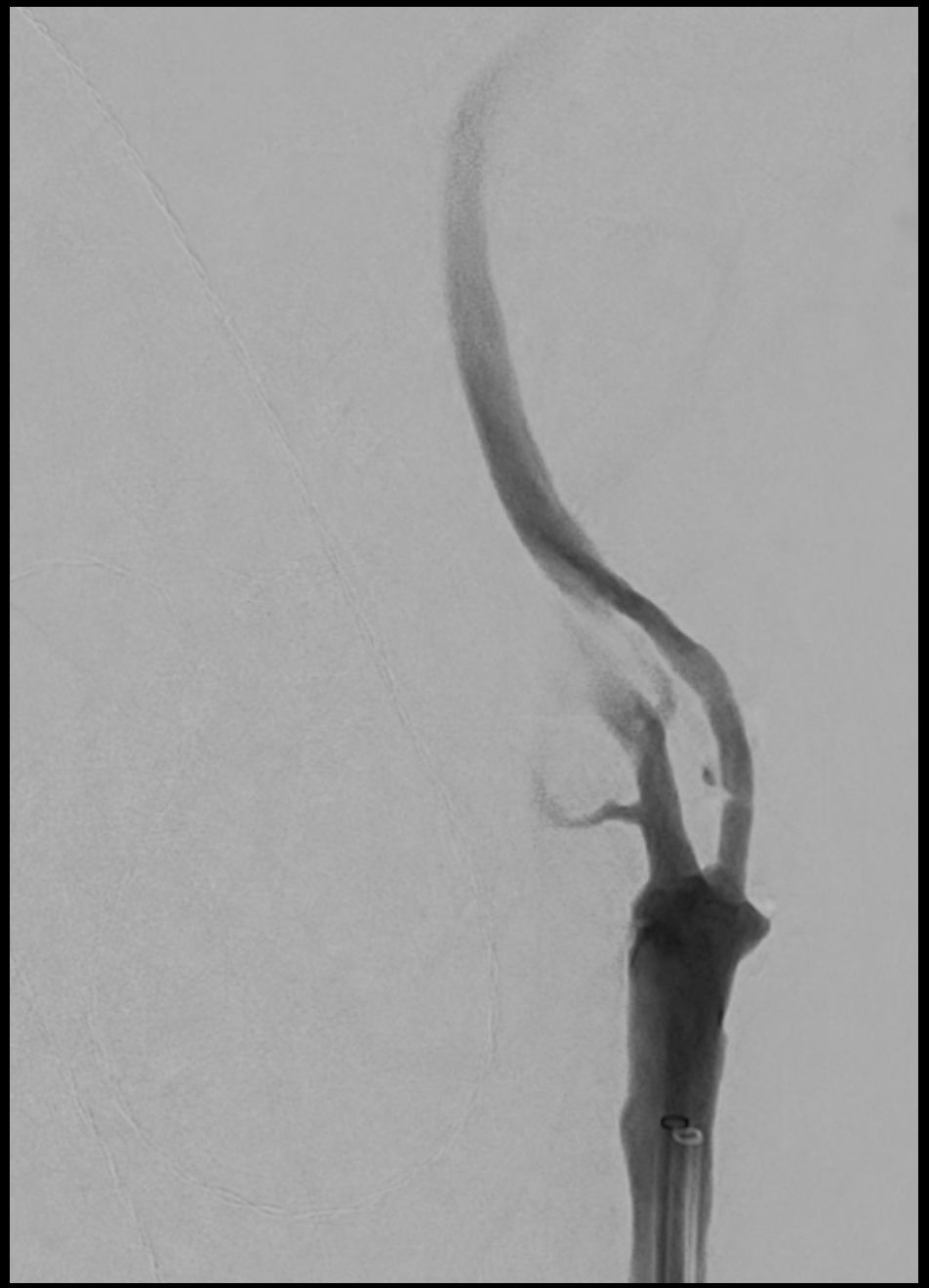

Embotrap 6.5/40mm

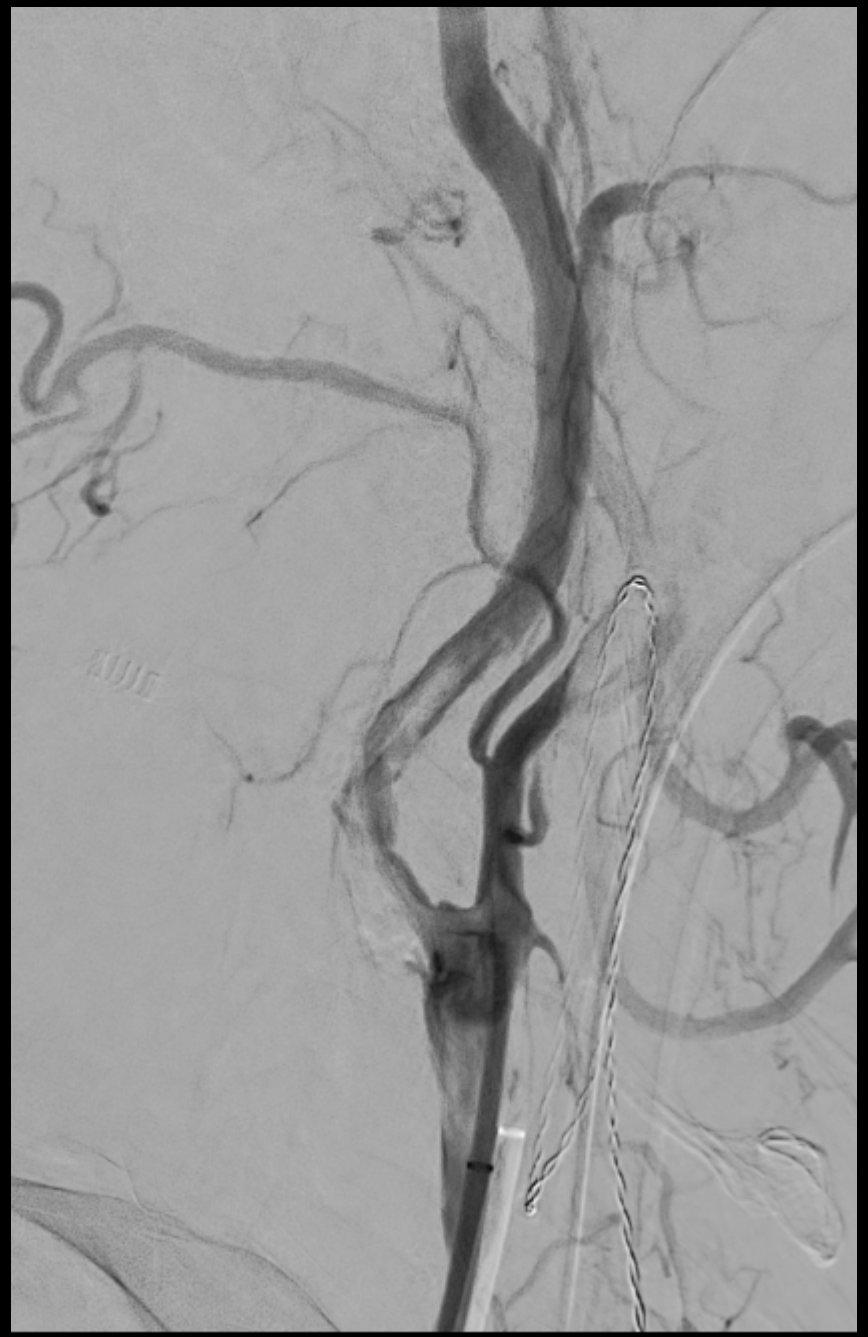


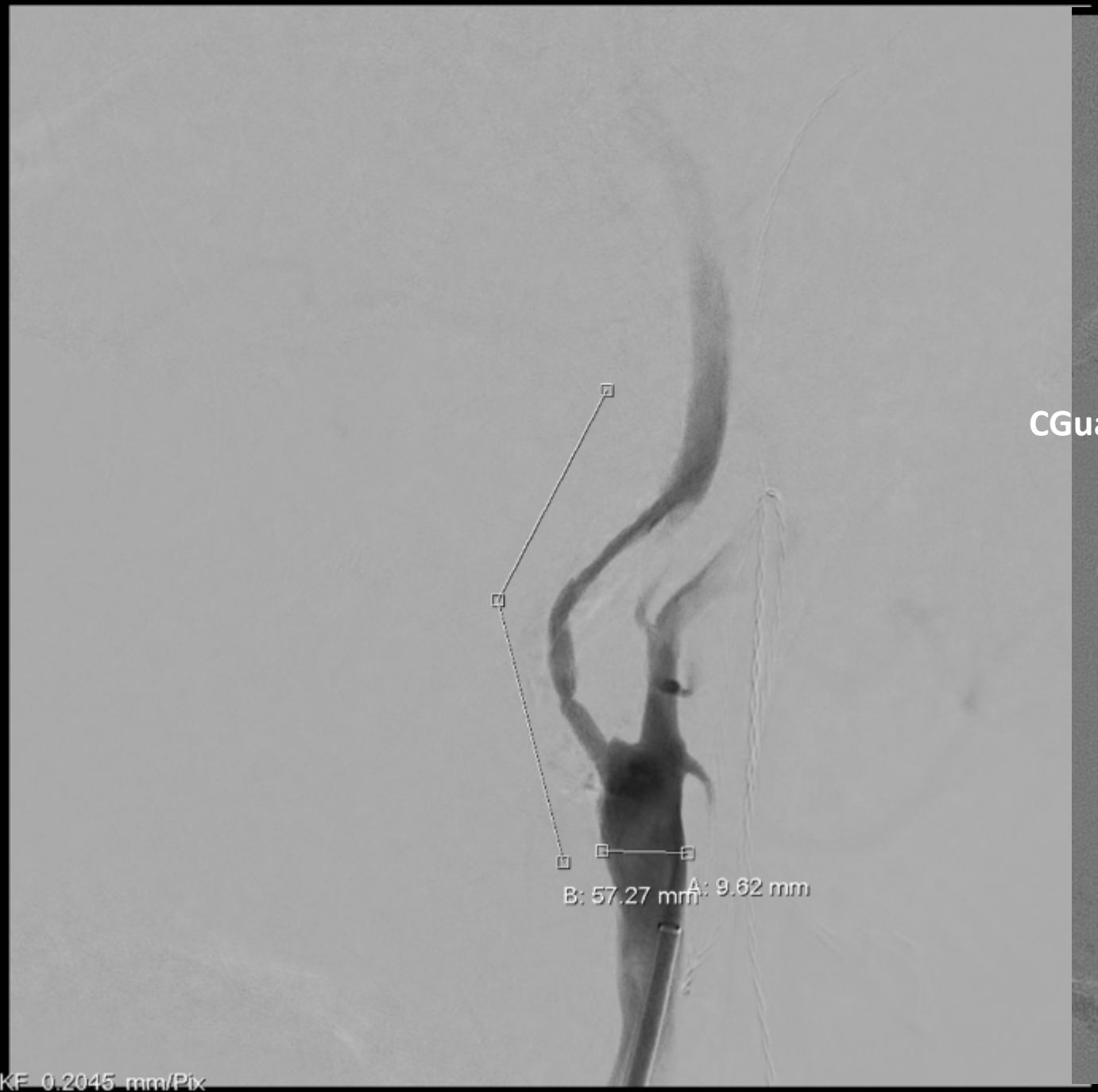

15 mm
(prj)

