Diversores de flujo en aneurismas cerebrales. Indicaciones actuales y futuras

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INTRODUCCIÓN

- EVT TERAPIA ELECCIÓN POR SU EFICACIA Y SEGURIDAD
- ANEURISMAS CUELLO ANCHO O DIFICILES DE TRATAR POR COILING SIMPLE, REMODELLING Y SAC ABRIÓ NUEVAS OPCIONES
- REMODELLING Y SAC HAN MOSTRADO EN DETERMINADOS ANEURISMAS ALTAS TASAS DE RECANALIZACIÓN
- APARICIÓN FD HA APORTADO NUEVAS OPCIONES TERAPÉUTICAS

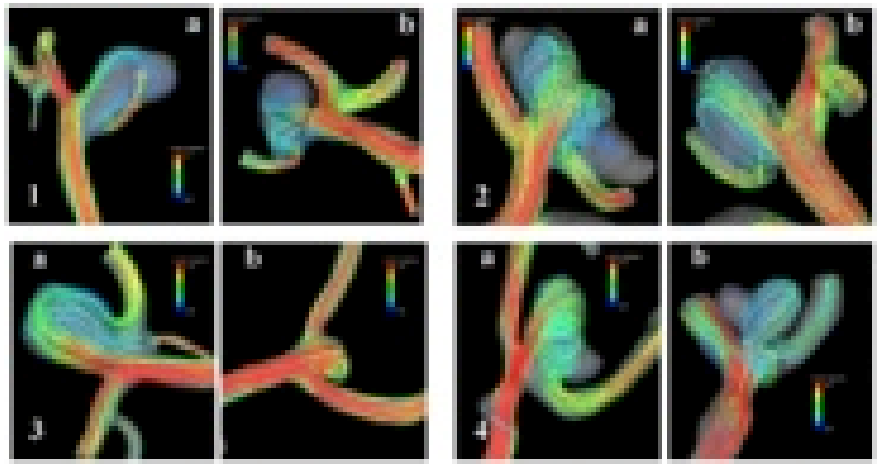
INTRODUCCIÓN II

- **2 CARACTERÍSTICAS BÁSICAS**

  POROSIDAD: RATIO SUPERFICIE SIN METAL / SUPERFICIE CON METAL
  Porosity

  DENSIDAD PORO: NRO POROS / UNIDAD DE SUPERFICIE
  Mesh Density

- **OBJETIVO**: ALTERAR INTERCAMBIO FLUJO ENTRE ARTERIA AFERENTE Y EL SACO ANEURISMÁTICO



INTRODUCCIÓN III

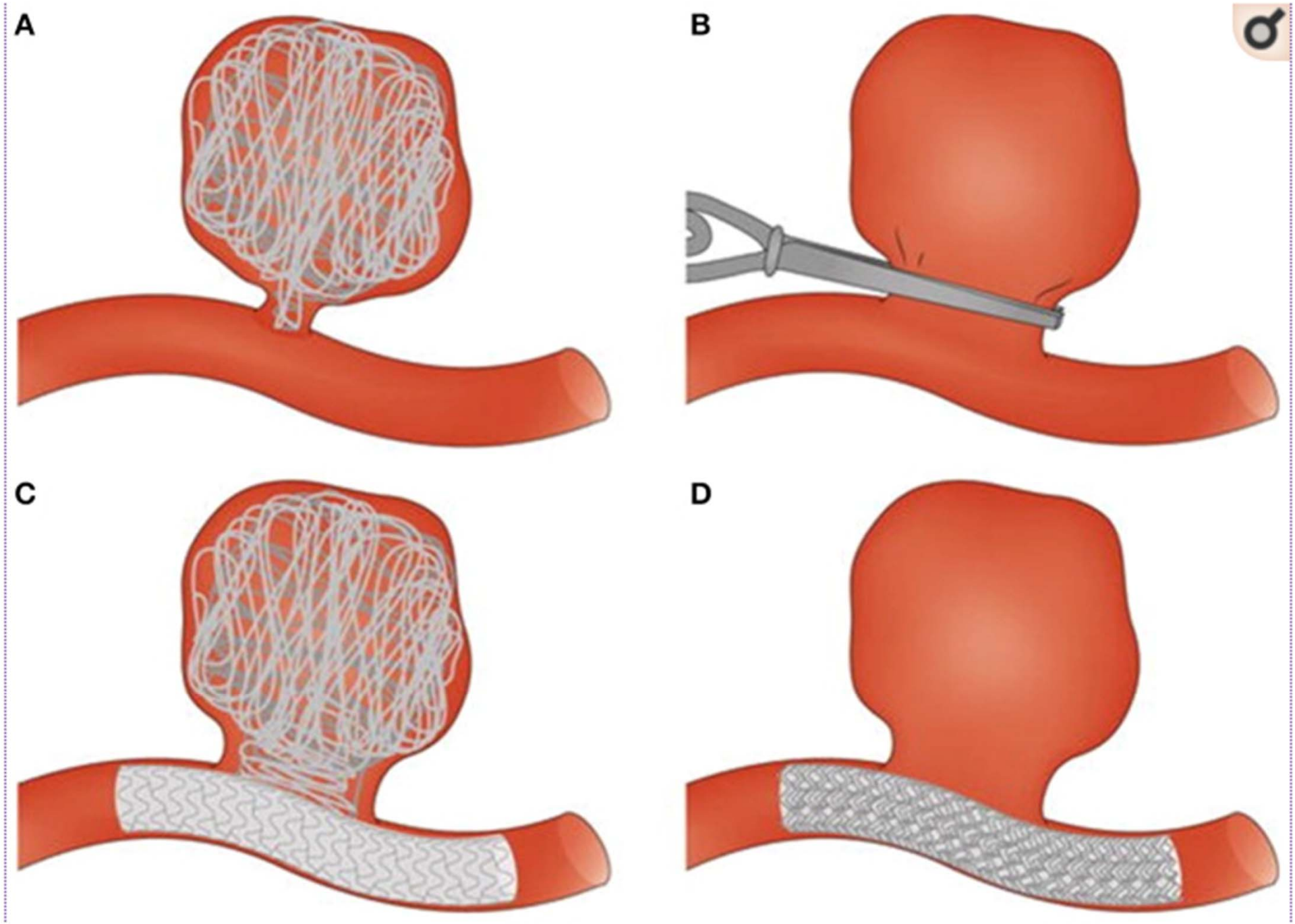
- RECONSTRUCCIÓN ENDOLUMINAL DE LA ARTERIA
- EVITAMOS MANIPULACIÓN SACO ANEURISMÁTICO

  ↓ RIESGO RUPTURA

- DEBE ALTERAR EL FLUJO INTRAANEURISMÁTICO SIN COMPROMETER SALIDA RAMAS SANAS ADYACENTES
- REQUIERE BAJA POROSIDAD Y ALTA DENSIDAD DE POROS

  IDEAL: ↓ POROSITY ↑ MESH DENSITY

- IMPRESCINDIBLE BUEN POSICIONAMIENTO PARED (CONCEPTO ENDOLEAK Y TROMBOSIS)
- **NECESIDAD DOBLE ANTIAGREGACIÓN EFECTIVA**


A
B
C
D

The Changing Landscape of Treatment for Intracranial Aneurysm

Christopher S. Lozano, Andres M. Lozano, Julian Spears

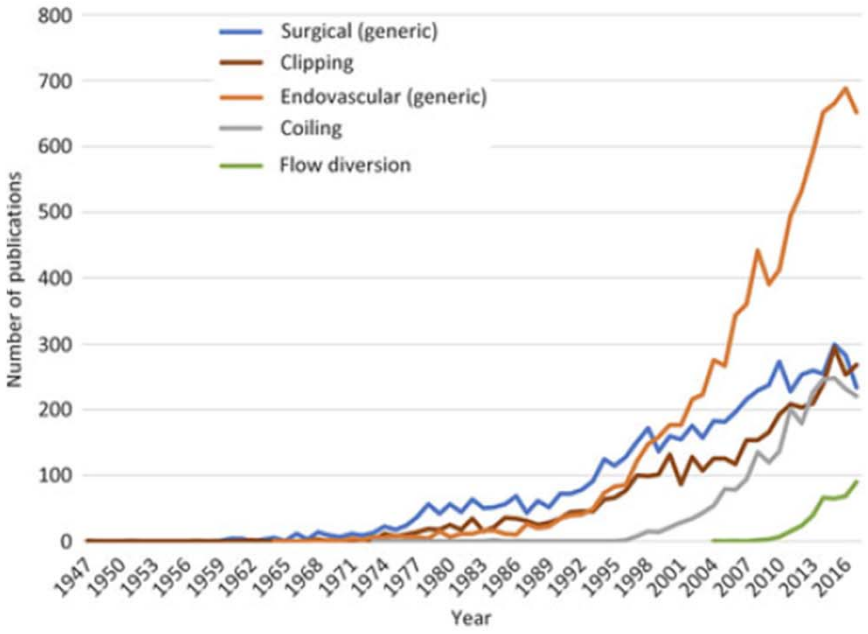


Figure 1: *Annual counts of papers published on surgical and endovascular IA treatments until 2017. Data were derived from the Scopus database as described in methods.*

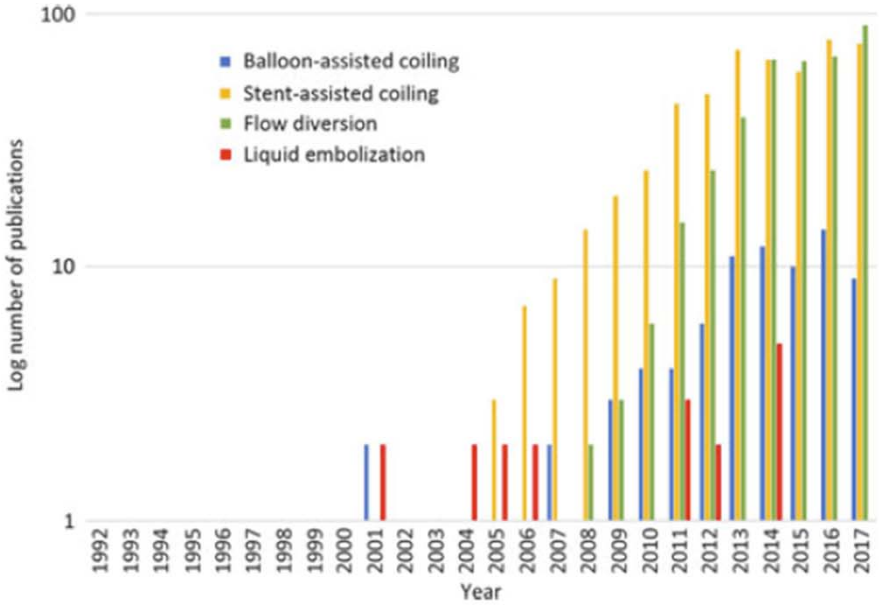


Figure 2: *Annual counts of papers published on four different endovascular approaches for IA until 2017. Note the counts are displayed on a logarithmic scale. The four approaches are balloon-assisted coiling, stent-assisted coiling, flow diversion, and liquid material embolization.*

Table 2: The most highly cited publications on cerebral aneurysm treatment derived from Scopus up to 2017. Papers with over 400 citations (citation classics) are listed

Rank	Authors	Year	Title	Topic area(s)	Number of citations
1	Molyneux A. et al.	2002	International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical	Surgical + endovascular	2317
2	Hunt W.E.				
3	Wiebers D.				
4	Molyneux				
5	Wiebers D.				
6	Raymond J.				
7	Connolly E.				
8	Bederson J.				
9	Van Gijn J.				
10	Vifuela F.				
11	Kassell N.I.				
12	Pickard J.I.		subarachnoid haemorrhage: British aneurysm nimodipine trial		
13	Murayama Y. et al.	2003	Guglielmi detachable coil embolization of cerebral aneurysms: 11 Years' experience	Endovascular	601
14	Lylyk P. et al.	2009	Curative endovascular reconstruction of cerebral aneurysms with the pipeline embolization device: The Buenos Aires experience	Endovascular	561
15	Guglielmi G. et al.	1992	Endovascular treatment of posterior circulation aneurysms by electrothrombosis using electrically detachable coils	Endovascular	495
16	Molyneux A.J. et al.	2009	Risk of recurrent subarachnoid haemorrhage, death, or dependence and standardised mortality ratios after clipping or coiling of an intracranial aneurysm in the International Subarachnoid Aneurysm Trial (ISAT): long-term follow-up	Surgical +Endovascular	490
17	Suarez J.I. et al.	2006	Aneurysmal subarachnoid hemorrhage	Surgical + endovascular	479
18	Zubillaga A.F. et al.	1994	Endovascular occlusion of intracranial aneurysms with electrically detachable coils: Correlation of aneurysm neck size and treatment results	Endovascular	466
19	Roy D. et al.	2001	Endovascular treatment of unruptured aneurysms	Endovascular	462
20	Brisman J.L. et al.	2006	Cerebral aneurysms	Surgical + endovascular	448
21	Nelson P.K. et al.	2011	The pipeline embolization device for the intracranial treatment of aneurysms trial	Endovascular	412
22	Solenski N.J. et al.	1995	Medical complications of aneurysmal subarachnoid hemorrhage: A report of the multicenter, cooperative aneurysm study	Medical	411
23	Moret J. et al.	1997	Reconstruction technique for wide neck intracranial aneurysms: Long-term angiographic and clinical results	Endovascular	409
24	Alberts M.J. et al.	2005	Recommendations for comprehensive stroke centers: A consensus statement from the brain attack coalition	Surgical + endovascular	401

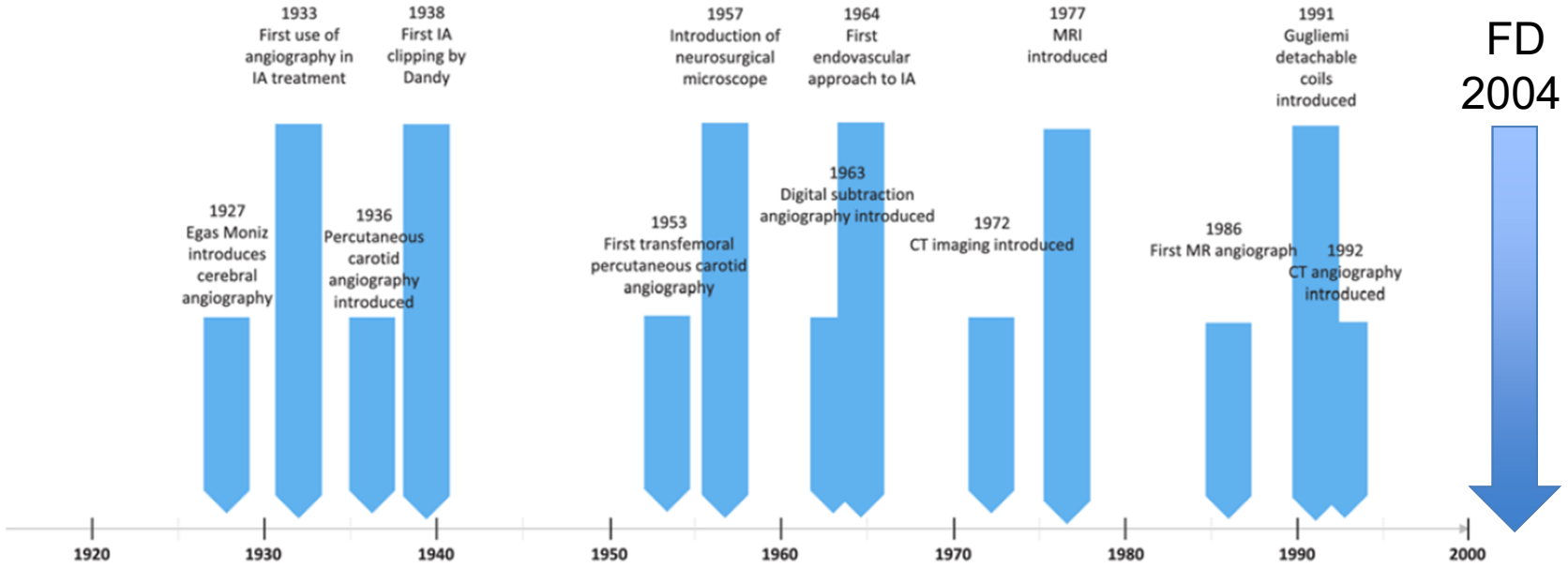


Figure 3: *Timeline showing milestones and major innovations in treatment of IA.*

Clin Neuroradiol (2012) 22:295–303
DOI 10.1007/s00062-012-0178-6

REVIEW ARTICLE

Pipeline Embolization Device for Intracranial Aneurysm: A Systematic Review

G. K. K. Leung · A. C. O. Tsang · W. M. Lui

- 10 ESTUDIOS: 414 PTS / 448 ANEURISMAS 40% GRANDES
- 2 DISPOSITIVOS POR ANEURISMA (MEDIA)
- COMPLICACIONES: 10,3 % GLOBALES
  6,3 % EVENTOS VASC. INTRACRANEALES
  2,2 % MORTALIDAD
- MORBIMORTALIDAD NO ROTOS vs ROTOS

  6,1 vs 18,8 % Y 0,8 vs 12,5 %
- STENT PREVIO CONDICIONABA MÁS COMPLICACIONES Y MENOR OCLUSIÓN
- OCLUSIÓN COMPLETA A 6 M 82,8 %

Stroke
JOURNAL OF THE AMERICAN HEART ASSOCIATION

American Heart Association | American Stroke Association

Endovascular Treatment of Intracranial Aneurysms With Flow Diverters: A Meta-Analysis

Waleed Brinjikji, Mohammad H. Murad, Giuseppe Lanzino, Harry J. Cloft and David F. Kallmes

Stroke. 2013;44:442-447; originally published online January 15, 2013;

- 29 ESTUDIOS: 1452 PTS / 1654 ANEURISMAS 40% GRANDES
- PIPELINE Y SILK
- MORBIMORTALIDAD 5% / 4%
- OCLUSIÓN COMPLETA 76 %
- RIESGO OCLUSIÓN PERFORANTES 3% (MAYOR EN CIRC. POST)

SILK (10 series)

- DEPLOYMENT FAILURE 3%
- COMPLETE OBLITERATION AFTER 13 M 86%
- NO RECANALIZATION
- POSTPROCEDURAL PARENT ARTERY OCCLUSION 5%
- EMBOLIC EVENTS 7%
- BASILAR ARTERY ANEURYSMS EMBOLIC EVENTS 25%
- IN-STENT STENOSIS 10%
- INTRACRANIAL HEMORRHAGE 3%
- OVERALL NEUROLOGICAL MORBI MORTALITY 6 + 4%
- DELAYED ANEURYSM RUPTURE …

PIPELINE (11 SERIES – 482 ANEURISMAS) (SILK)

- DEPLOYMENT FAILURE 2% (3%)
- COMPLETE OBLITERATION AFTER 12M 94% (86%) (Lylyk et al)
- NO RECANALIZATION
- POSTPROCEDURAL PARENT ARTERY OCCLUSION 5%
- EMBOLIC EVENTS 3% (7%)
- BASILAR ARTERY ANEURYSMS EMBOLIC EVENTS 25%
- IN-STENT STENOSIS 7% (10%)
- INTRACRANIAL HEMORRHAGE 4% (3%)
- OVERALL NEUROLOGICAL MORBI MORTALITY 2 + 3% (6 + 4%)
- REMOTE LOBAR HEMORRHAGE …

Surpass

- 200 patients with 252 aneurysms from three centers who received treatment using 215 devices, from January 2013 through March 2015
  - Queen's University HospitaL. LONDON
  - Hospital Clinic. BARCELONA
  - Hacettepe University Hospitals. ANKARA

Patients

Patients	200
Aneurysms	252
Females (%)	152
Mean Age yrs (range)	55 (24-82)
Presentation/Indications for Treatment	%
Incidental Finding/Headaches	72
Recurrent after Coiling/Coiling and Stenting	50
Cranial Nerve Deficit/Mass Effect	22
Associated Second Ruptured Aneurysm	24
Subarachnoid Hemorrhage (SAH)	24
Recurrent after Clipping/Failed Clipping	4
Acute large vessel dissection (Cervical ICA)	4

Aneurysms

Total Aneurysms Treated	252
<5mm	66
5mm to 9.9mm	106
10mm to 20mm	52
>20mm	28
Measurements (mean)	
Aneurysm Dome Size (mm)	9.8
Aneurysm Neck Size (mm)	4.8
Dome : Neck Ratio	3.6
Morphology	(%)
Saccular	84(134)
Fusiform / Dissecting	35 (54)

Technical Assessment & Follow-Up

Follow-Up

- N=104 of 200 patients had an imaging FU, from 1 day to 12 months (mean 8 months)
- Technical Difficulty (Operative)
- Clinical Assessment (Postoperative increase in mRs)
- Imaging FU (DSA/ MRA/ CT-DSA) : 89% of cases with FU showed 90-100% aneurysm sac occlusion and segmental remodeling on FU imaging

Technical Data	
Average Access/ Stent delivery time (min.)	48/12
Technical Success	190 (95%)
Incorrect Placement w/ partial Aneurysm Coverage	4
Intraoperative Thrombus Formation	0
Average Number Devices Per Aneurysm	0.84
Average Number Devices Per Patient	1.07
In-implant Stenosis (Asx/Sx)	10/1
Parent Artery Occlusion (Asx/Sx)	2/1
Aneurysmal Bleed	0/0
Parenchymal Bleed – not related to Aneurysm	1 /1

Clinical Results

- COMPLICATIONS

Aneurysm Location	Thromboembolic	Bleeding	Death	TOTAL
Anterior Circulation	4	2	2	8
Posterior Circulation	4	1	1	6

Morbimortalidad 5,7% (mortalidad 1,5%)

Table 2 | Morbidity, mortality, and occlusion rates for FDDs as reported from case series, systemic reviews, and meta-analysis.

	FDD used	Morbidity rate (%)	Mortality rate (%)	Complete occlusion at follow-up (%)
Leung et al. (systemic review)	PED (1–3.2/patient)	Ruptured and unruptured aneurysms: 6.3 Ruptured only: 18.8 Unruptured only: 6.1	Ruptured and unruptured aneurysms: 2.2 Ruptured only: 12.5 Unruptured only: 0.8	82.8
Saatci et al.	PED (1.3/patient)	1	0.5	91.2
Brinjikji et al. (meta-analysis)	PED and SFD	5	4	76
Pistocchi et al.	PED and SFD	3.7	0	78.9
Briganti et al. (meta-analysis)	PED and SFD	3.7	5.9	85

Table 1.

Characteristics of the 18 included studies.

Study	N° of participating centers and countries	Type	Morbidity	Mortality	N° of patients	N° of aneurysms	Type of FDD		
							PED	Silk	Surpass
Lylyk et al. 2009[7]	Unicenter (Argentina)	Prospective	0%	0%	53	63	72	–	–
Byrne et al. 2010[8]	Multicenter (England)	Prospective	4%	8%	70	70	–	67	–
Lubicz et al. 2010[9]	Multicenter (Belgium)	Prospective	15%	4%	29	34	–	36	–
Berge et al. 2012[10]	Multicenter (France)	Retrospective	7.8%	3%	65	77	–	73	–
Briganti et al. 2012[11]	Multicenter (Italy)	Retrospective	3.7%	5.9%	273	295	182	151	–
McAuliffe et al. 2012[12]	Multicenter (Australia)	Prospective	0%	0%	54	57	98	–	–
Fischer et al. 2012[13]	Unicenter (Germany)	Retrospective	5.6%	1.1%	88	101	235	–	–
Wagner et al. 2012[14]	Unicenter (Denmark)	Retrospective	5%	5%	22	26	–	23	–
Maimon et al. 2012[15]	Unicenter (Israel)	Retrospective	7.2%	3.6%	28	32	–	31	–
Pistocchi et al. 2012[16]	Unicenter (France)	Prospective	3.7%	0%	26	30	9	23	–
Tähtinen et al. 2012[17]	Multicenter (Finland)	Retrospective	4%	4%	24	24	–	29	–
Saatci et al. 2012[18]	Unicenter (Turkey)	Retrospective	1%	0.5%	191	251	324	-	–
Velioglu et al. 2012[19]	Unicenter (Turkey)	Retrospective	6.6%	6.6%	76	87	–	91	–
Yu et al. 2012[20]	Multicenter (China)	Prospective	3.5%	3.5%	143	178	213	–	–
Colby et al. 2013[21]	Unicenter (USA)	Retrospective	3%	3%	34	41	64	–	–
Çinar et al. 2013[22]	Unicenter (Turkey)	Prospective	0%	2.2%	45	55	66	–	–
O'Kelly et al. 2013[23]	Multicenter (Canada)	Retrospective	4.3%	6.4%	97	97	156	–	–
Wakhloo et al. 2015[24]	Multicenter (USA/Europe)	Prospective	4.2%	2.4%	165	186	–	–	165
Total					1483	1704	1349	524	165

FDD: flow-diverter device; PED: pipeline embolization device; USA: United States of America.