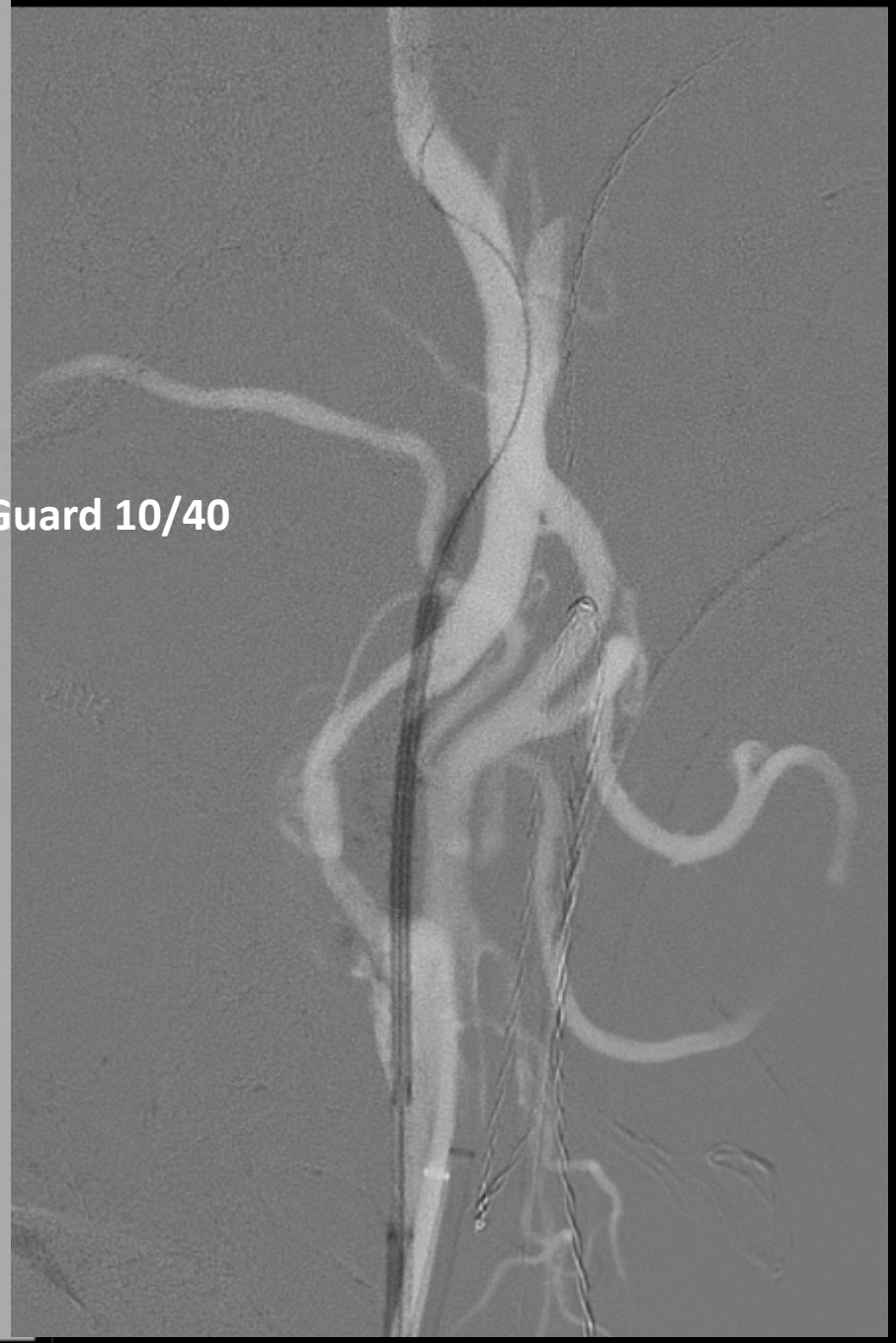




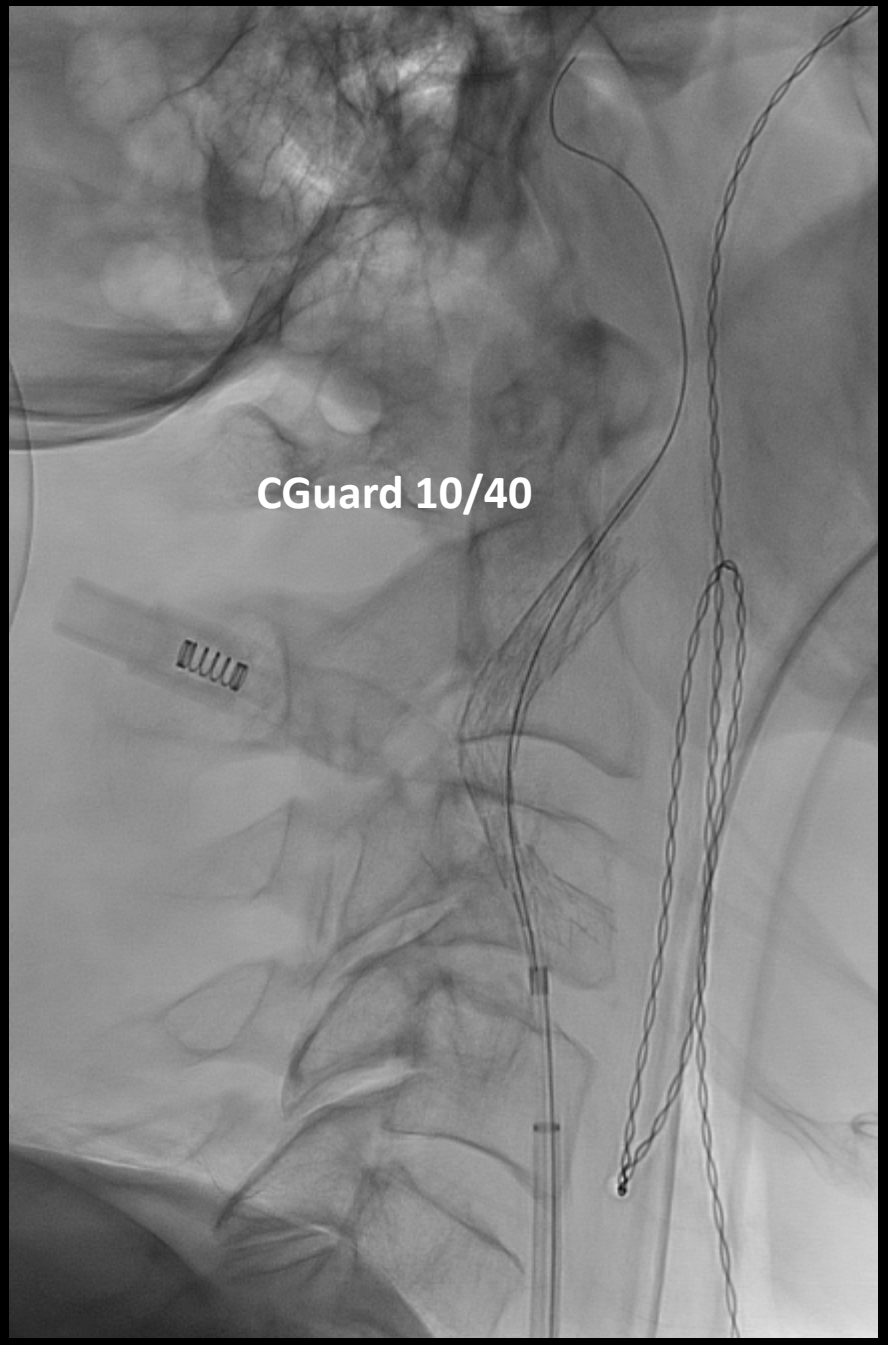


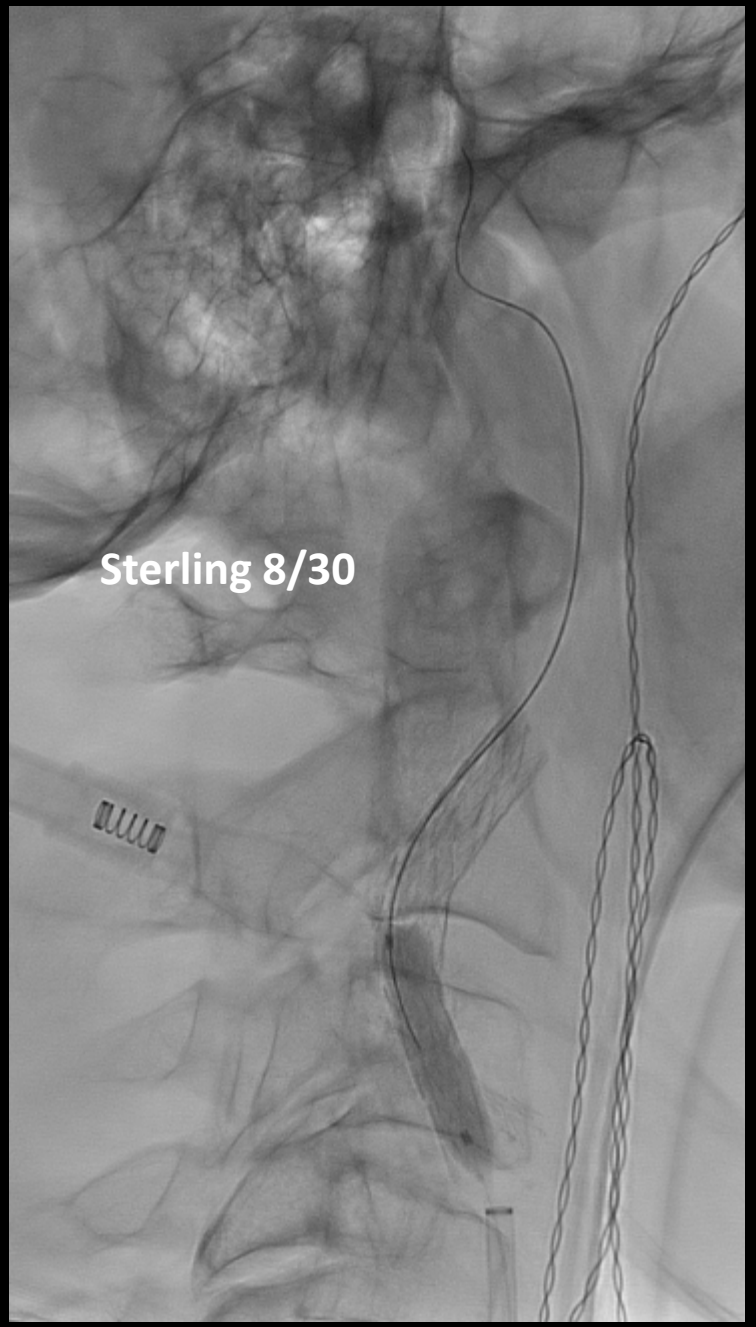


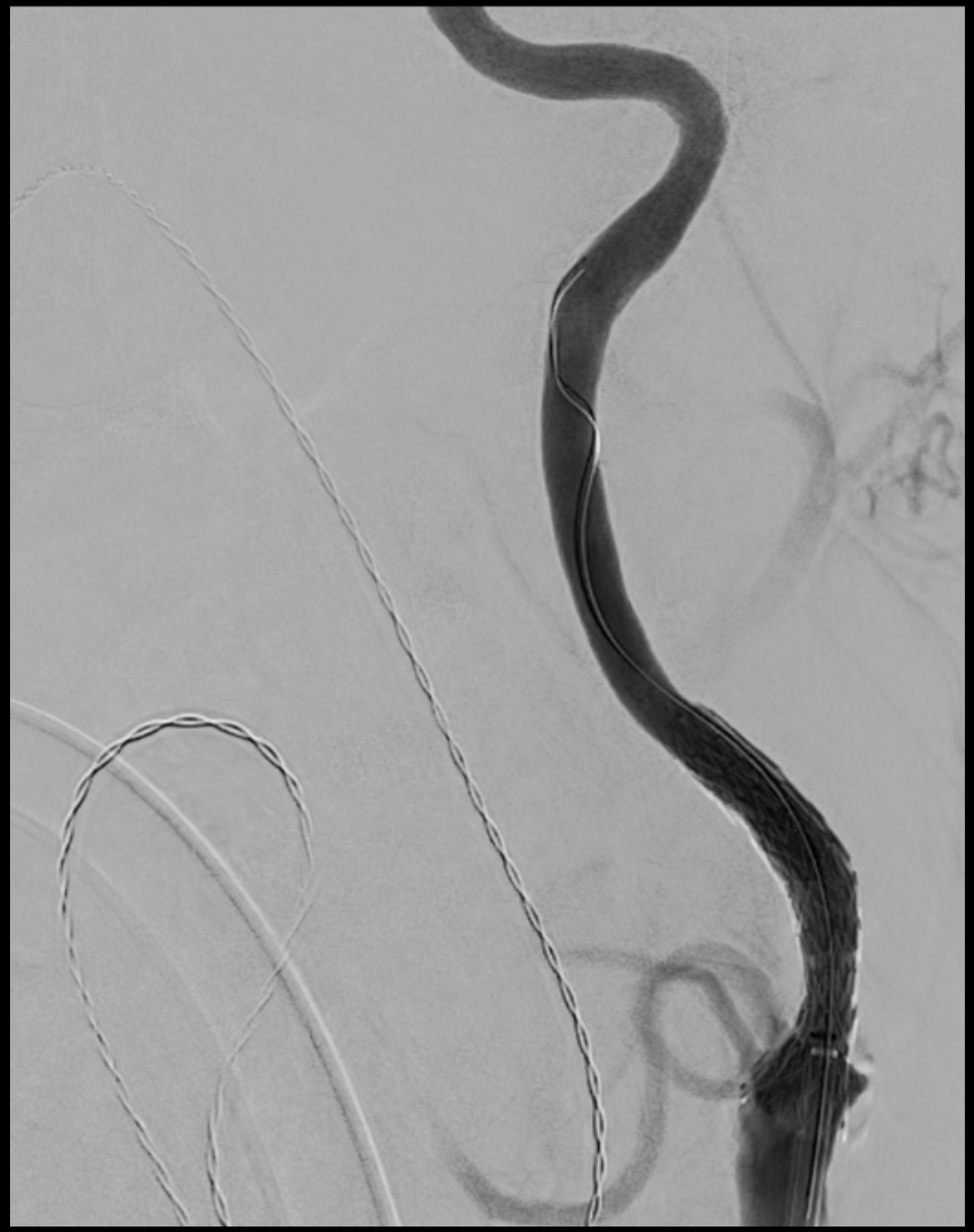


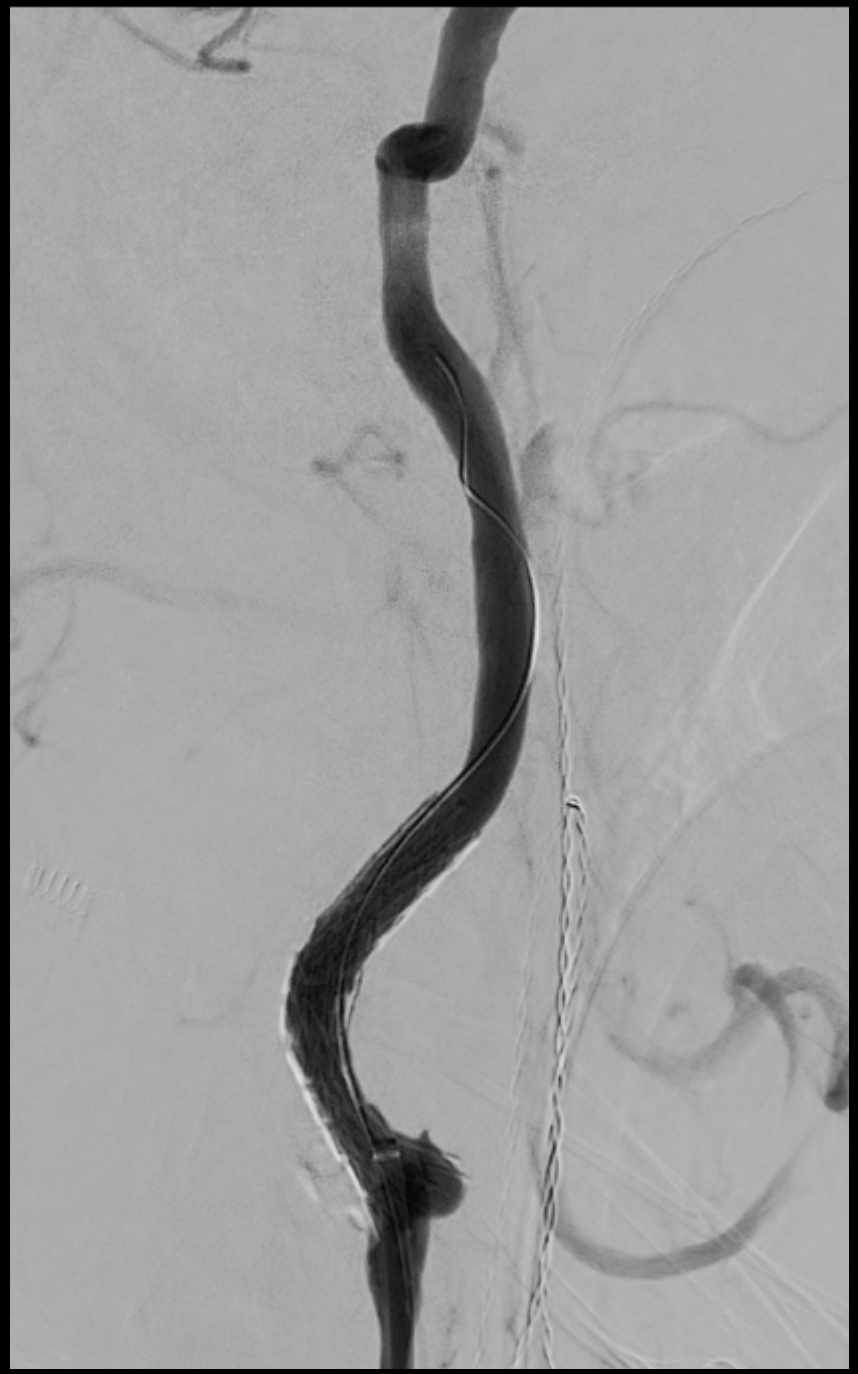


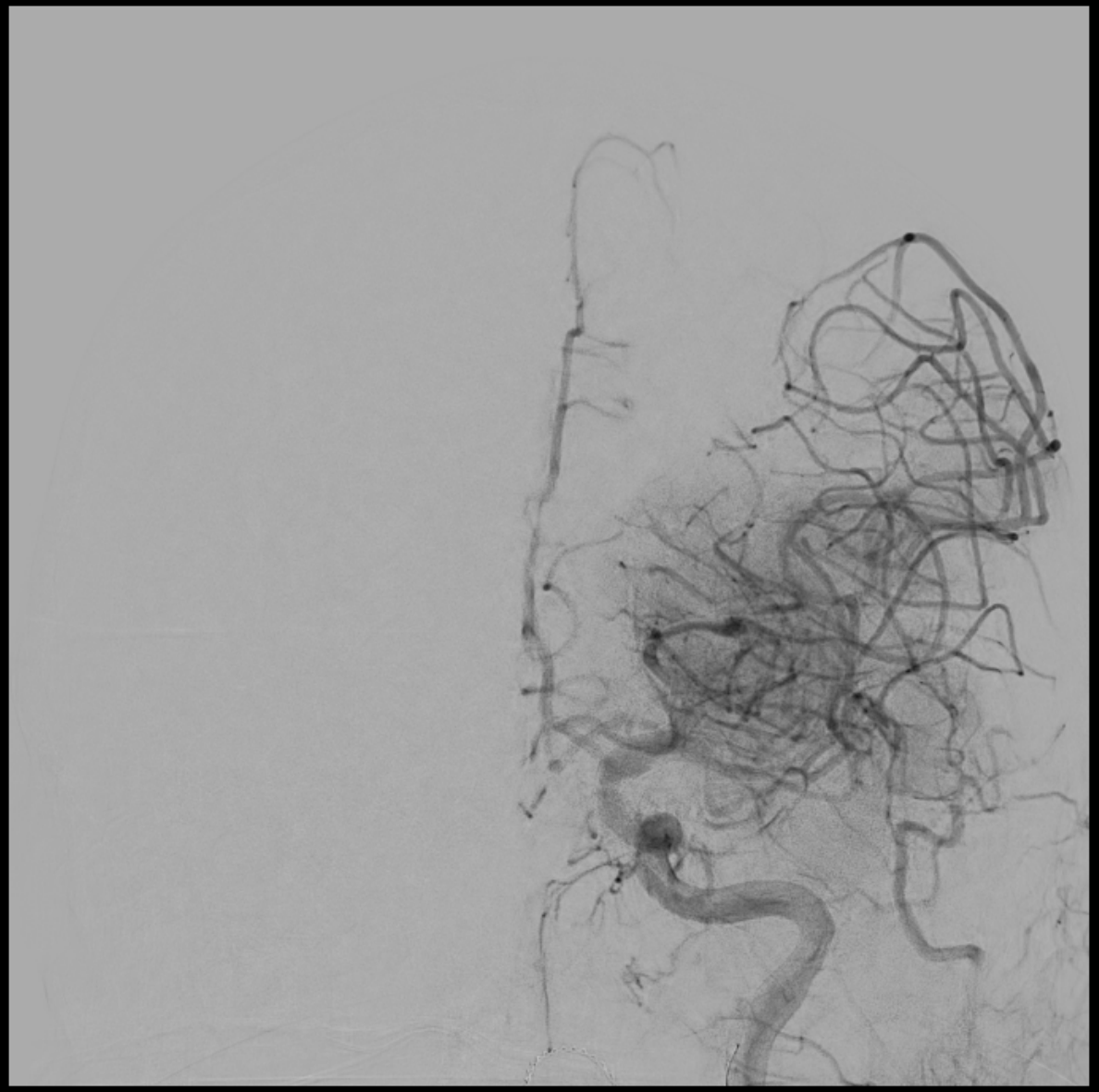