NRJ THE NEURORADIOLOGY JOURNAL

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doi: 10.1177/1971400915602803

PMCID: PMC4757311
PMID: 26314872

Endovascular treatment of cerebral aneurysms using flow-diverter devices: A systematic review

Francesco Briganti,[✉1] Giuseppe Leone,[1] Mariano Marseglia,[1] Giuseppe Mariniello,[2] Ferdinando Caranci,[3] Arturo Brunetti,[3] and Francesco Maiuri[2]

Table 3.

Results and complications (18 studies).

Technical procedural problems (17 studies)	**8.3% (range 0–23.1%)**	
Parent artery thrombosis or significant (>50%) stenosis	Acute stage (12 studies)	3.8% (range 0–8.3%)
	Late (16 studies)	6.8% (0–18%)
Ischemic complications (18 studies)	4.1% (range 0–14.2%)	
Hemorrhagic complications (18 studies)	2.9% (range 0–7.5%)	
Neurological morbidity (18 studies)	3.5% (range 0–15%)	
Mortality (18 studies)	3.4% (range 0–8%)	
Rate of complete aneurysm occlusion (18 studies)	Overall rate at final follow-up (18 studies)	81.5% (range 69%–100%)
	Immediate (six studies)	10.8% (range 2%–18.2%)
	Three months (three studies)	60% (range 44%–85%)
	Six months (nine studies)	74.5% (range 50%–93%)
	12 months (eight studies)	89.6% (range 81%–100%)
	Only overall data (3–12 months) (five studies)	77% (range 69%–87%)

Complications associated with the use of flow-diverting devices for cerebral aneurysms: a systematic review and meta-analysis

Neurosurg Focus Volume 42 • June 2017

Geng Zhou, PhD,[1] Ming Su, MD,[2] Yan-Ling Yin, MD,[3] and Ming-Hua Li, PhD[1]

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OBJECTIVE The objective of this study was to review the literature on the use of flow-diverting devices (FDDs) to treat intracranial aneurysms (IAs) and to investigate the safety and complications related to FDD treatment for IAs by performing a meta-analysis of published studies.

METHODS A systematic electronic database search was conducted using the Springer, EBSCO, PubMed, Medline, and Cochrane databases on all accessible articles published up to January 2016, with no restriction on the publication year. Abstracts, full-text manuscripts, and the reference lists of retrieved articles were analyzed. Random-effects meta-analysis was used to pool the complication rates across studies.

RESULTS Sixty studies were included, which involved retrospectively collected data on 3125 patients. The use of FDDs was associated with an overall complication rate of 17.0% (95% confidence interval [CI] 13.6%–20.5%) and a low mortality rate of 2.8% (95% CI 1.2%–4.4%). The neurological morbidity rate was 4.5% (95% CI 3.2%–5.8%). No significant difference in the complication or mortality rate was observed between 2 commonly used devices (the Pipeline embolization device and the Silk flow-diverter device). A significantly higher overall complication rate was found in the case of ruptured IAs than in unruptured IA (odds ratio 2.3, 95% CI 1.2–4.3).

CONCLUSIONS The use of FDDs in the treatment of IAs yielded satisfactory results with regard to complications and the mortality rate. The risk of complications should be considered when deciding on treatment with FDDs. Further studies on the mechanism underlying the occurrence of adverse events are required.

https://thejns.org/doi/abs/10.3171/2017.3.FOCUS16450

KEY WORDS intracranial aneurysm; flow-diverting device; complication; delayed rupture

Conclusiones de la Bibliografía

- Indicación inicial en aneurismas Grandes/Gigantes y fusiformes. Sifón carotídeo y TB
- Unica alternativa terapéutica en muchos casos
- Tasa de complicaciones variable
  - Incrementada en fase aguda
  - Mayor en fosa posterior
- Morbimortalidad razonable en casos indicados
- Algunas complicaciones hemorrágicas inherentes a la doble antiagregación
- Mejora técnica rápida y variada

INDICACIONES

- ANEURISMAS GRANDES O GIGANTES

¿CUÁL ES LA HISTORIA NATURAL O CON LOS TRATAMIENTOS CONVENCIONALES DE ESTOS ANEURISMAS?

ANEURISMAS GRANDES O GIGANTES (>10 MM.)

- Bad Clinical Evolution

- Annual rupture rate of 4.37% for 10- to 24-mm aneurysms and 33.4% for aneurysms larger than 24 mm. [1]

- Surgical treatment is often challenging and can be associated with significant morbidity [2]

- Coil embolization remains the most commonly used endovascular technique for securing large and giant aneurysms

1. Morita A, Kirino T, Hashi K, et al. The natural course of unruptured cerebral aneurysms in a Japanese cohort. N Engl J Med 2012;366:2474–82
2. Kalani MY, Zabramski JM, Hu YC, et al. Extracranial-intracranial bypass and vessel occlusion for the treatment of unclippable giant middle cerebral artery aneurysms. Neurosurgery 2013;72:428–35, discussion 435–36

Coiling of Large and Giant Aneurysms: Complications and Long-Term Results of 334 Cases

N. Chalouhi, S. Tjoumakaris, L.F. Gonzalez, A.S. Dumont, R.M. Starke, D. Hasan, C. Wu, S. Singhal, L.A. Moukarzel, R. Rosenwasser, and P. Jabbour

ABSTRACT

BACKGROUND AND PURPOSE: Large and giant intracranial aneurysms are increasingly treated with endovascular techniques. The goal of this study was to retrospectively analyze the complications and long-term results of coiling in large and giant aneurysms (≥10 mm) and identify predictors of outcome.

MATERIALS AND METHODS: A total of 334 large or giant aneurysms (≥10 mm) were coiled in our institution between 2004 and 2011. Medical charts and imaging studies were reviewed to determine baseline characteristics, procedural complications, and clinical/angiographic outcomes. Aneurysm size was 15 mm on average. Two hundred twenty-five aneurysms were treated with conventional coiling; 88, with stent-assisted coiling; 14, with parent vessel occlusion; and 7, with balloon-assisted coiling.

RESULTS: Complications occurred in 10.5% of patients, with 1 death (0.3%). Aneurysm location and ruptured aneurysms predicted complications. Angiographic follow-up was available for 84% of patients at 25.4 months on average. Recanalization and retreatment rates were 39% and 33%, respectively. Larger aneurysm size, increasing follow-up time, conventional coiling, and aneurysm location predicted both recurrence and retreatment. The annual rebleeding rate was 1.9%. Larger aneurysm size, increasing follow-up time, and aneurysm location predicted new or recurrent hemorrhage. Favorable outcomes occurred in 92% of patients. Larger aneurysm size, poor Hunt and Hess grades, and new or recurrent hemorrhage predicted poor outcome.

CONCLUSIONS: Coiling of large and giant aneurysms has a reasonable safety profile with good clinical outcomes, but aneurysm reopening remains very common. Stent-assisted coiling has lower recurrence, retreatment, and new or recurrent hemorrhage rates with no additional morbidity compared with conventional coiling. Aneurysm size was a major determinant of recanalization, retreatment, new or recurrent hemorrhage, and poor outcome.

ANEURISMAS GRANDES O GIGANTES (>10 MM.)

ORIGINAL RESEARCH
INTERVENTIONAL

Coiling of Large and Giant Aneurysms: Complications and Long-Term Results of 334 Cases

N. Chalouhi, S. Tjoumakaris, L.F. Gonzalez, A.S. Dumont, R.M. Starke, D. Hasan, C. Wu, S. Singhal, L.A. Moukarzel, R. Rosenwasser, and P. Jabbour

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- Tasa de complicaciones: 10,5 %

- El tamaño del aneurisma fue un factor independiente de mal pronóstico

- Recurrencia 39 % 54% tras primer retto

- Retratamiento 33%

- Iguales números que en serie del 2003

- Stent-assisted coiling se asoció a menores tasas de recurrencia en el analisis multivariante en comparación con coiling

1. Murayama Y, Nien YL, Duckwiler G, et al. Guglielmi detachable coil embolization of cerebral aneurysms: 11 years' experience. J Neuro- surg 2003;98:959–66

ANEURISMAS GRANDES O GIGANTES (>10 MM.)

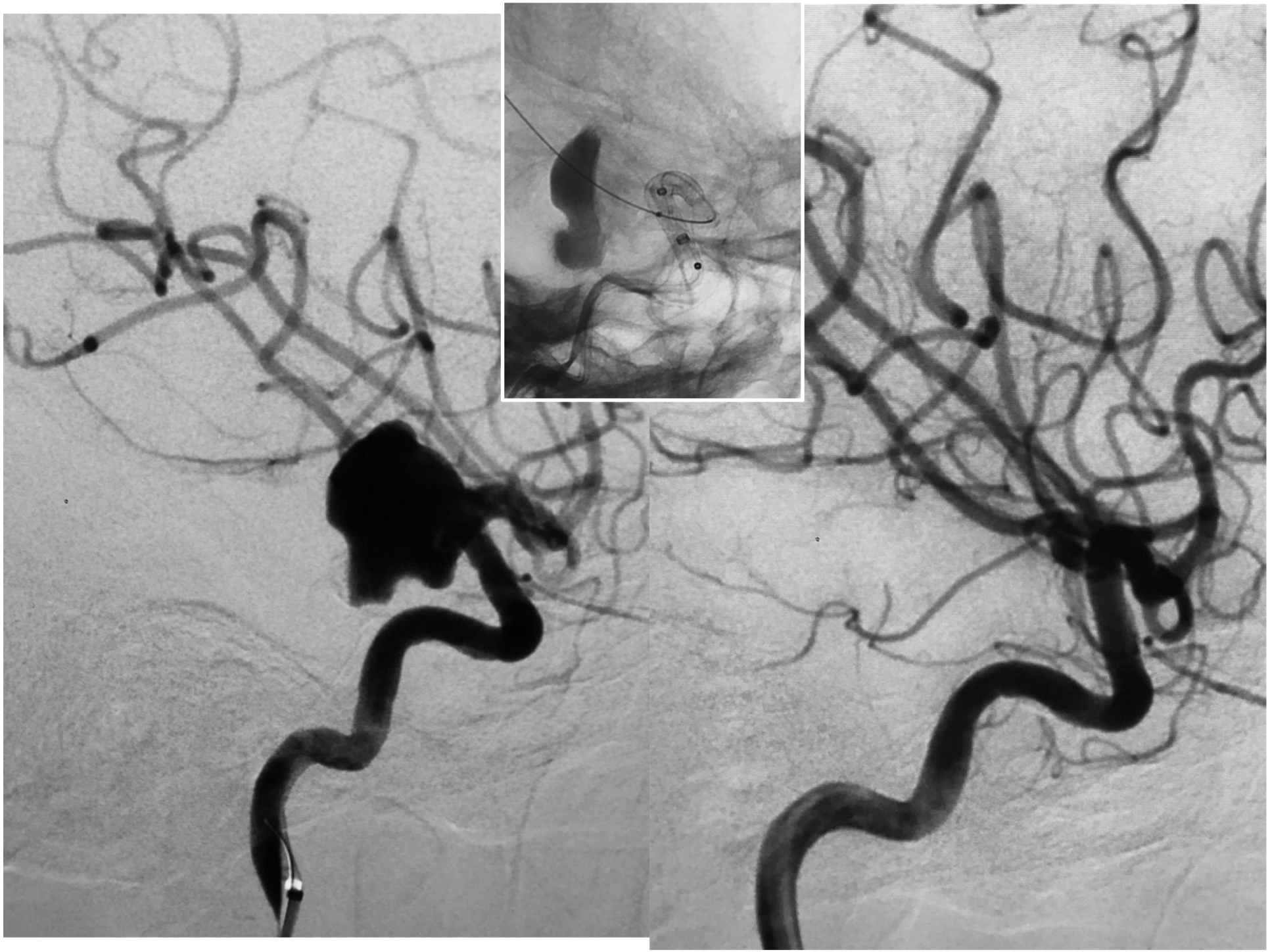
Background and Purpose—Flow diversion has emerged as an important tool for the management of intracranial aneurysms. The purpose of this study was to compare flow diversion and traditional embolization strategies in terms of safety, efficacy, and clinical outcomes in patients with unruptured, large saccular aneurysms (≥10 mm).

Methods—Forty patients treated with the Pipeline Embolization Device (PED) were matched in a 1:3 fashion with 120 patients treated with coiling based on patient age and aneurysm size. Fusiform and anterior communicating artery aneurysms were eliminated from the analysis. Procedural complications, angiographic results, and clinical outcomes were analyzed and compared.

Results—There were no differences between the groups in terms of patient age, sex, aneurysm size, and aneurysm location. The rate of procedure-related complications did not differ between the PED (7.5%) and the coil group (7.5%; $P=1$). At the latest follow-up, a significantly higher proportion of aneurysms treated with PED (86%) achieved complete obliteration compared with coiled aneurysms (41%; $P<0.001$). In multivariable analysis, coiling was an independent predictor of nonocclusion. Retreatment was necessary in fewer patients in the PED group (2.8%) than the coil group (37%; $P<0.001$). A similar proportion of patients attained a favorable outcome (modified Rankin Scale, 0–2) in the PED group (92%) and in the coil group (94%; $P=0.8$).

Conclusions—The PED provides higher aneurysm occlusion rates than coiling, with no additional morbidity and similar clinical outcomes. These findings suggest that the PED might be a preferred treatment option for large unruptured saccular aneurysms. **(*Stroke*. 2013;44:2150-2154.)**

Key Words: aneurysm ■ coils ■ flow diverter ■ pipeline embolization device



JNS

CLINICAL ARTICLE

J Neurosurg October 14, 2016

Pipeline for uncoilable or failed aneurysms: 3-year follow-up results

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OBJECTIVE The long-term effectiveness of endovascular treatment of large and giant wide-neck aneurysms using traditional endovascular techniques has been disappointing, with high recanalization and re-treatment rates. Flow diversion with the Pipeline Embolization Device (PED) has been recently used as a stand-alone therapy for complex aneurysms, showing significant improvement in effectiveness while demonstrating a similar safety profile to stent-supported coil treatment. However, relatively little is known about its long-term safety and effectiveness. Here the authors report on the 3-year safety and effectiveness of flow diversion with the PED in a prospective cohort of patients with large and giant internal carotid artery aneurysms enrolled in the Pipeline for Uncoilable or Failed Aneurysms (PUFS) trial.

METHODS The PUFS trial is a prospective study of 107 patients with 109 aneurysms treated with the PED. Primary effectiveness and safety end points were demonstrated based on independently monitored 180-day clinical and angiographic data. Patients were enrolled in a long-term follow-up protocol including 1-, 3-, and 5-year clinical and imaging follow-up. In this paper, the authors report the midstudy (3-year) effectiveness and safety data.

RESULTS At 3 years posttreatment, 74 subjects with 76 aneurysms underwent catheter angiography as required per protocol. Overall, complete angiographic aneurysm occlusion was observed in 71 of these 76 aneurysms (93.4% cure rate). Five aneurysms were re-treated, using either coils or additional PEDs, for failure to occlude, and 3 of these 5 were cured by the 3-year follow-up. Angiographic cure with one or two treatments of Pipeline embolization alone was therefore achieved in 92.1%. No recanalization of a previously completely occluded aneurysm was noted on the 3-year angiograms. There were 3 (2.6%) delayed device- or aneurysm-related serious adverse events, none of which led to permanent neurological sequelae. No major or minor late-onset hemorrhagic or ischemic cerebrovascular events or neurological deaths were observed in the 6-month through 3-year posttreatment period. Among 103 surviving patients, 85 underwent functional outcome assessment in which modified Rankin Scale scores of 0–1 were demonstrated in 80 subjects.

CONCLUSIONS Pipeline embolization is safe and effective in the treatment of complex large and giant aneurysms of the intracranial internal carotid artery. Unlike more traditional endovascular treatments, flow diversion results in progres-

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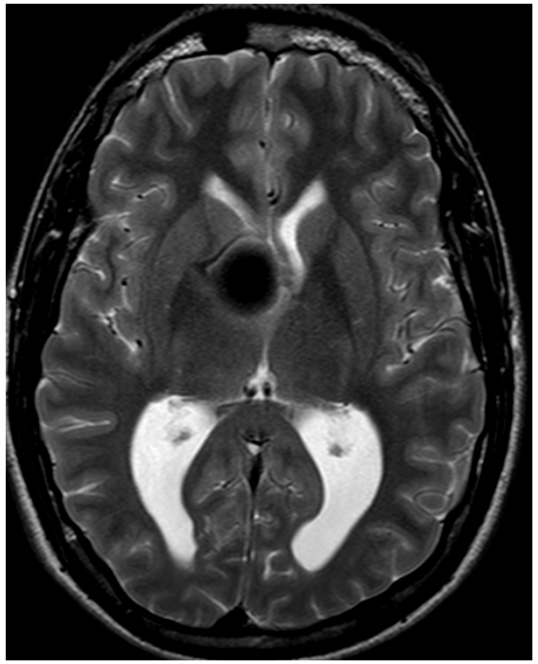

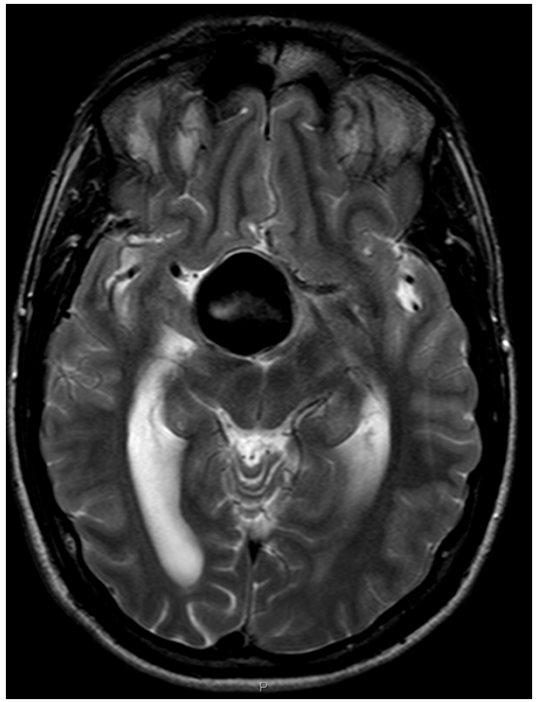

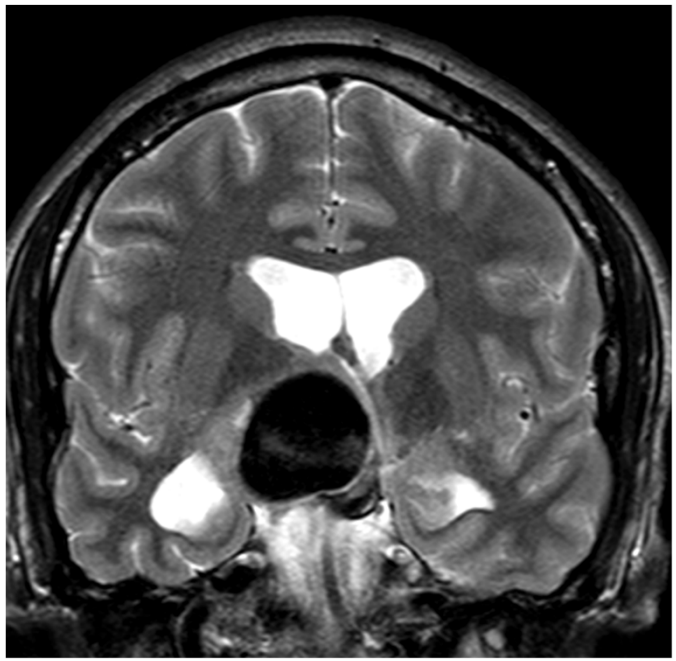


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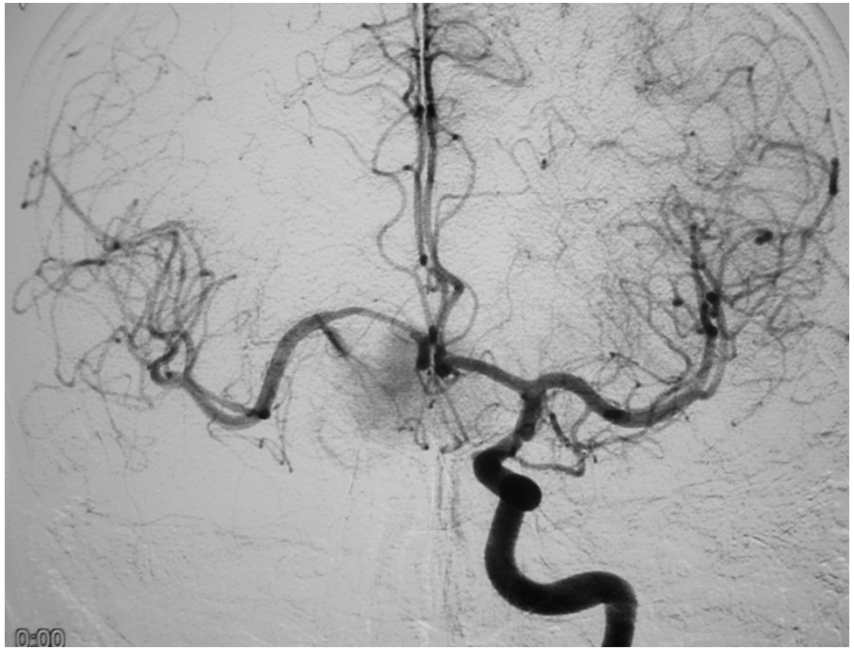
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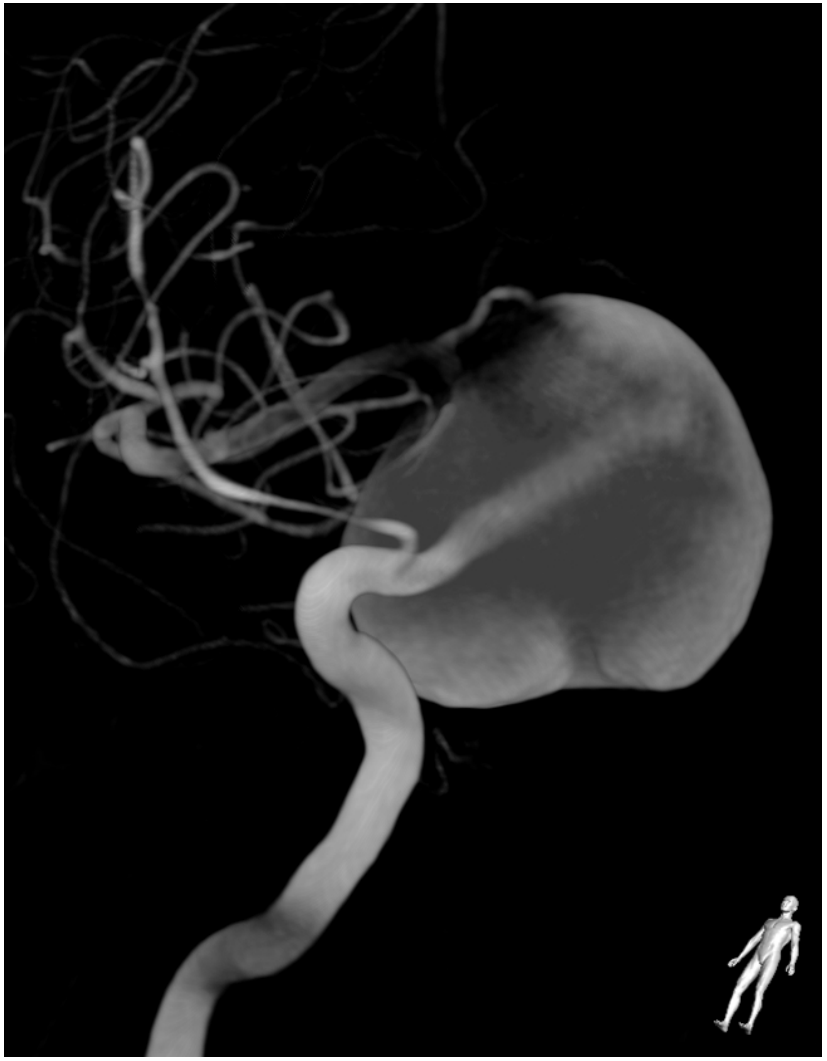