CGuard 10/40

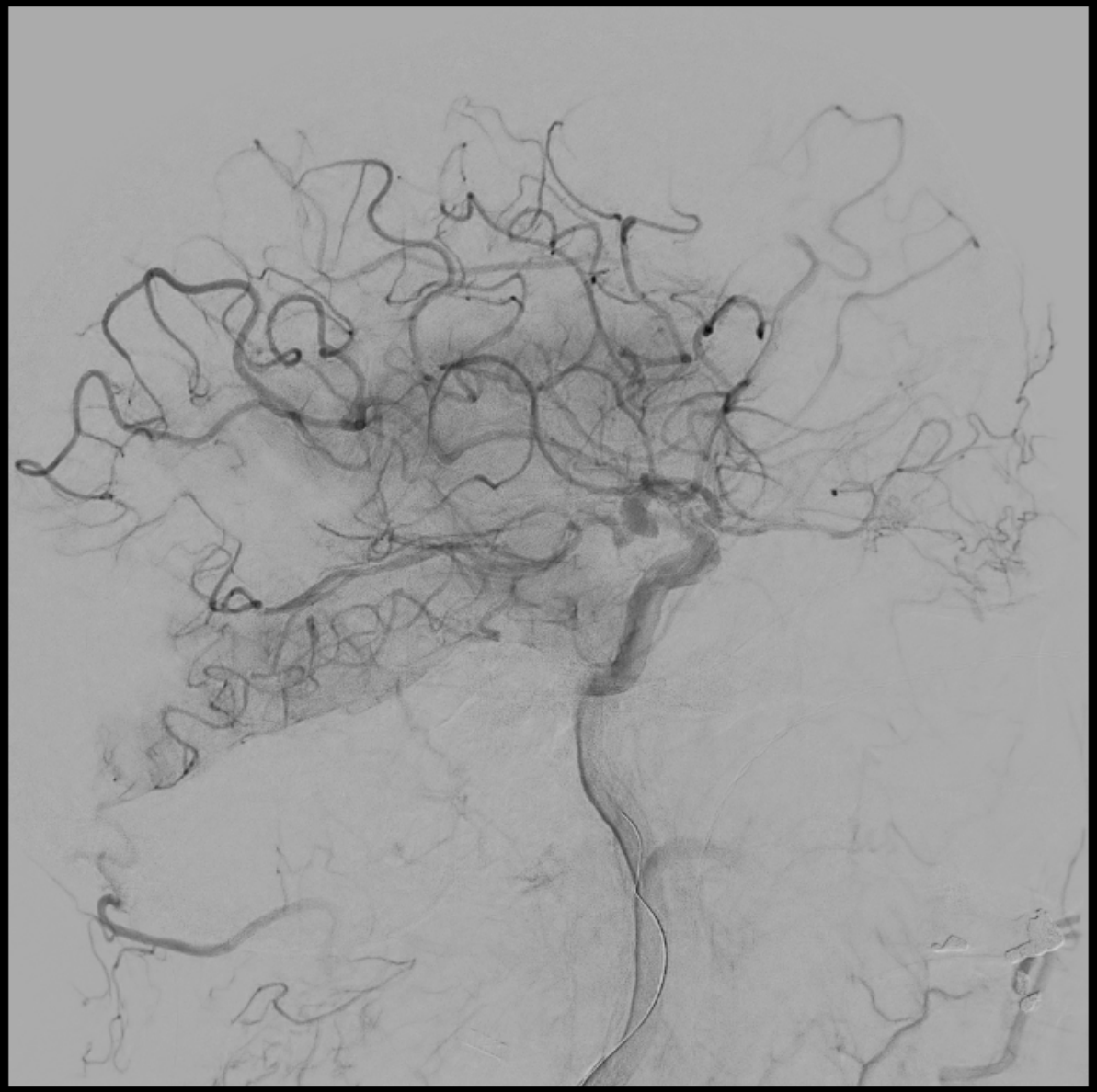

CGuard 10/40


Sterling 8/30







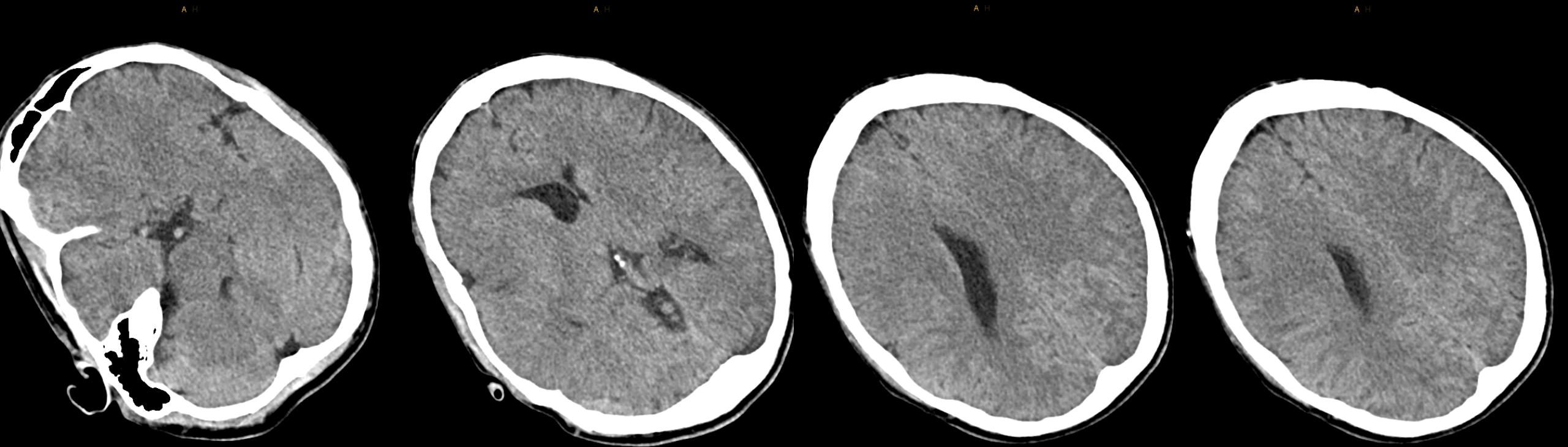


Male, 44 yo

neck pain after minor accident during soccer game

Chiropractic manouver (wife is a physiotherapist)

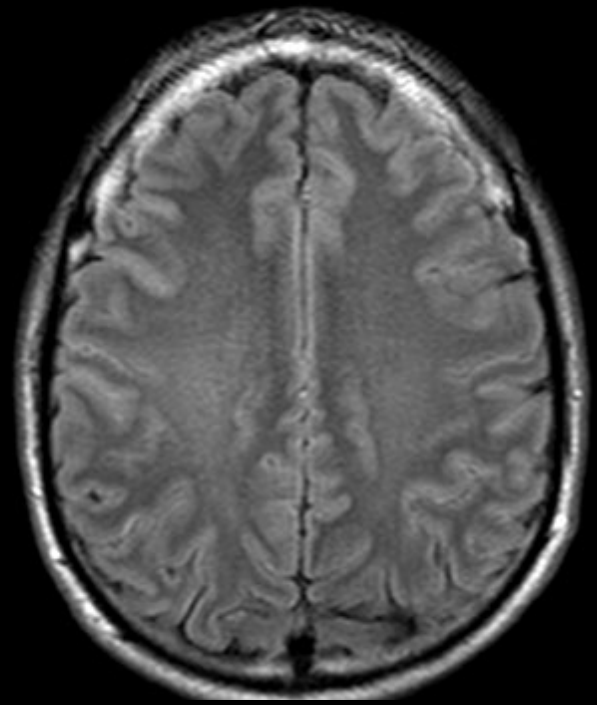
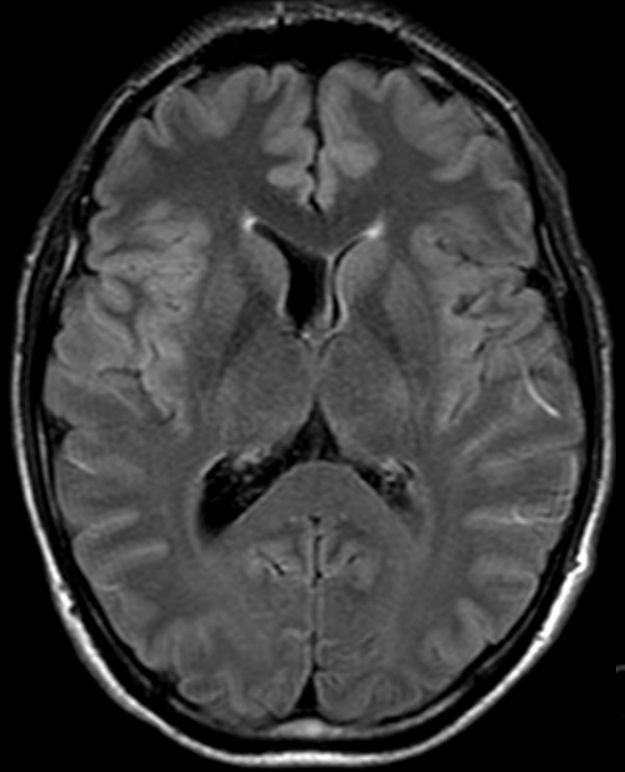
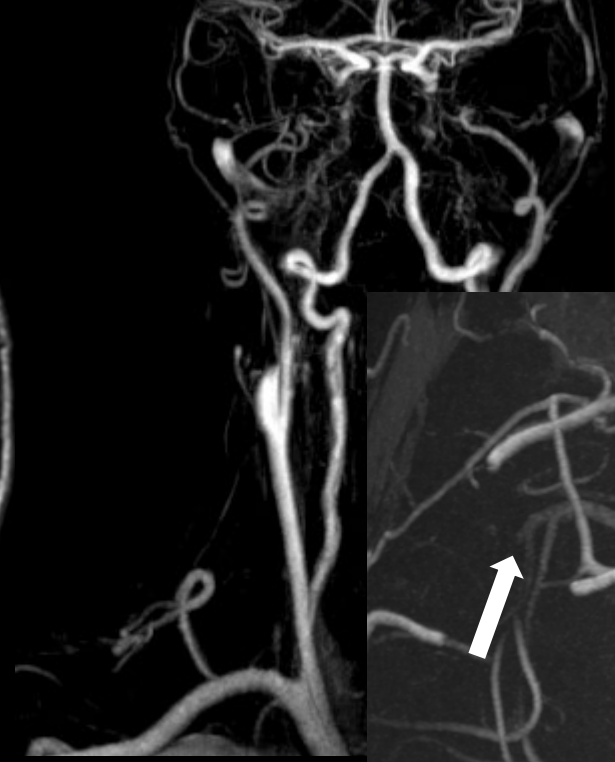
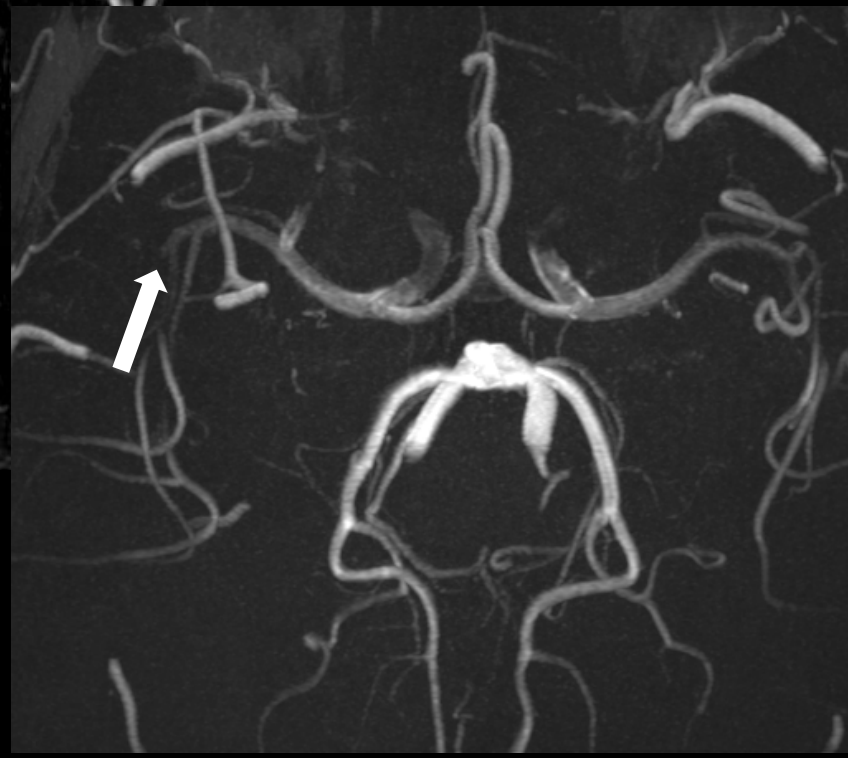
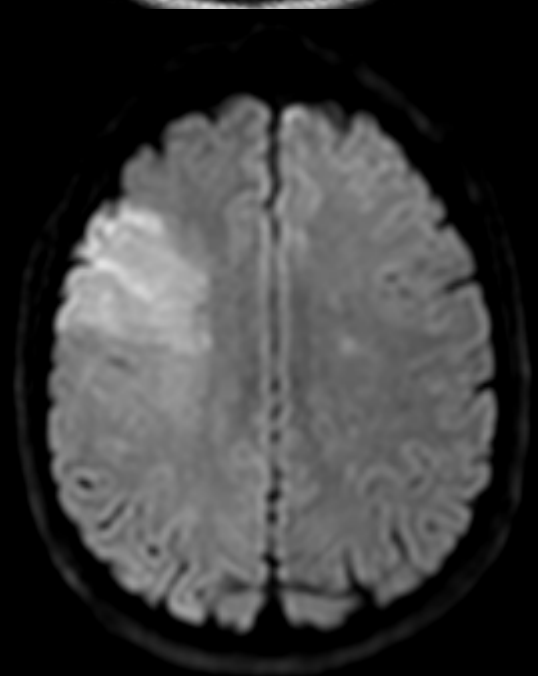
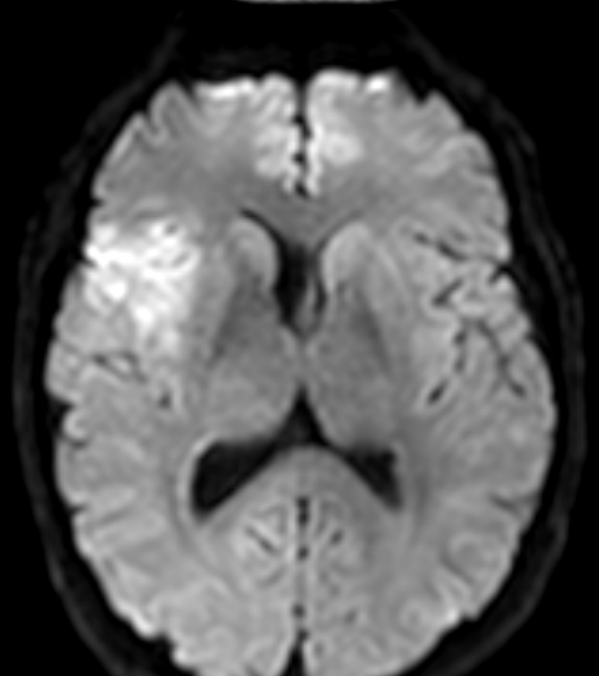
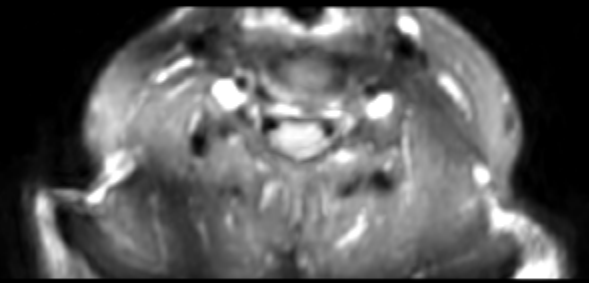
8pm: Hemiparesis of the left side (NIHSS 10)