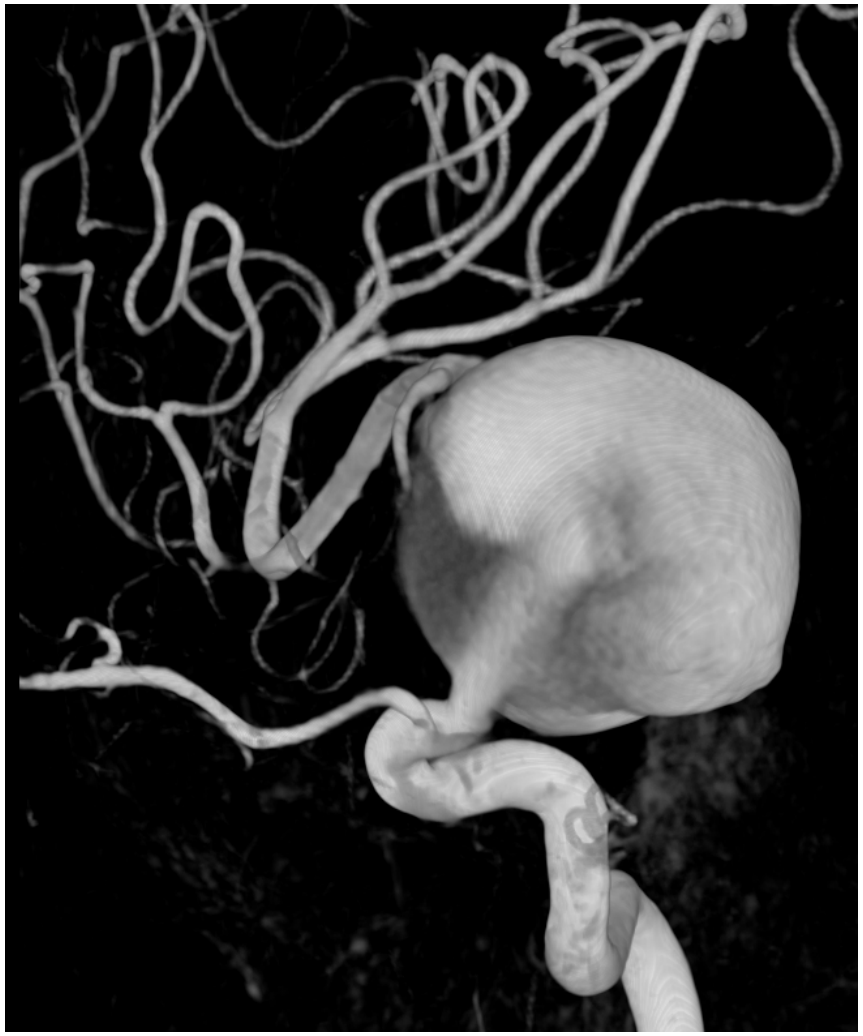

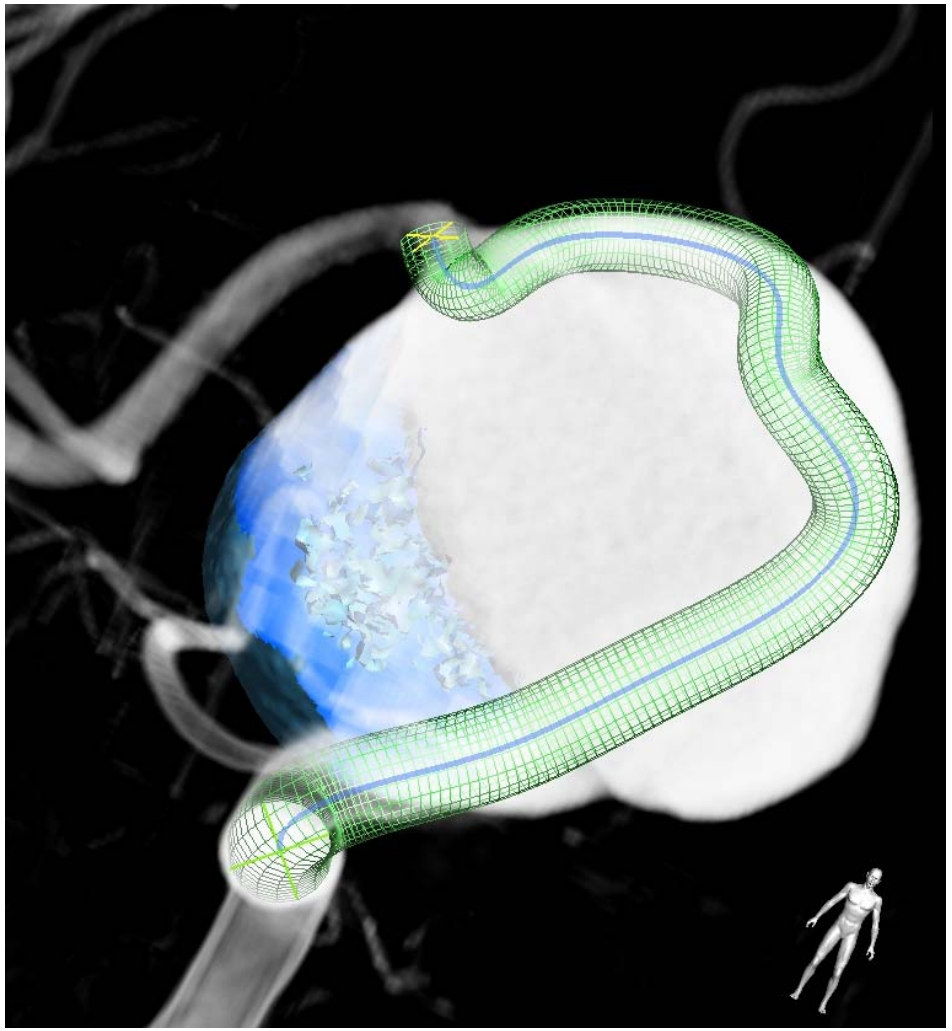

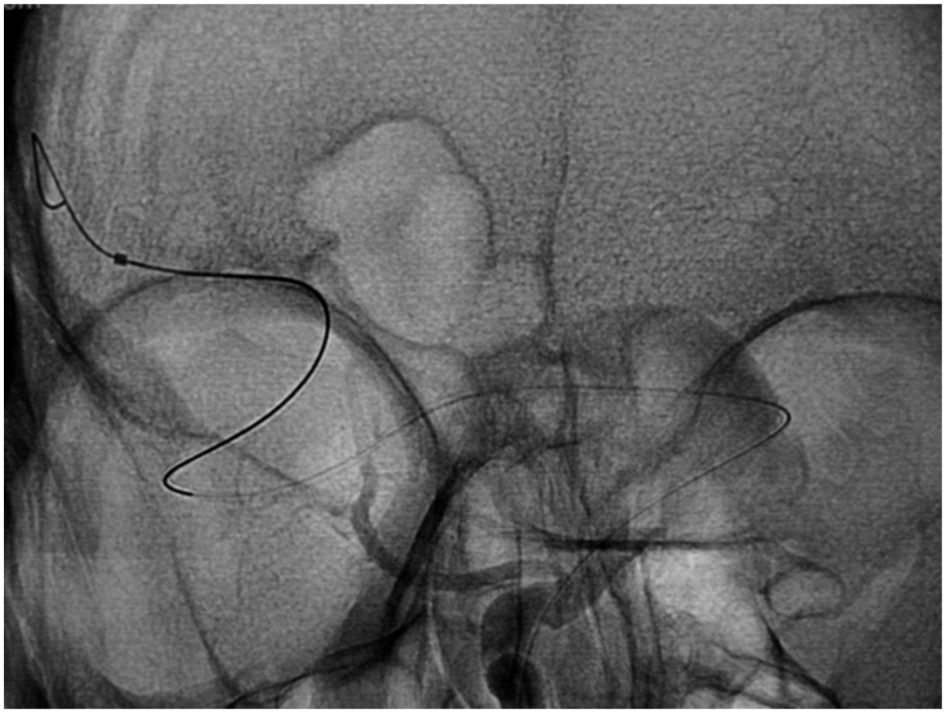

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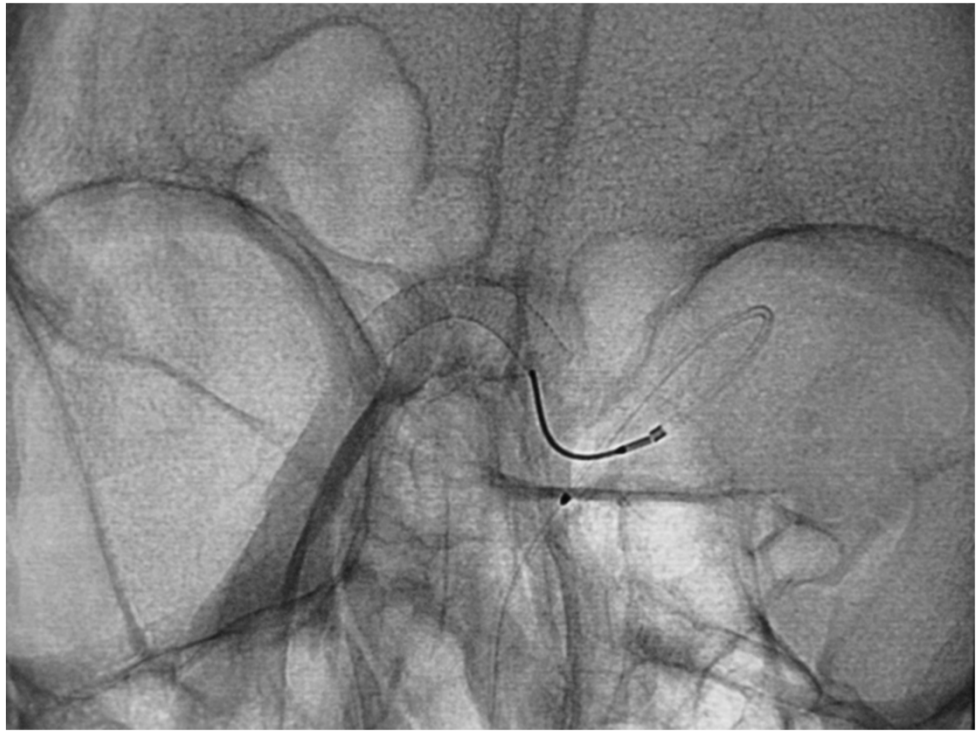