A H
A H
A H
A H

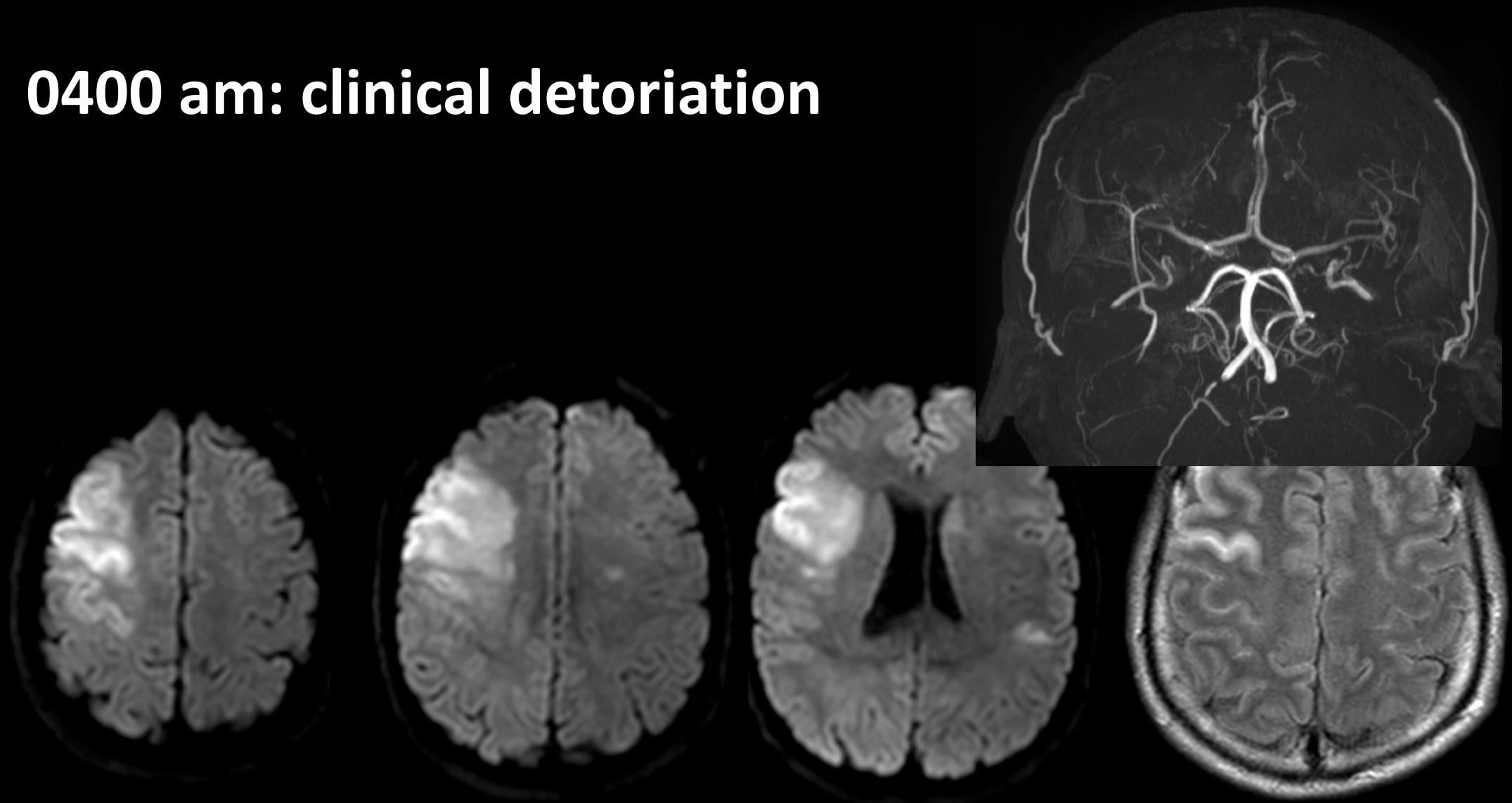
2am: arrival at our institution

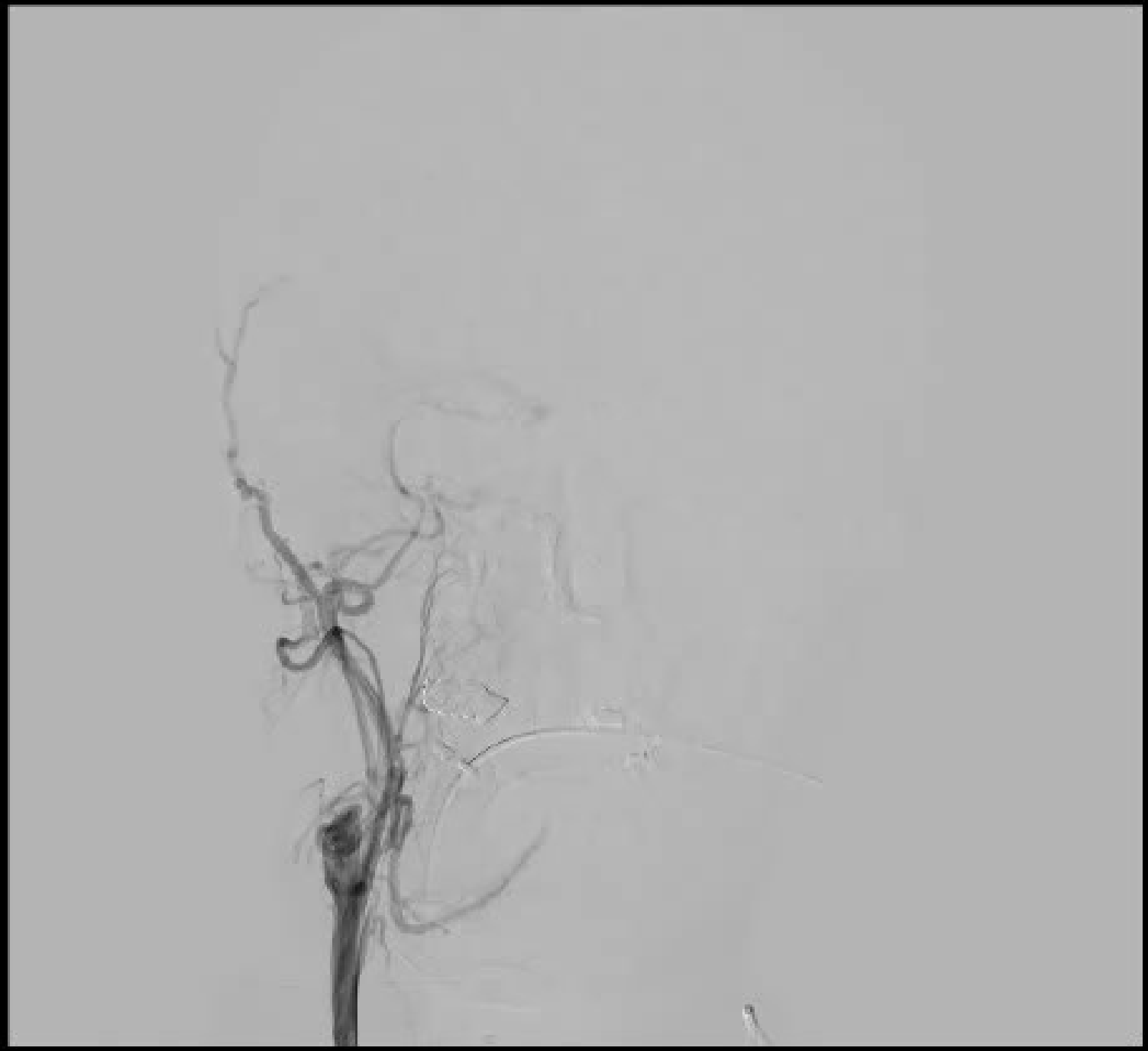
IV lysis was done

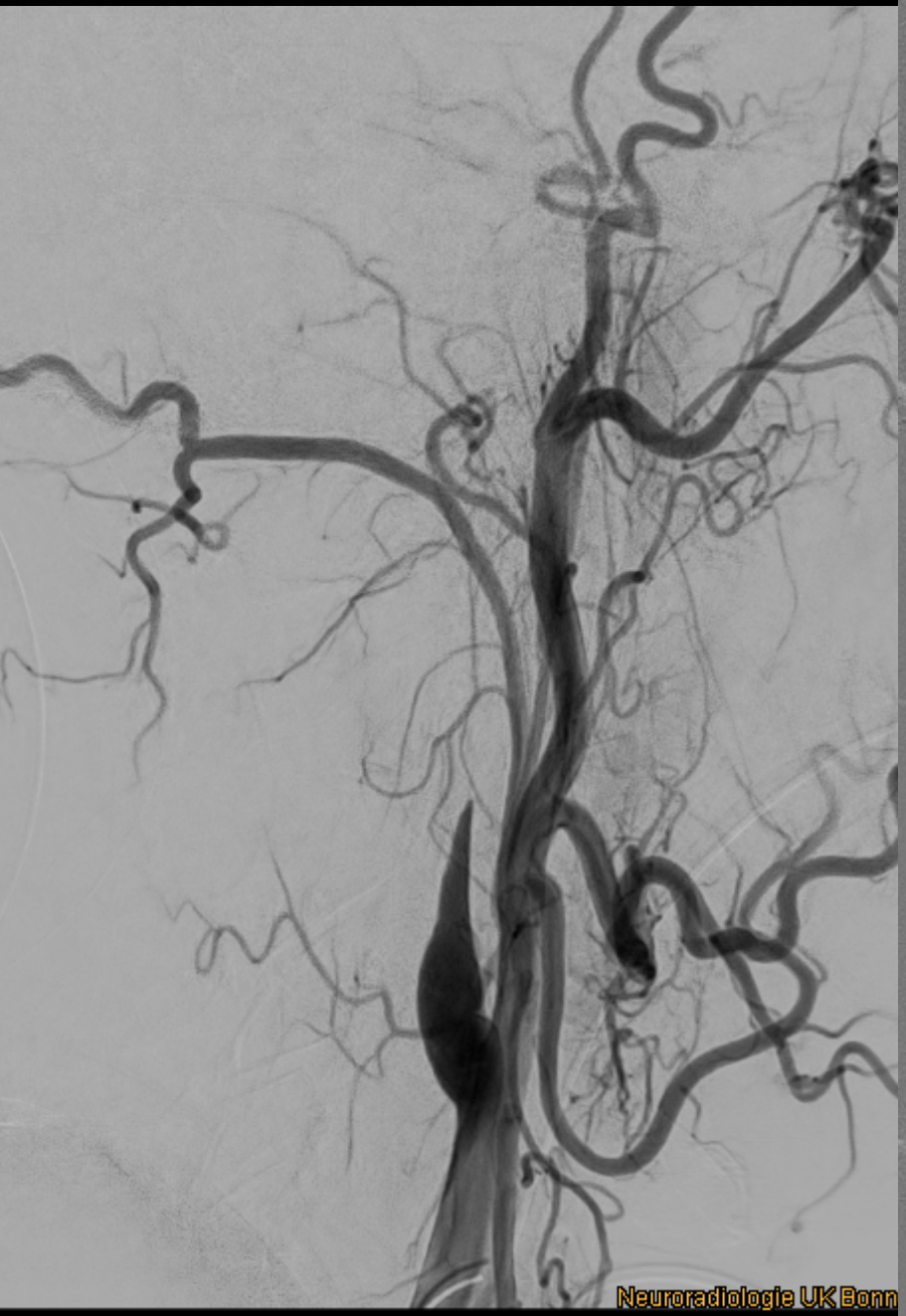
Hemiparesis now mild (NIHSS 4)

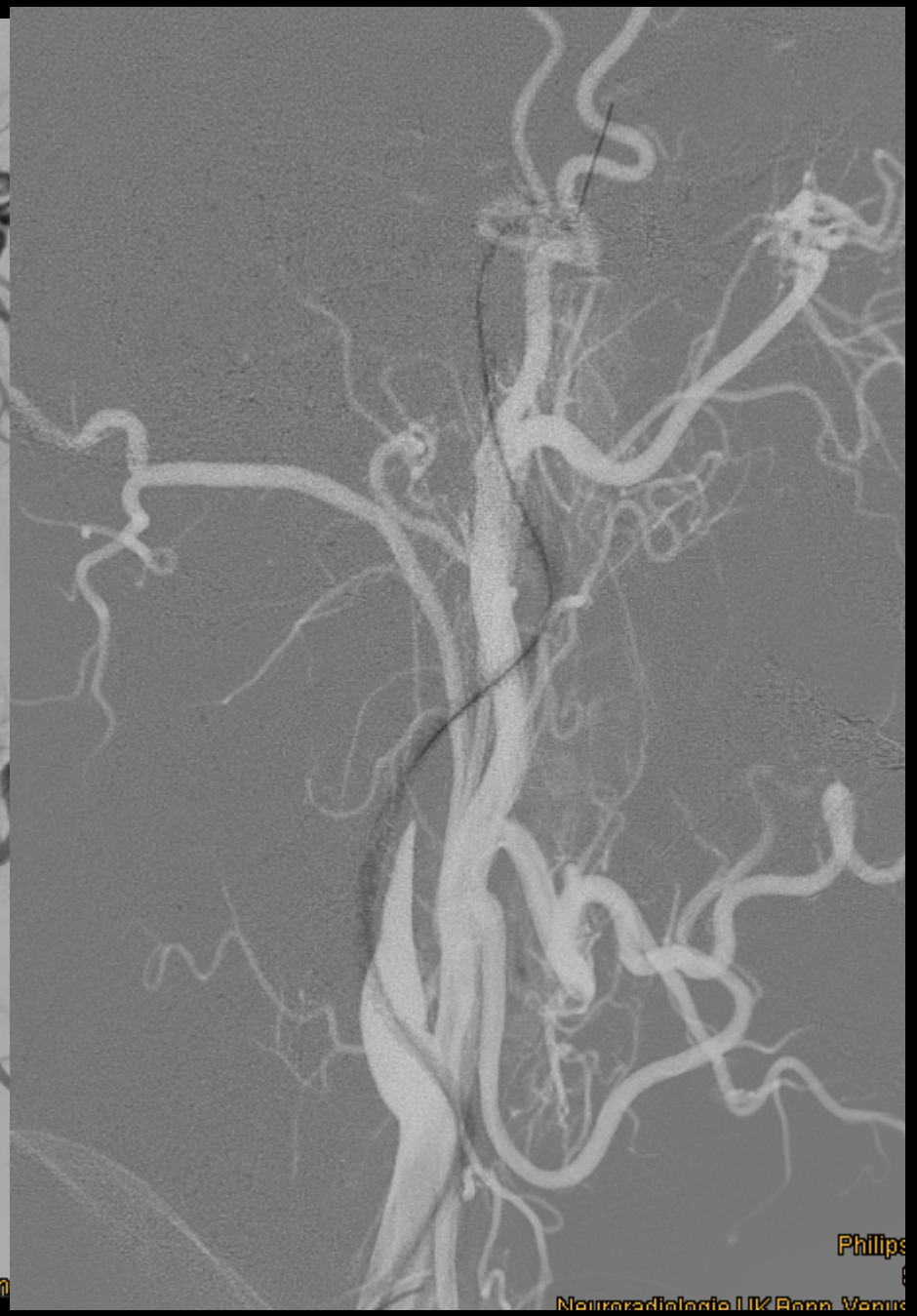








0400 am: clinical detoriation

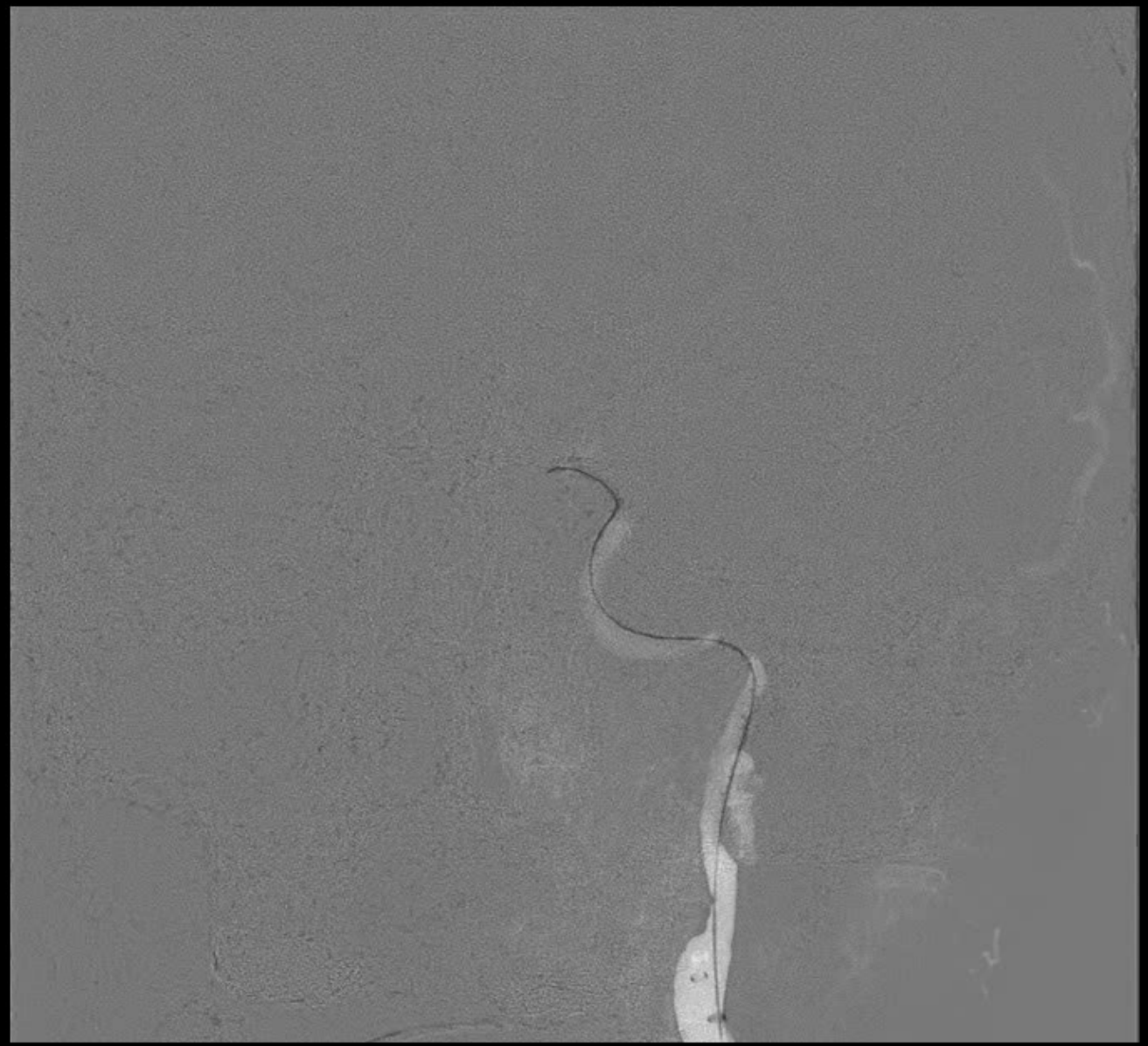


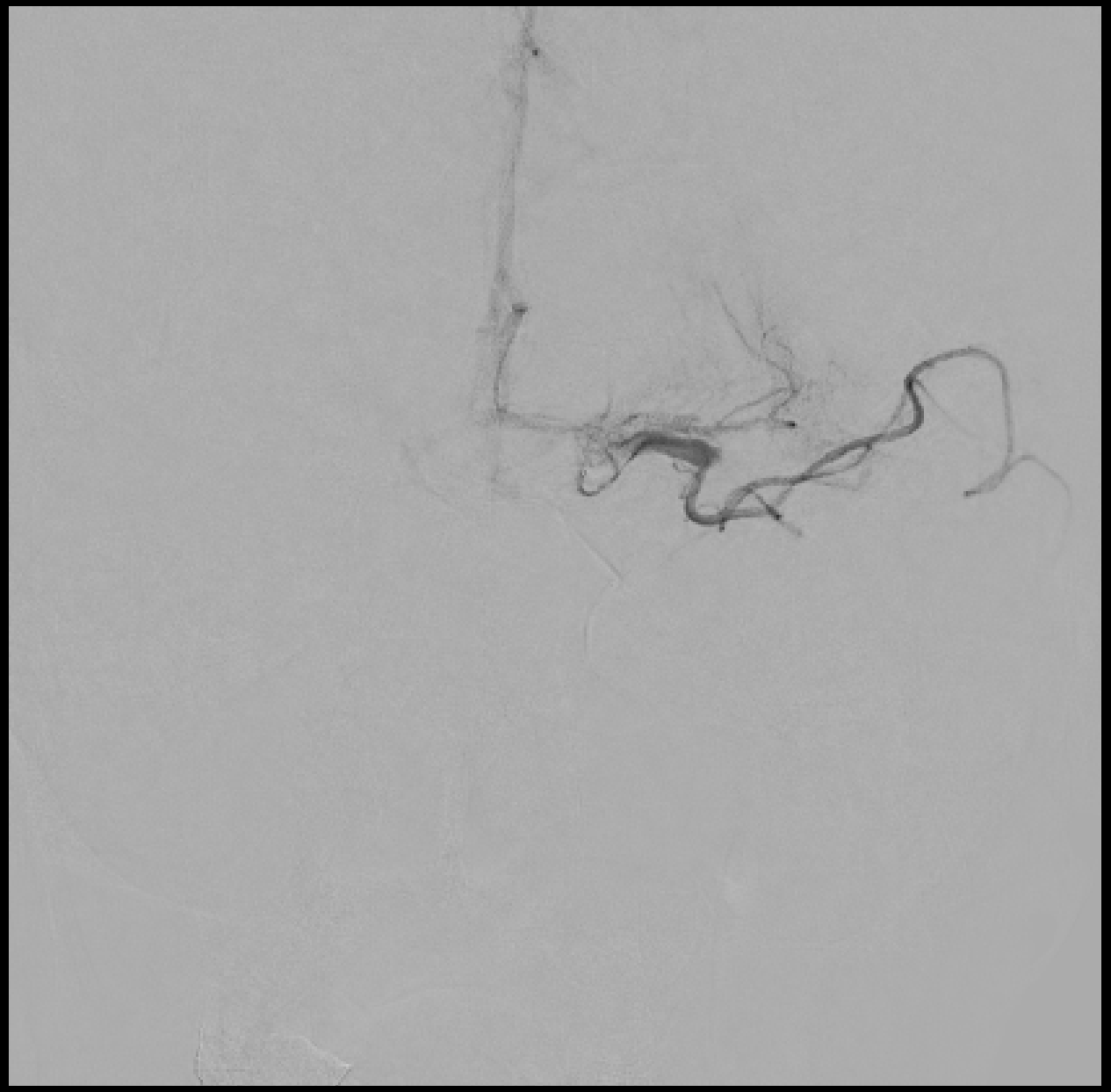


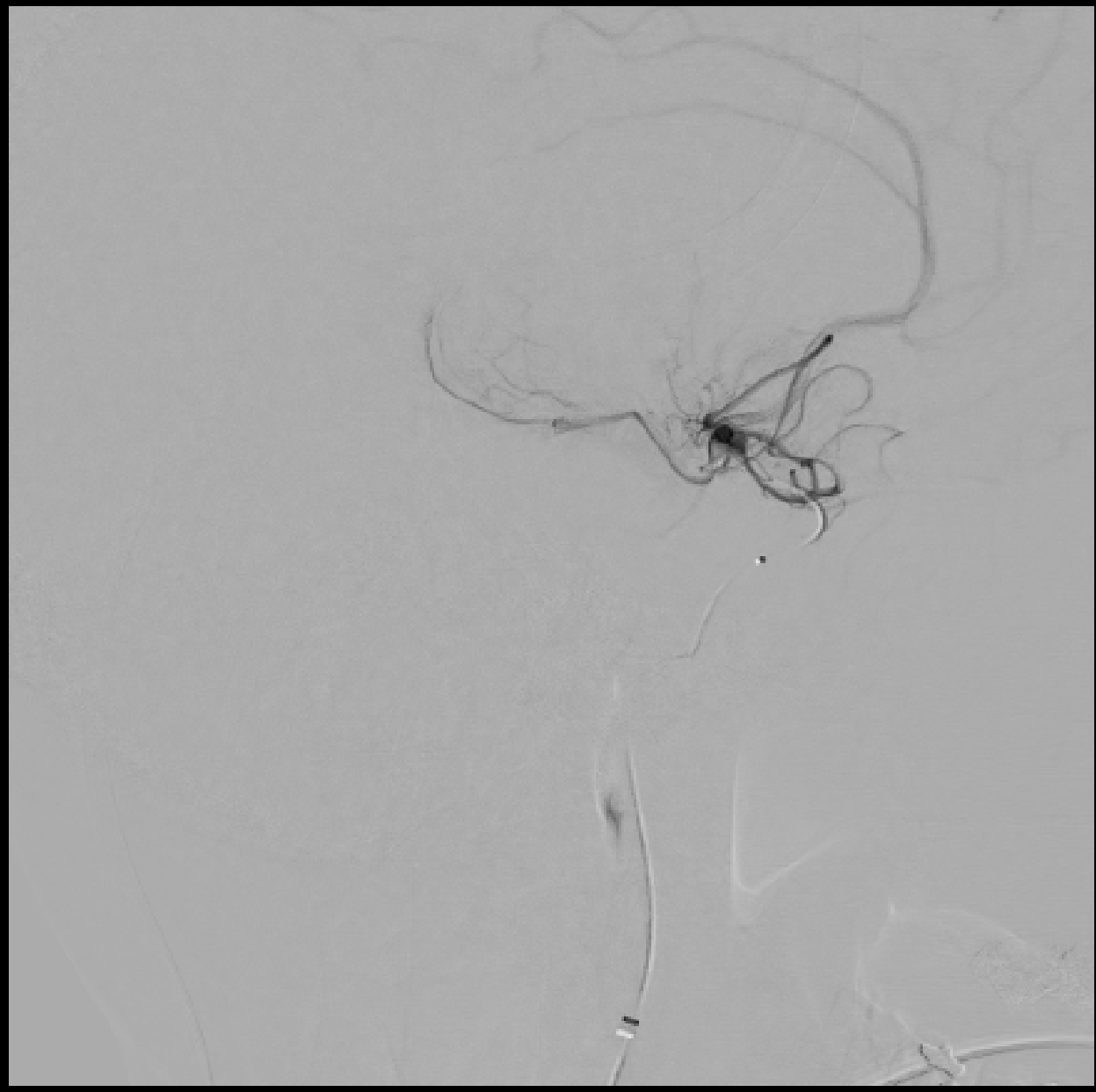


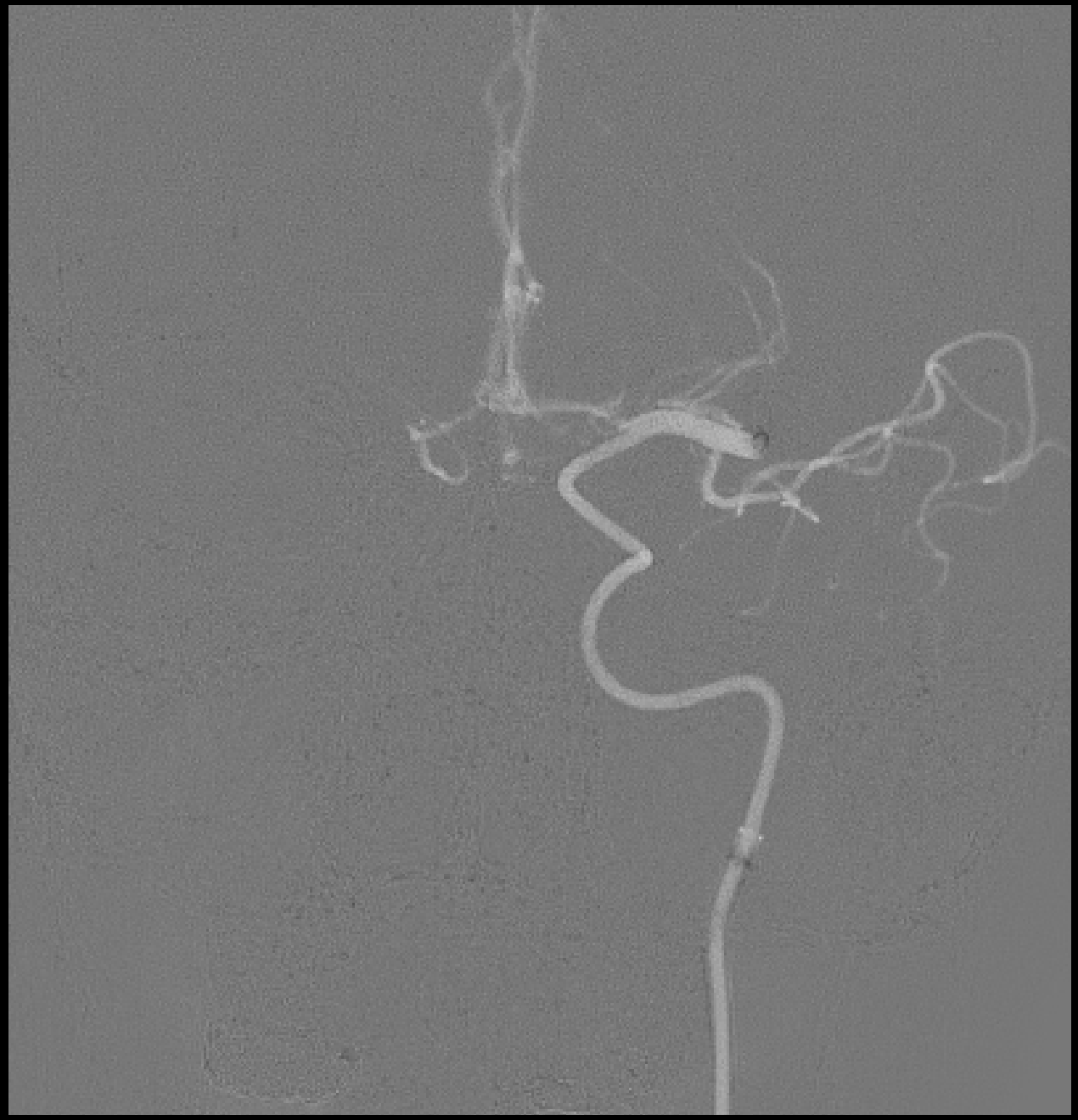


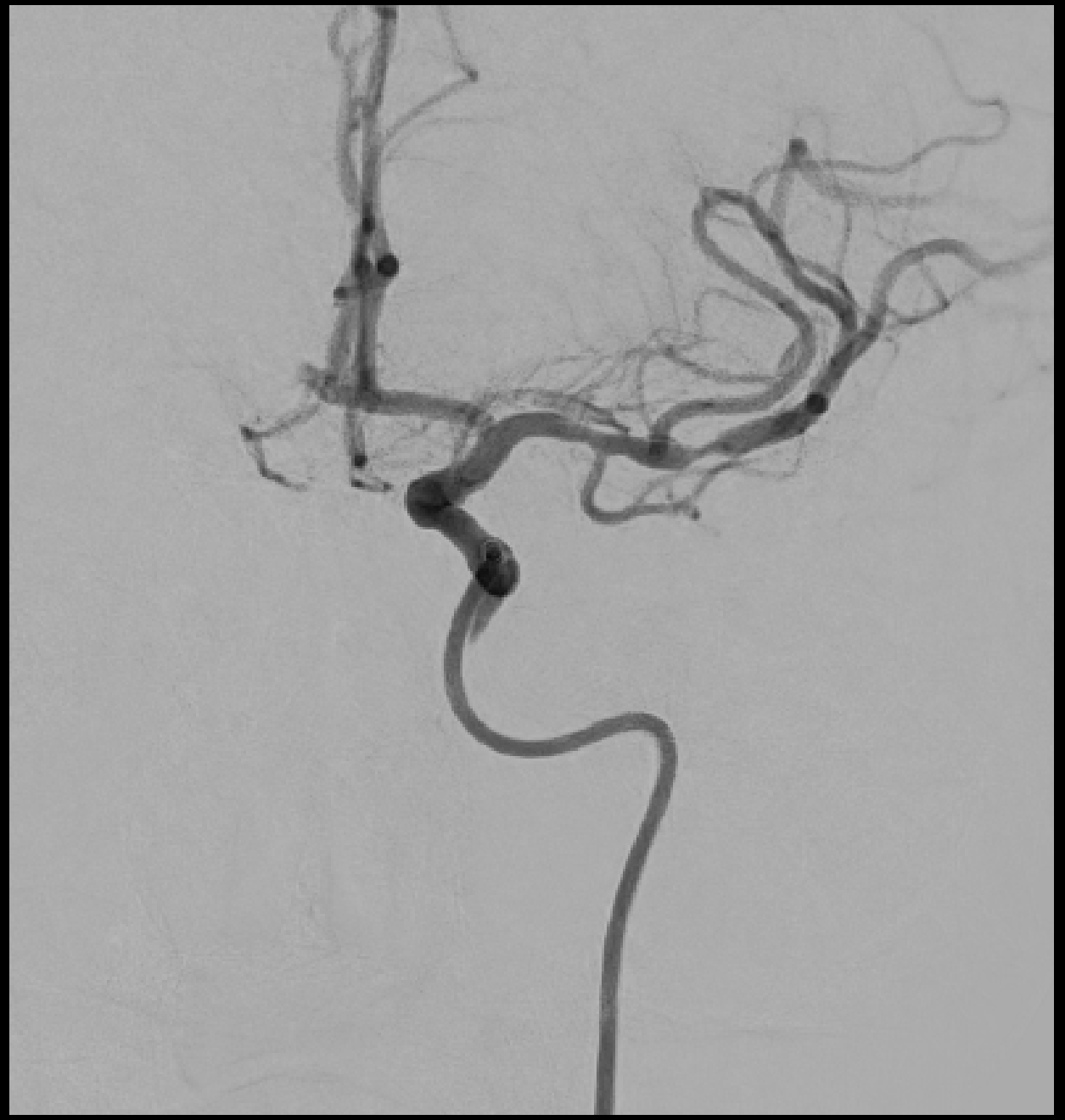
8F Vista Brite Tip
RED 068
Neuroslider 021
Synchro-14