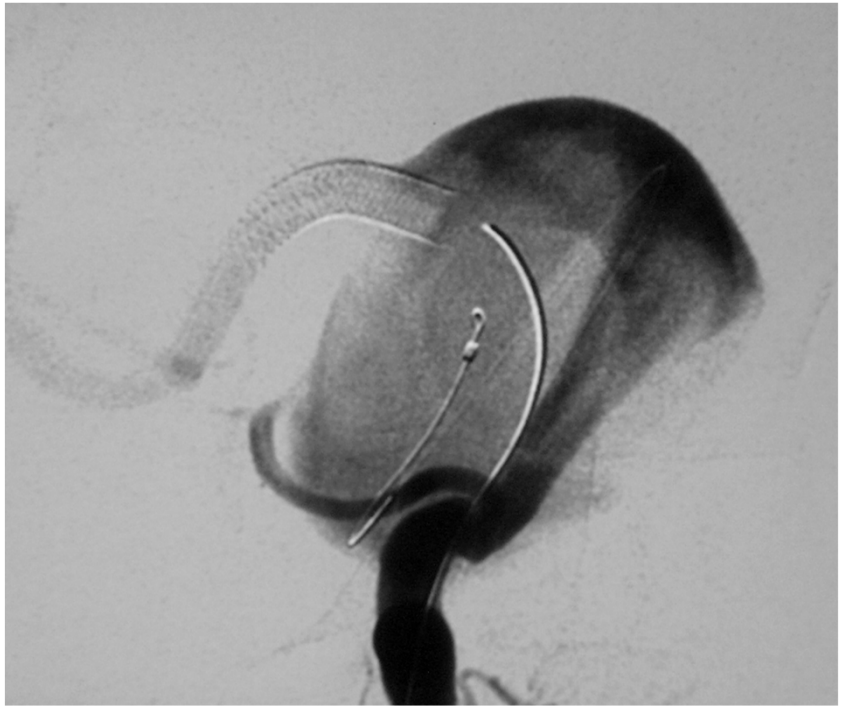

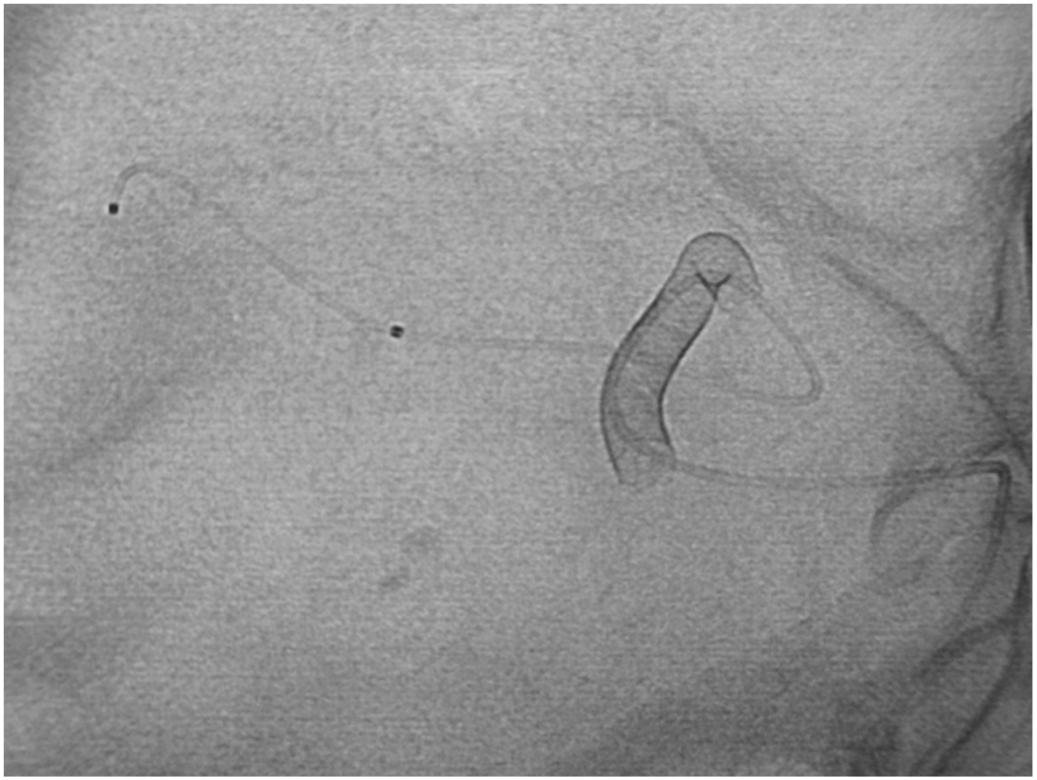

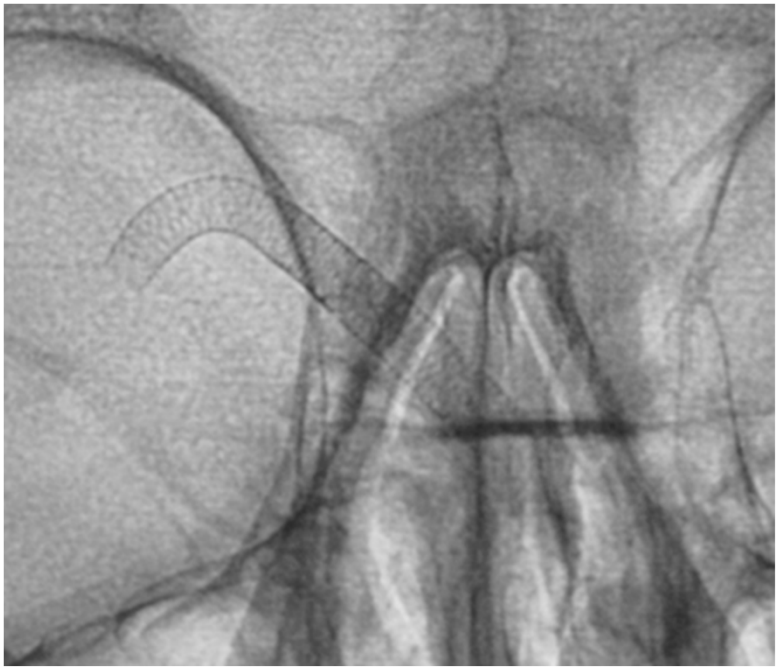

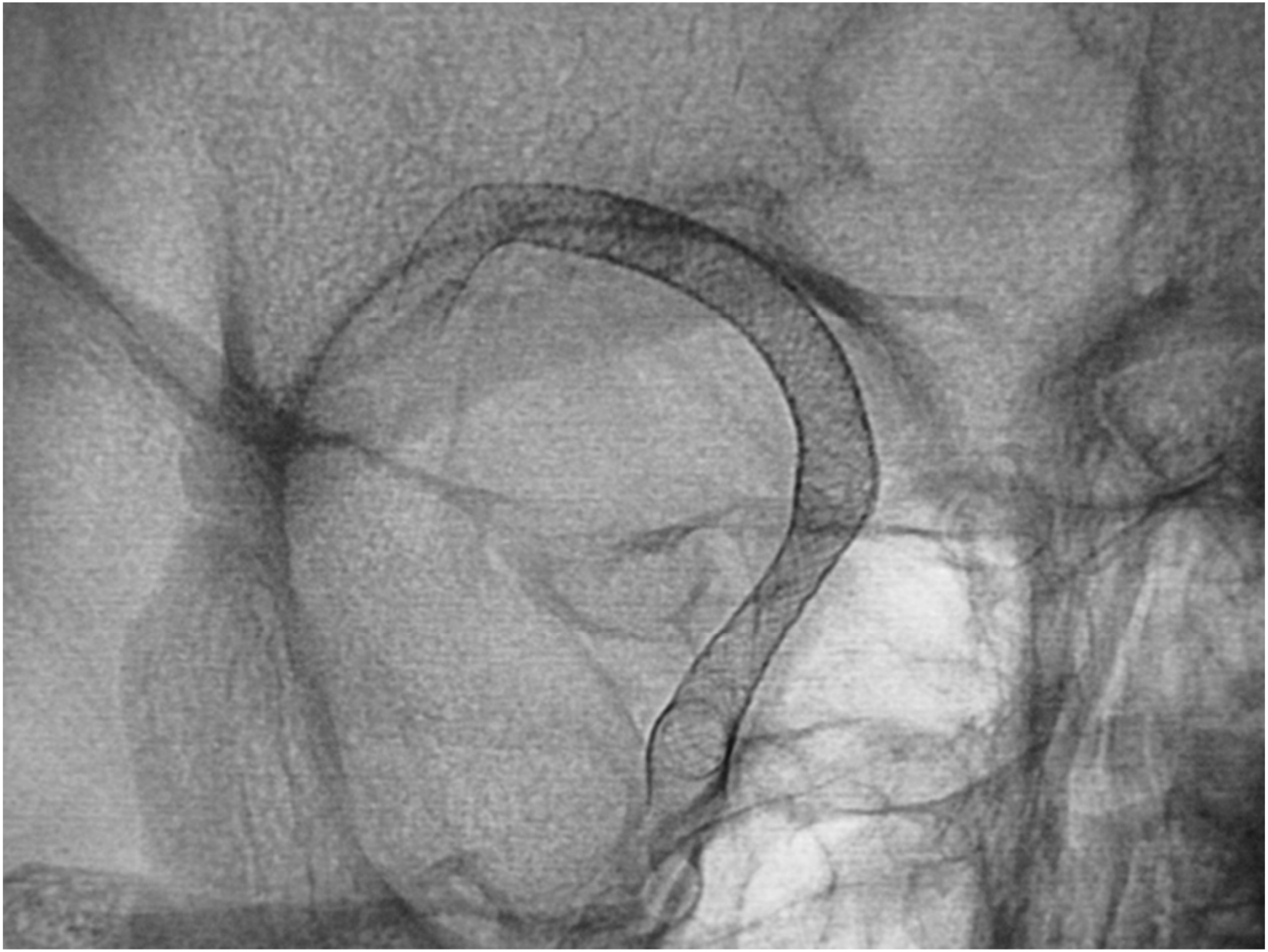

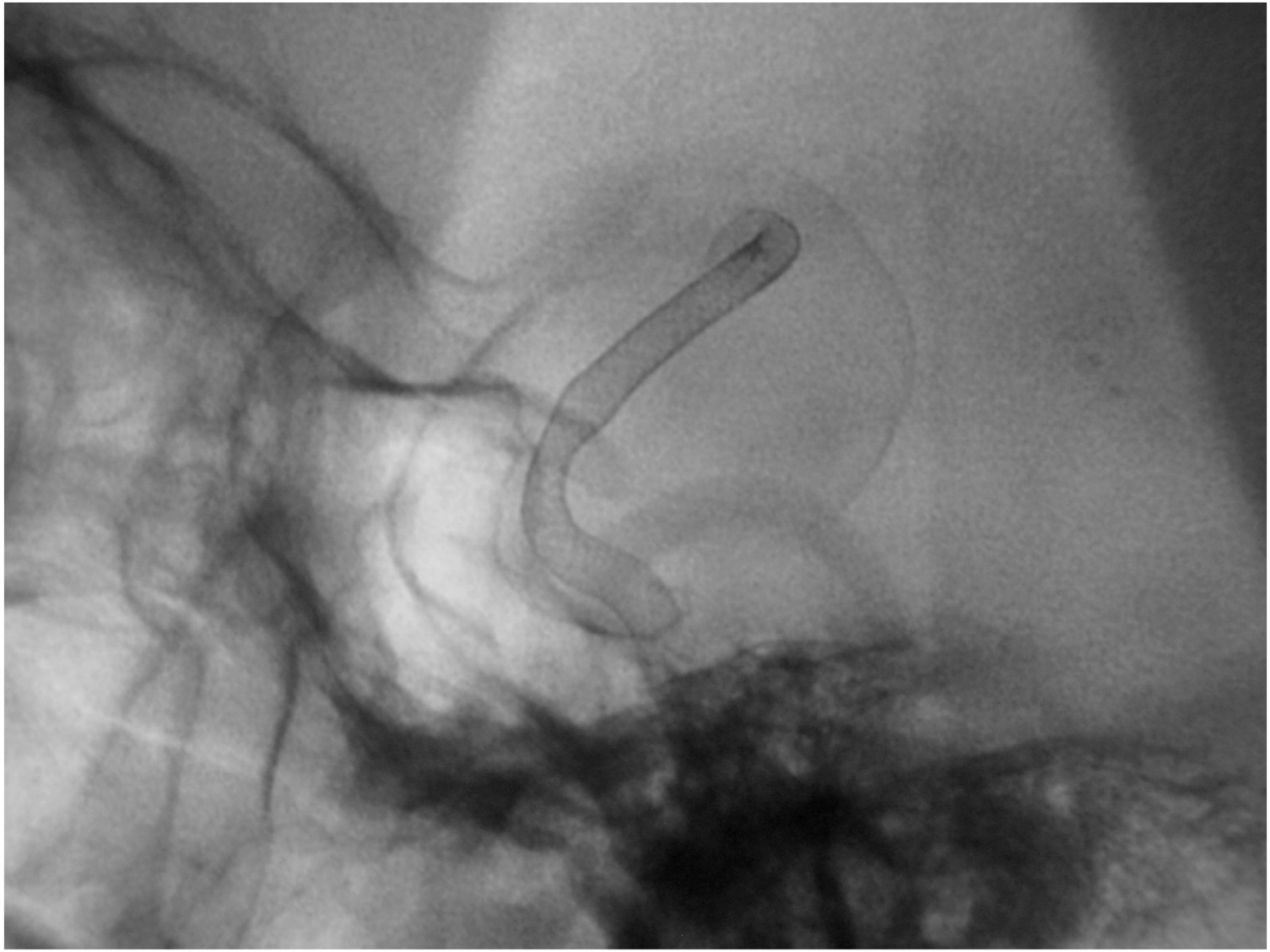

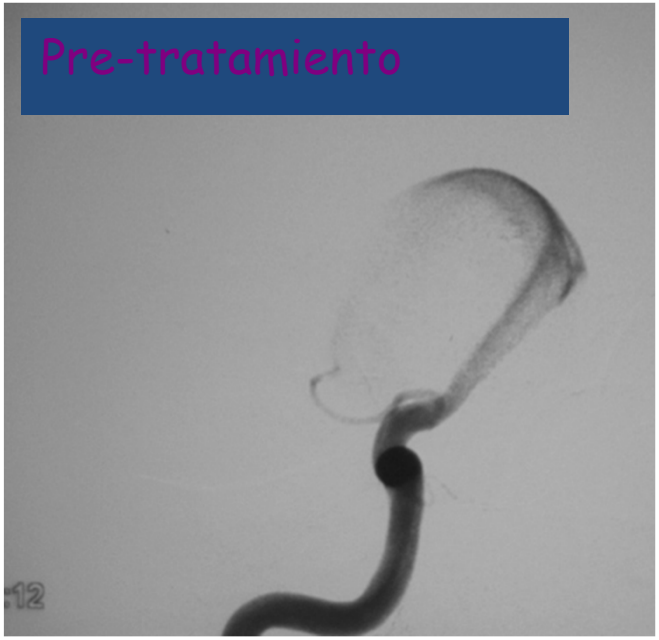
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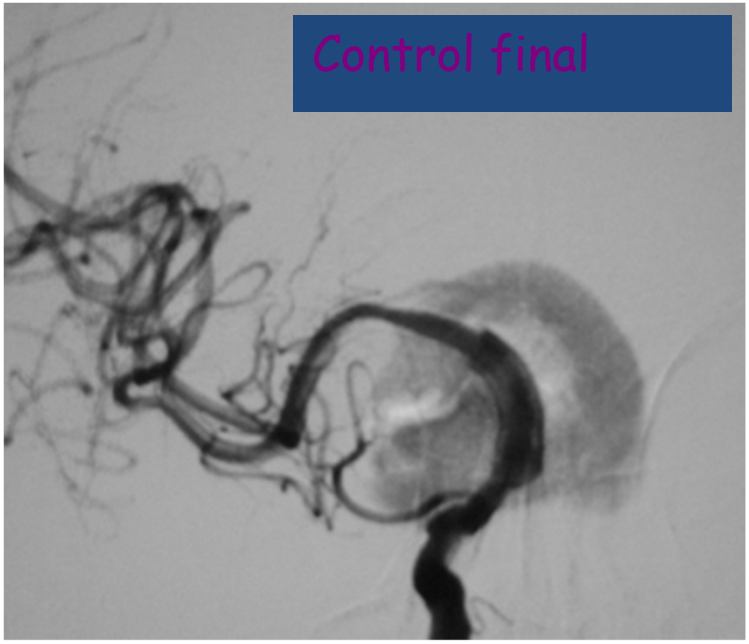