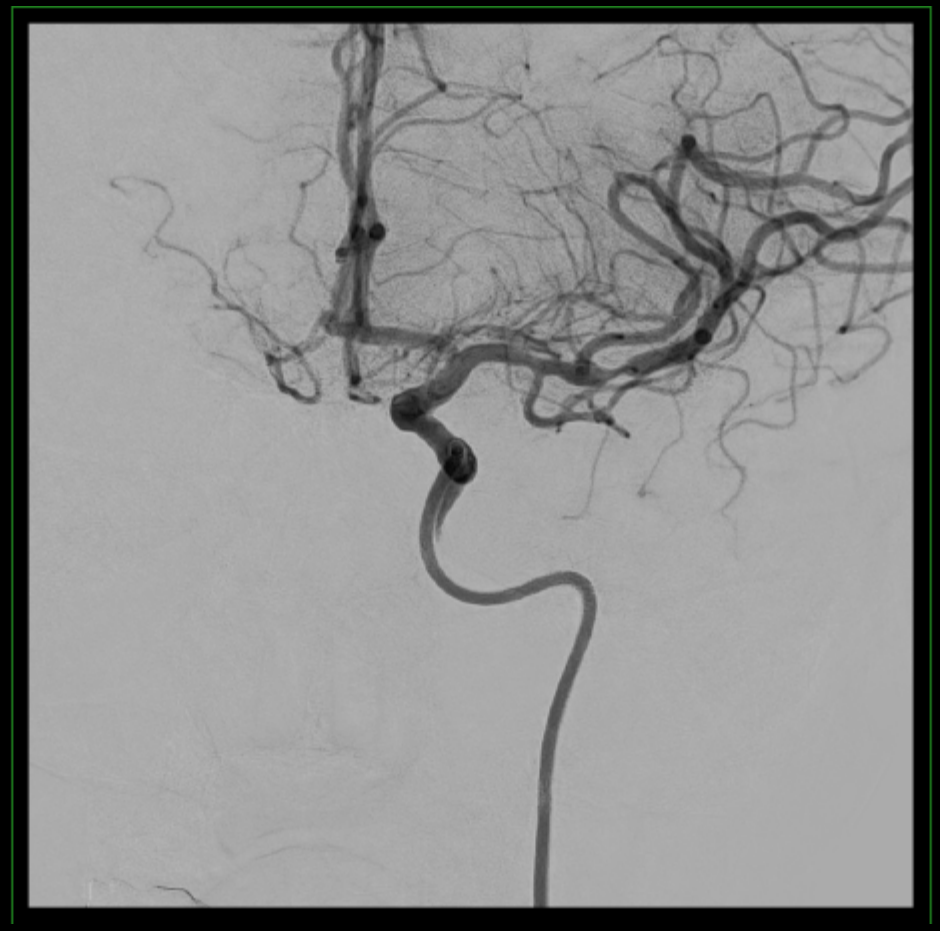

20 mm
(prj)

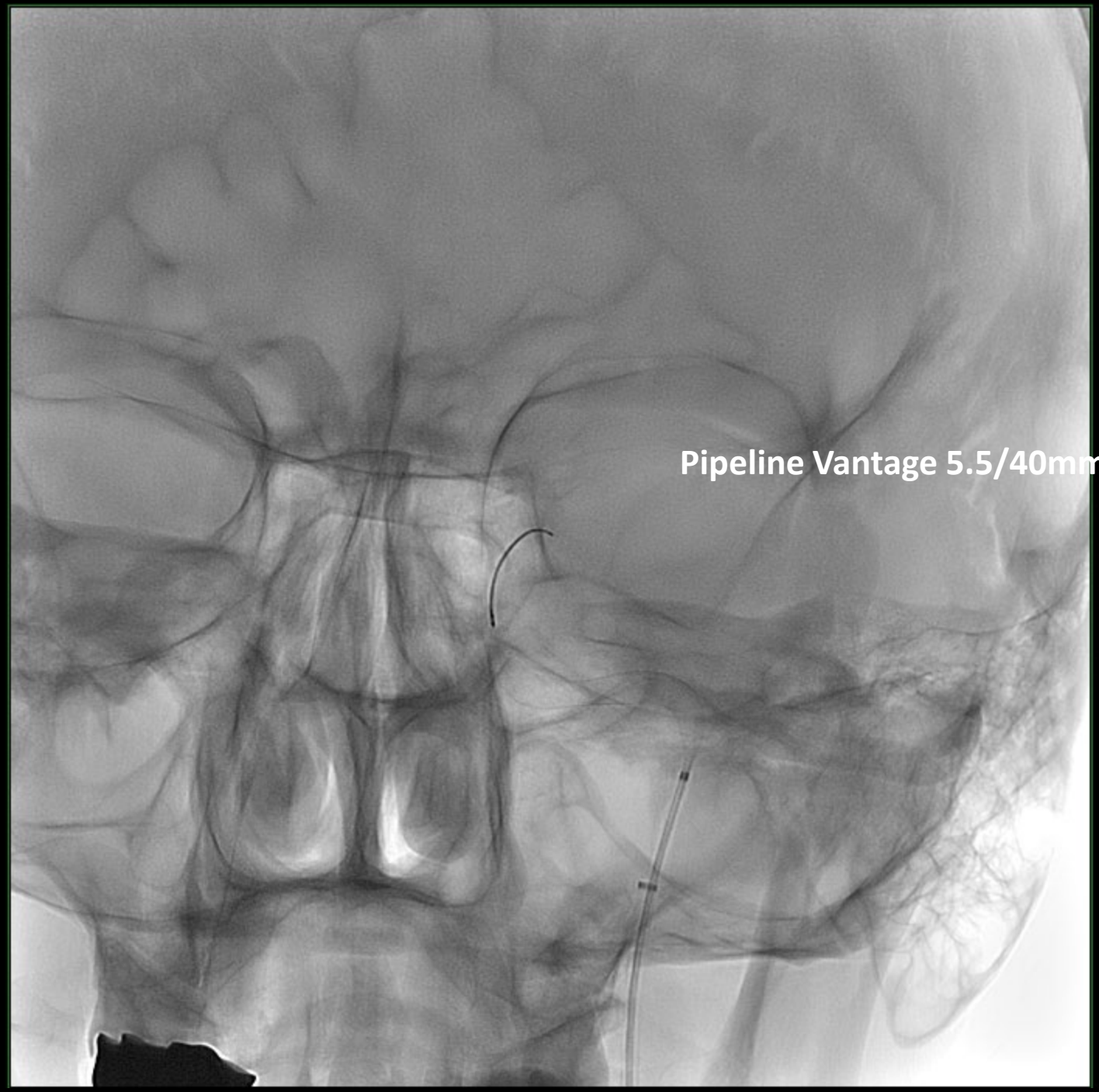


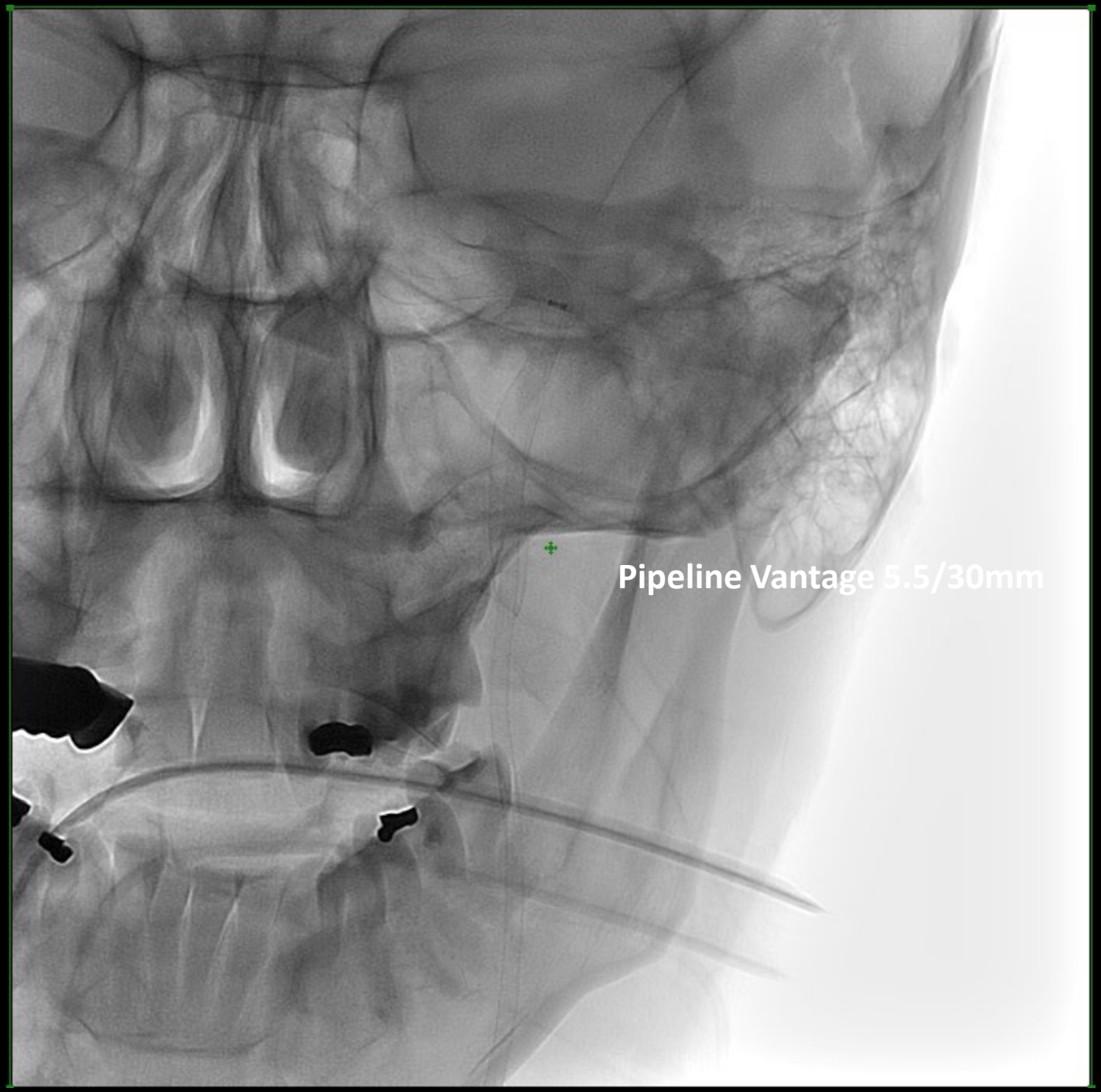


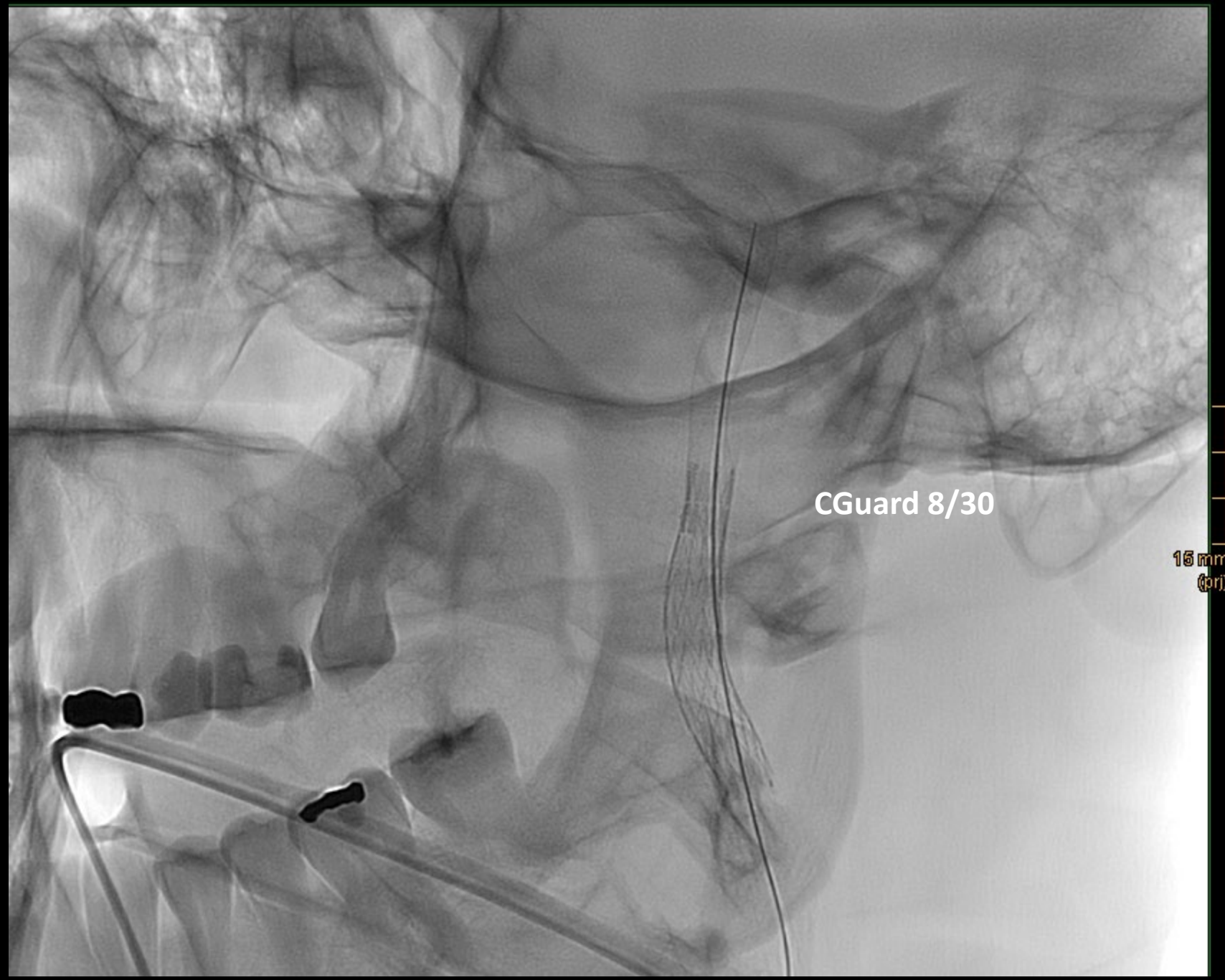


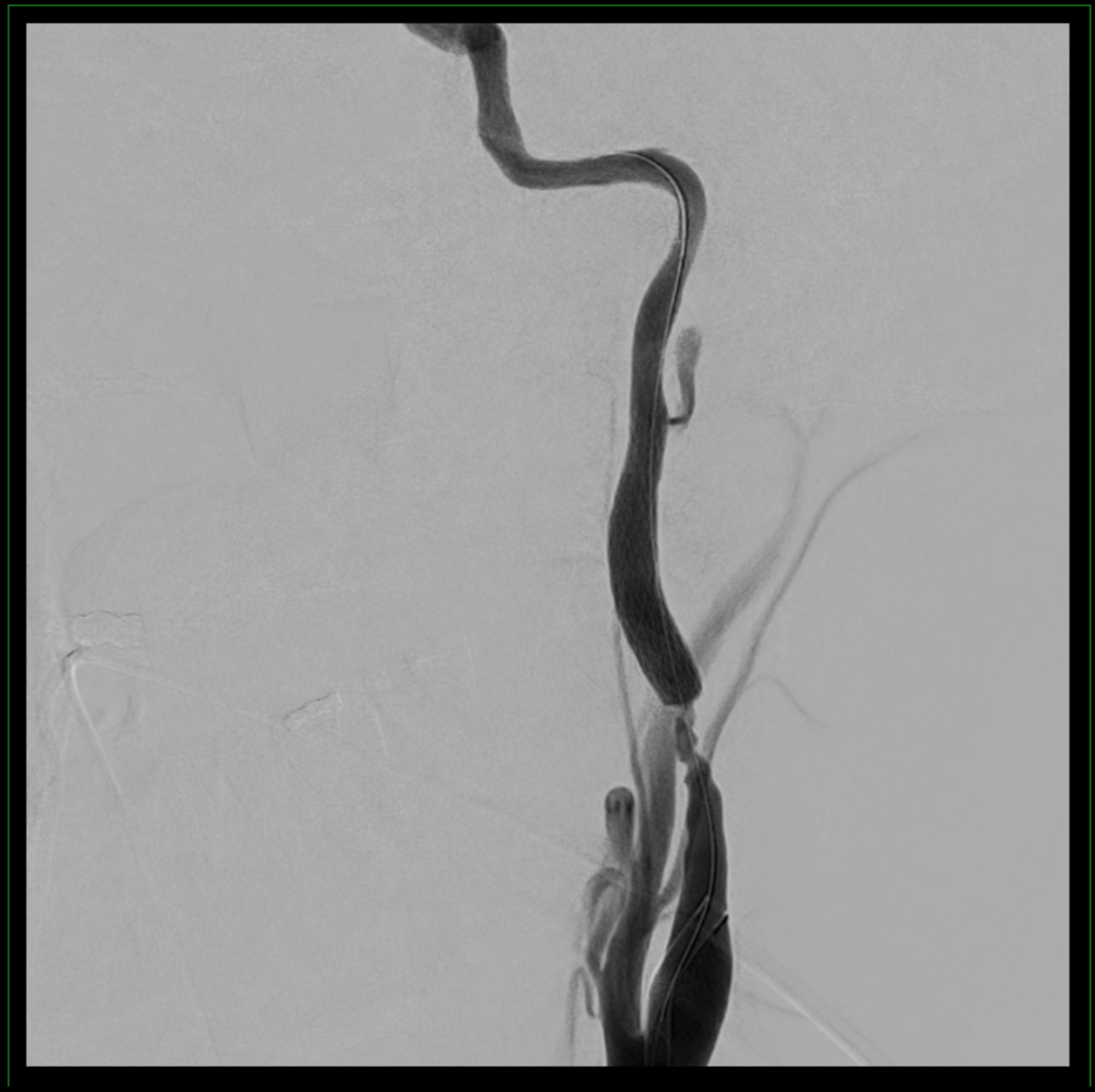


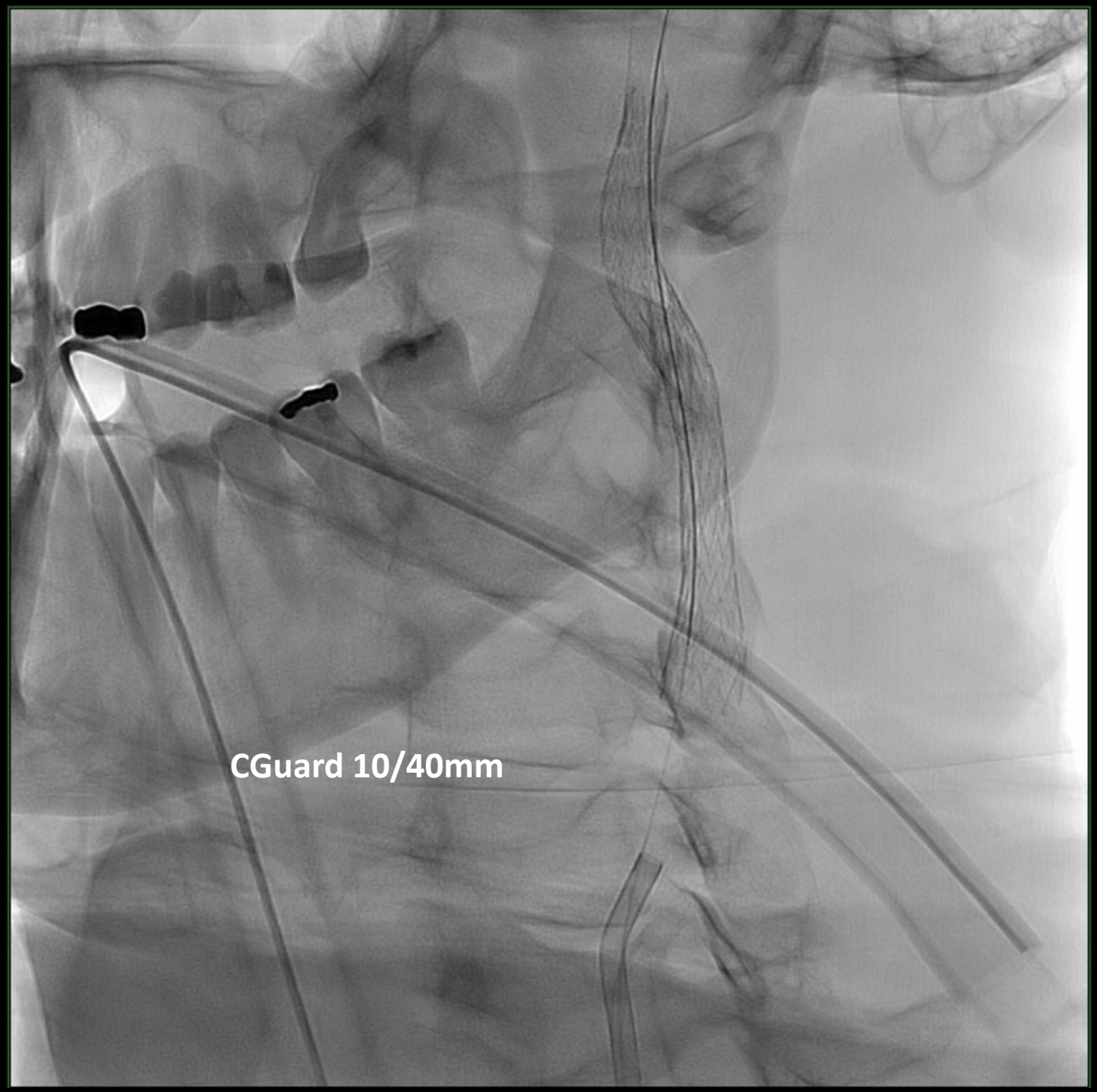

20 mm
(prj)

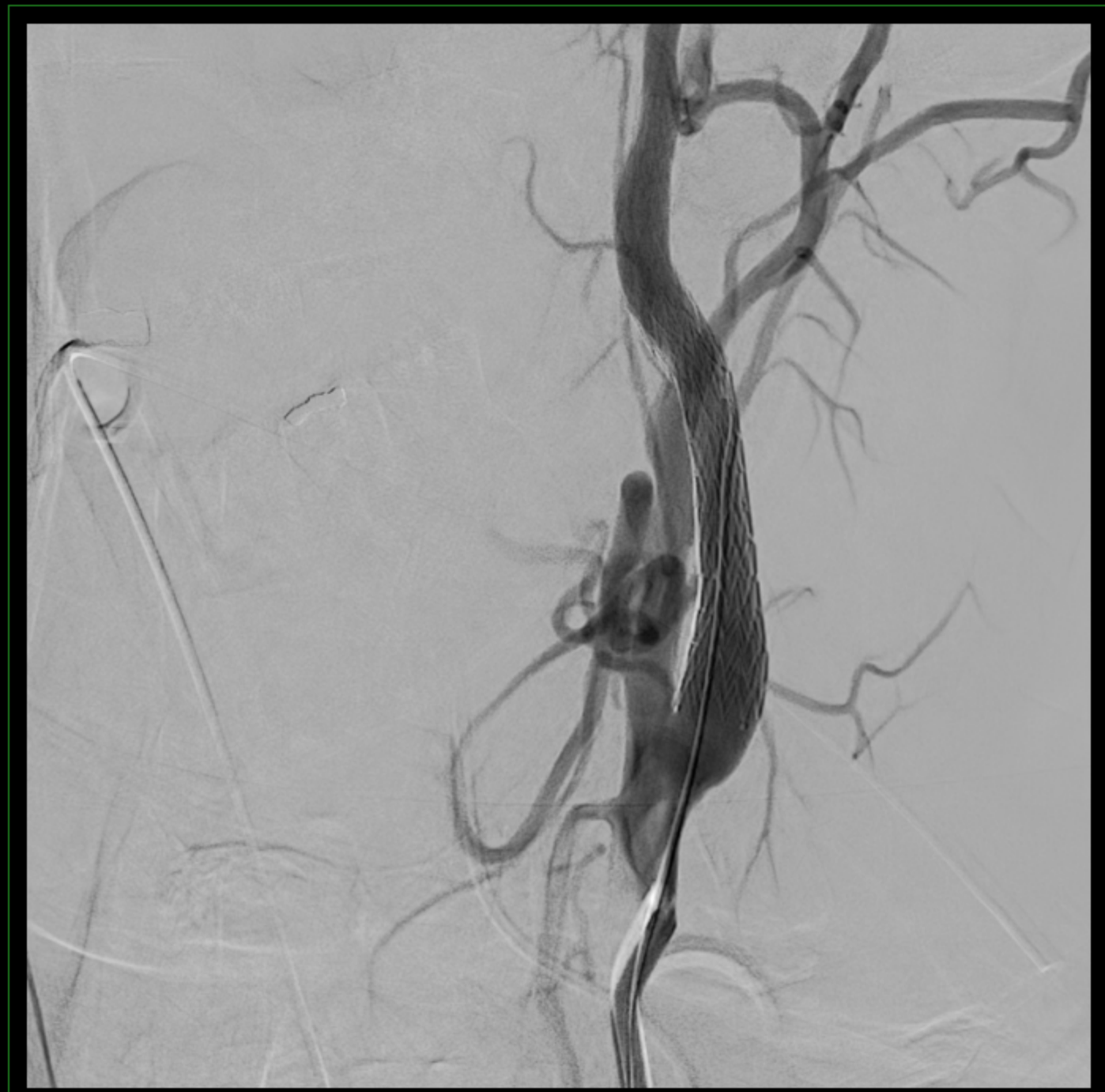

Pipeline Vantage 5.5/40mm
15 mm
(prj)

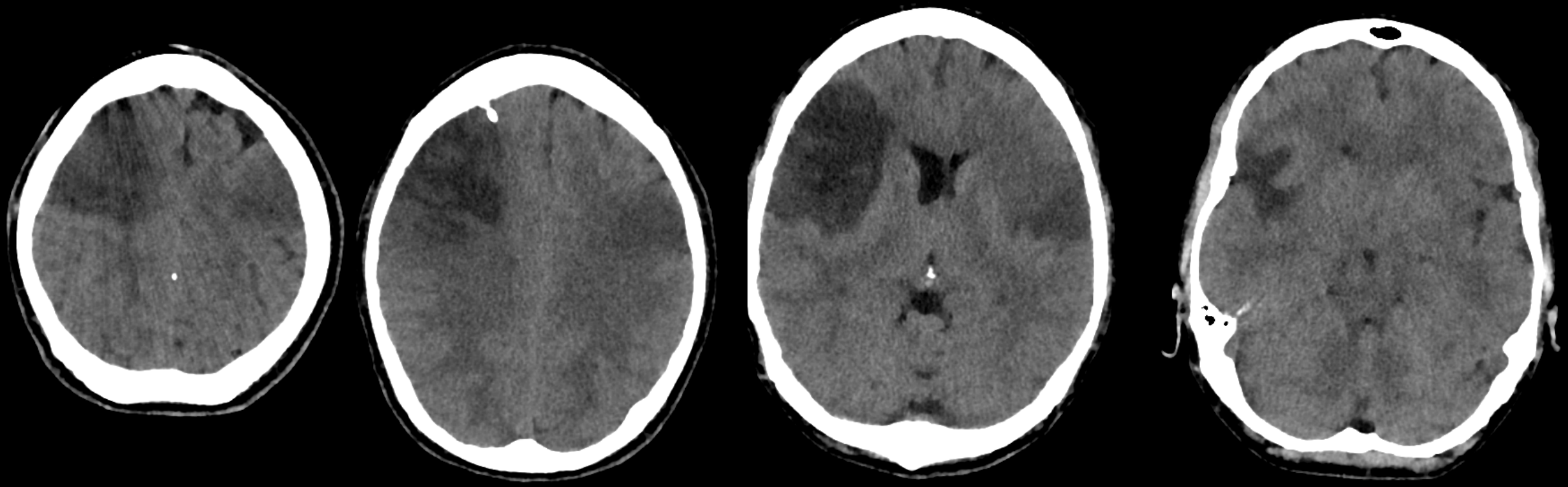

Pipeline Vantage 5.5/30mm
15 mm
(prj)


CGuard 8/30
15 mm
(prj)


15 mm
(prj)


CGuard 10/40mm
15 mm
(prj)


15 mm
(prj)



Buffalo Protocol for Tandem Lesions

- CTA including 4D CTA/P identifies tandem occlusion versus terminus occlusion
- If patient suspected to have tandem occlusion an NG tube is used to load 81mg Aspirin and 180mg Ticagrelor in Emergency room
- 8 French femoral sheath
- 8 French Walrus balloon guide catheter in CCA
- 0.014 wire used to cross the lesion under flow arrest
- If unable to cross with 014, 035 soft exchange with quick cross or MPA (if severe angulation) is utilized under Balloon flow arrest
- Angioplasty with 5-5.5mm by 30mm RX balloon used to gauge lesion length and is followed by stenting of cervical ICA
- Aggressive aspiration through balloon guide and then deflation of BGC to perform cervical and intracranial angiogram
- BGC advanced through the stent to distal (beyond stent) cervical location (to prevent stent retriever stent interaction)
- Intracranial mechanical thrombectomy performed with Aspiration or Stent retriever or combination

Conclusions

- Tandem lesions are the most disabling category of LVO AIS
- Tandem lesions are the most aggressive version of symptomatic carotid stenosis
- Balloon guides allow for adequate reversal of flow providing distal embolic protection during crossing, angioplasty and stenting of lesions
- Post stenting the Balloon guide can be rapidly advanced beyond the stenosis into distal cervical ICA for intracranial revascularization with stent retriever, aspiration or both.


Thank You