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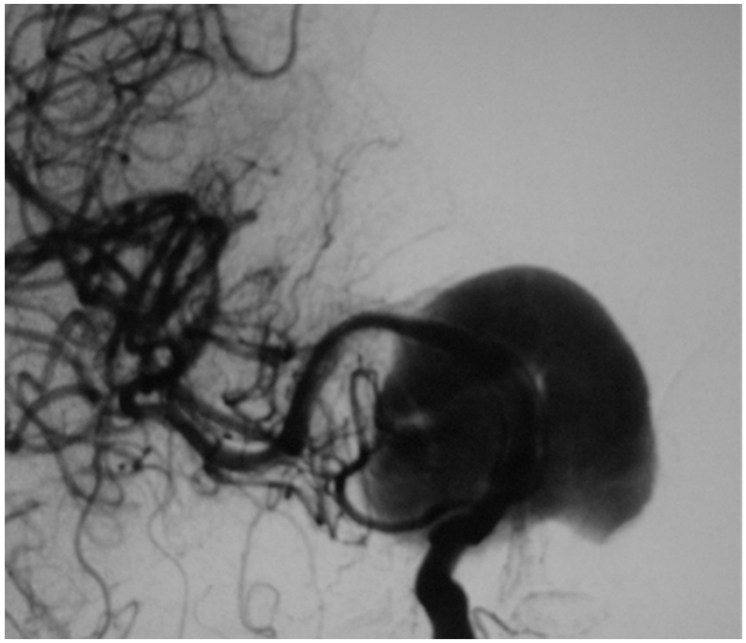

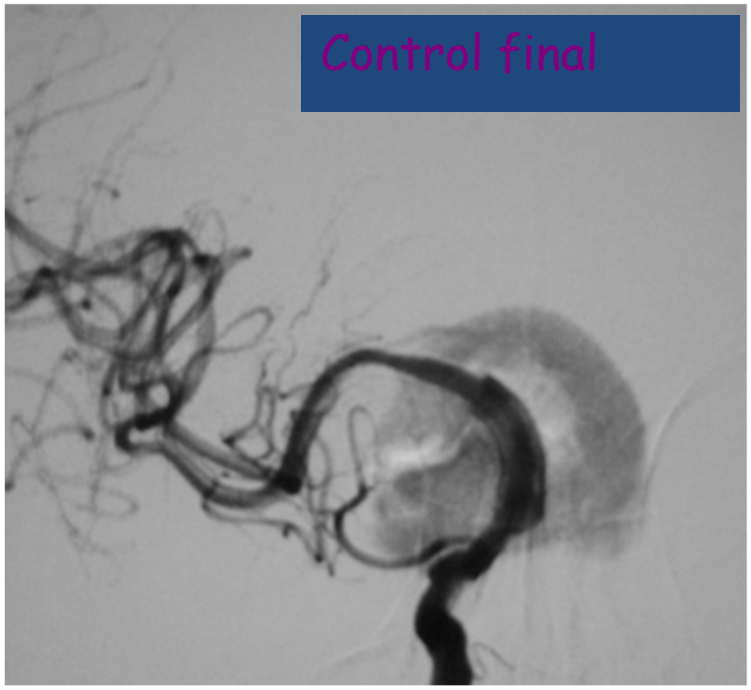
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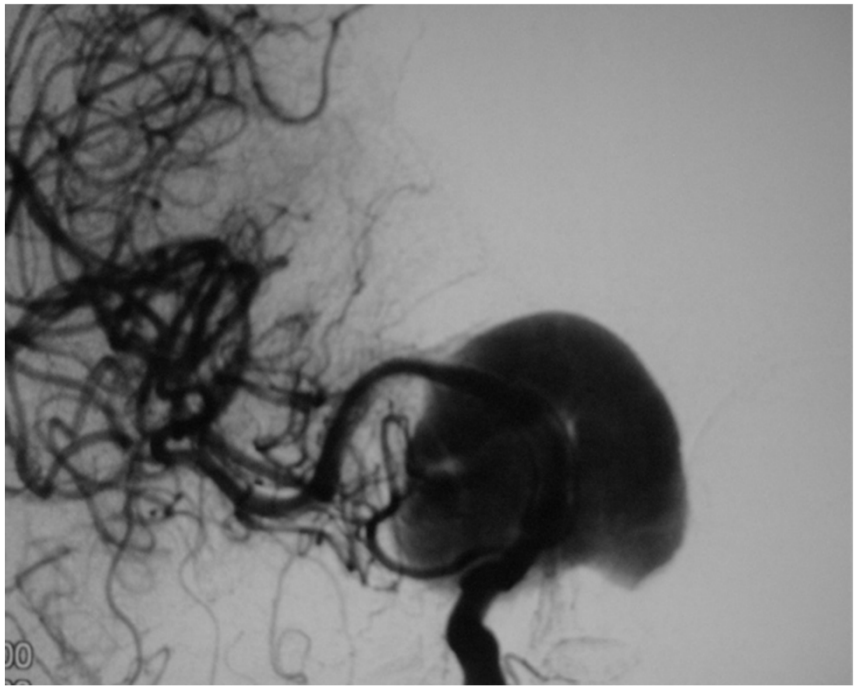

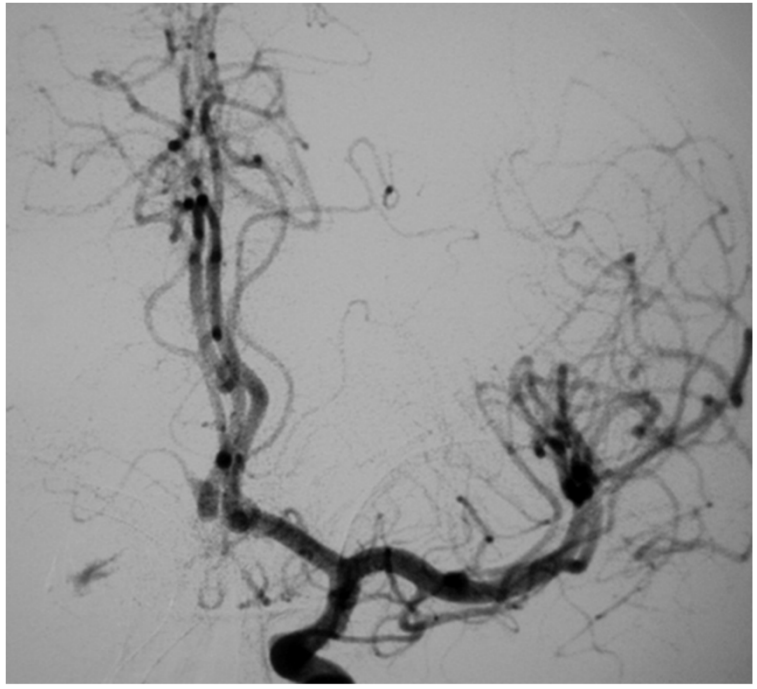

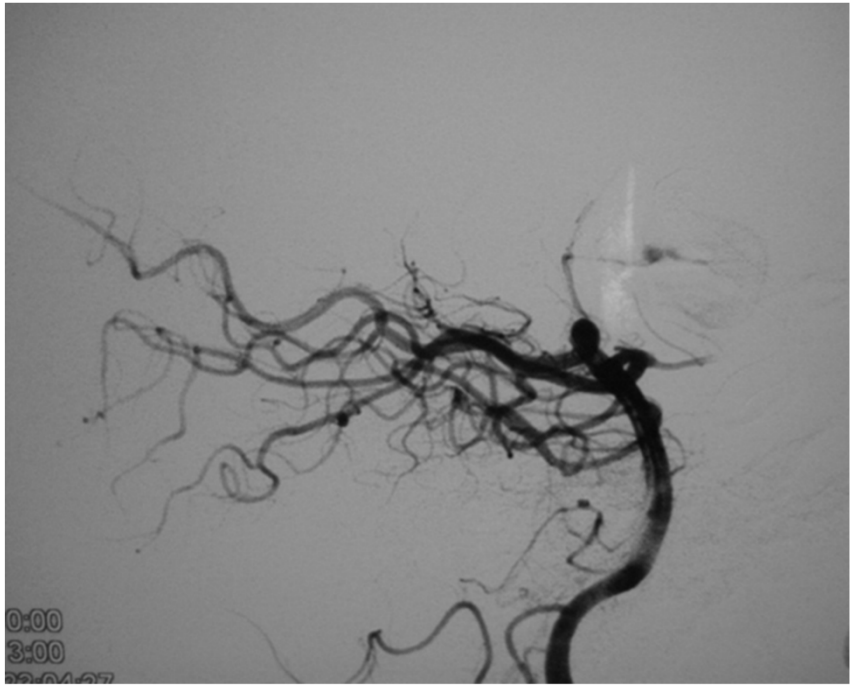
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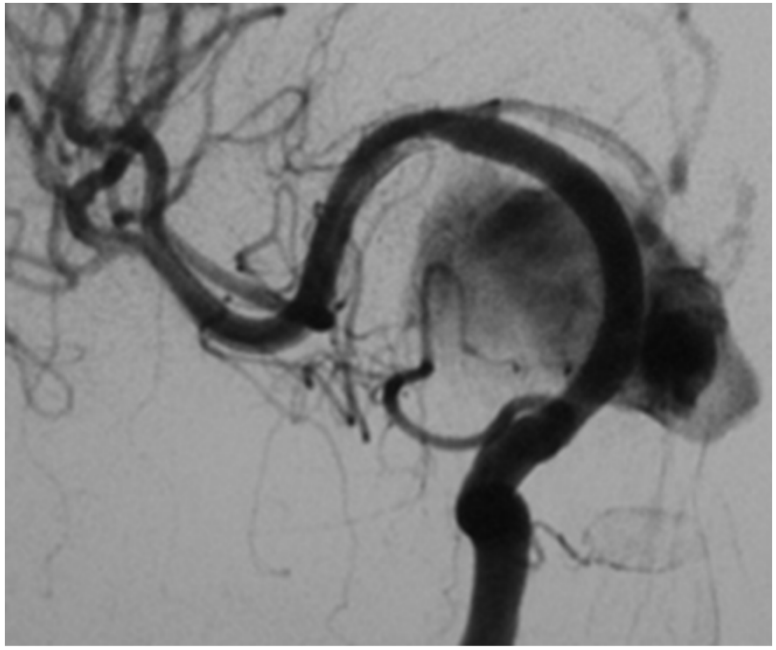

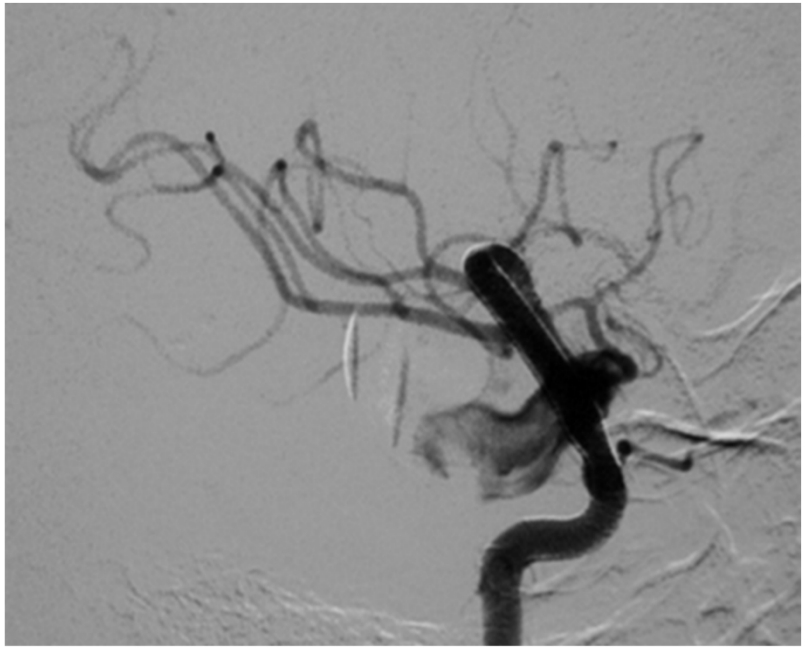

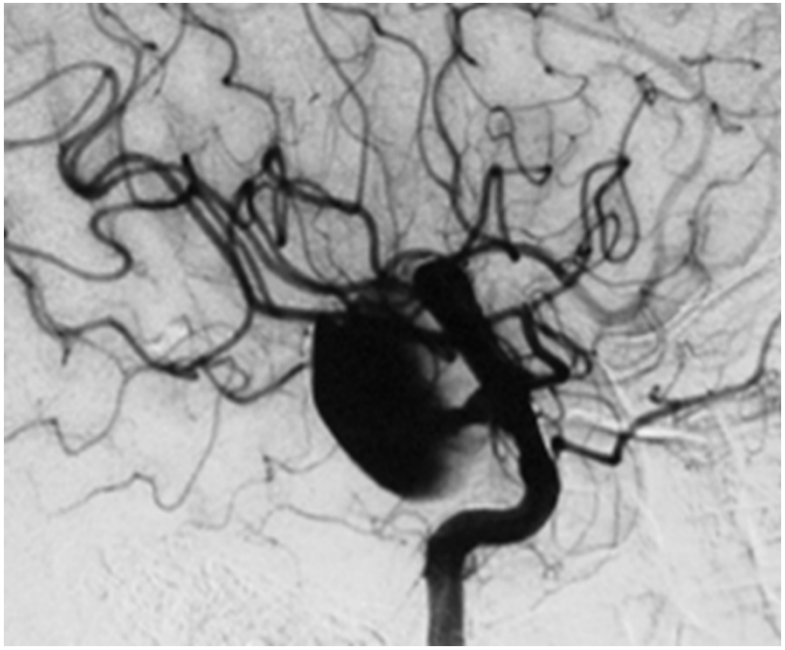

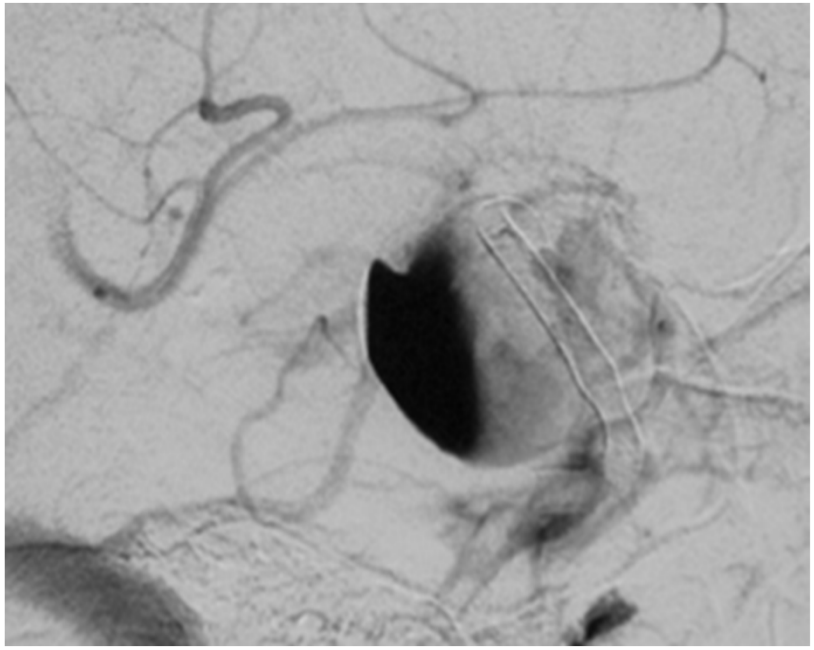

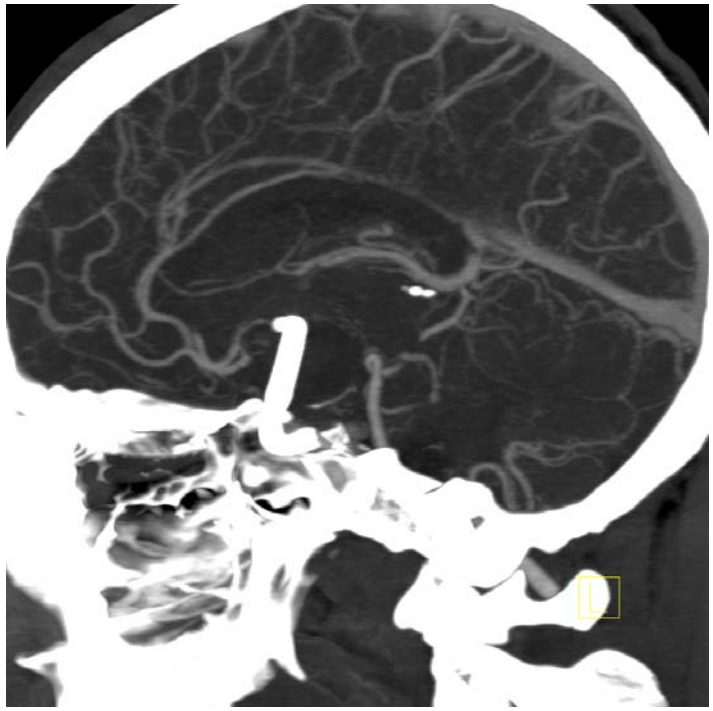

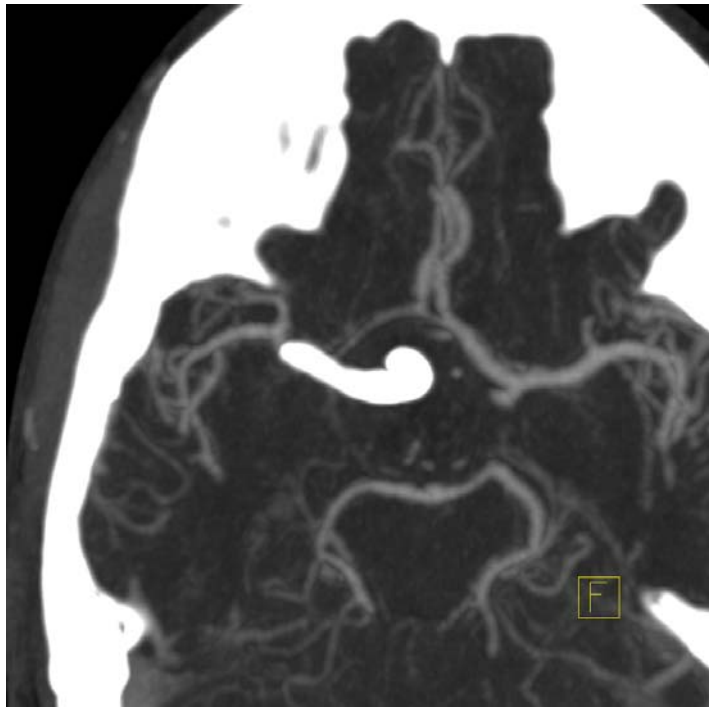

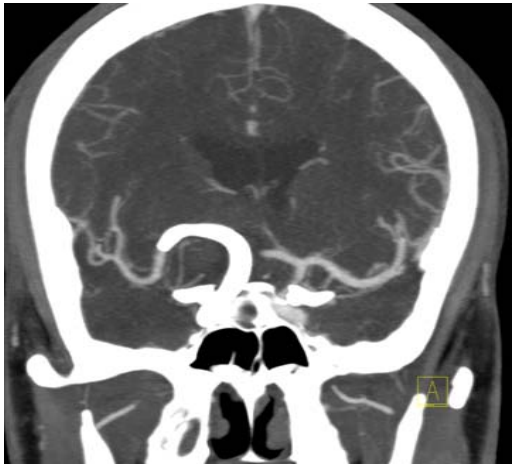

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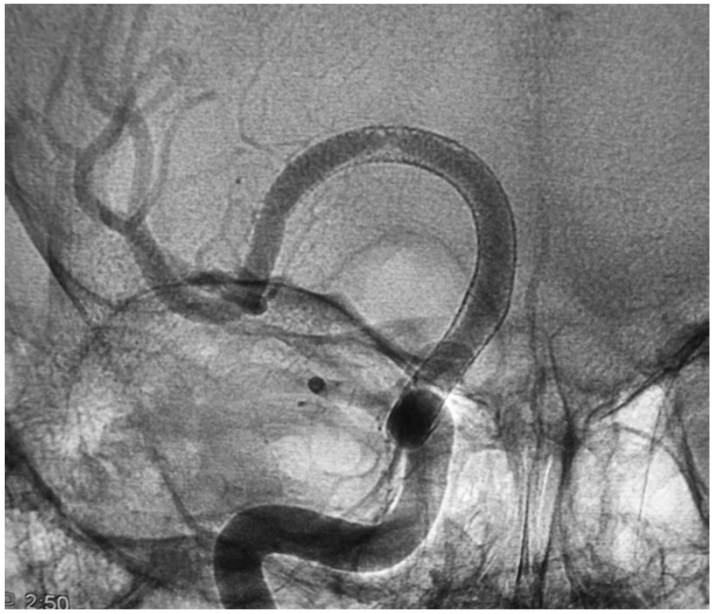

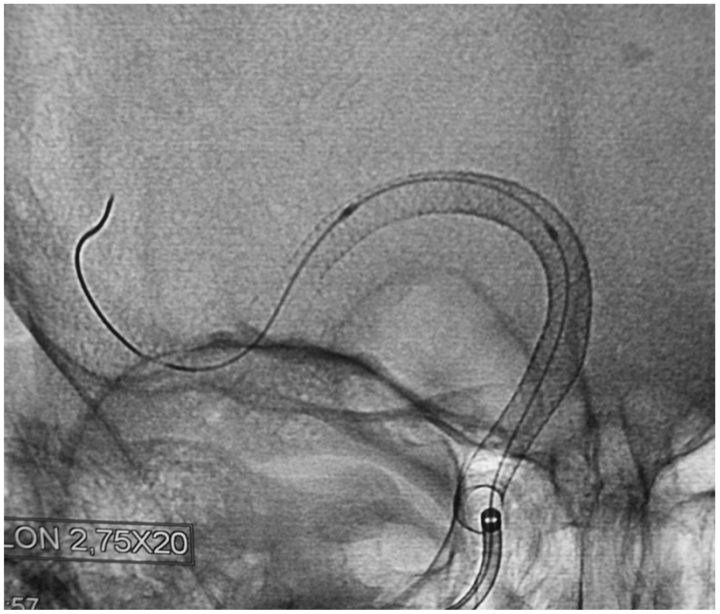

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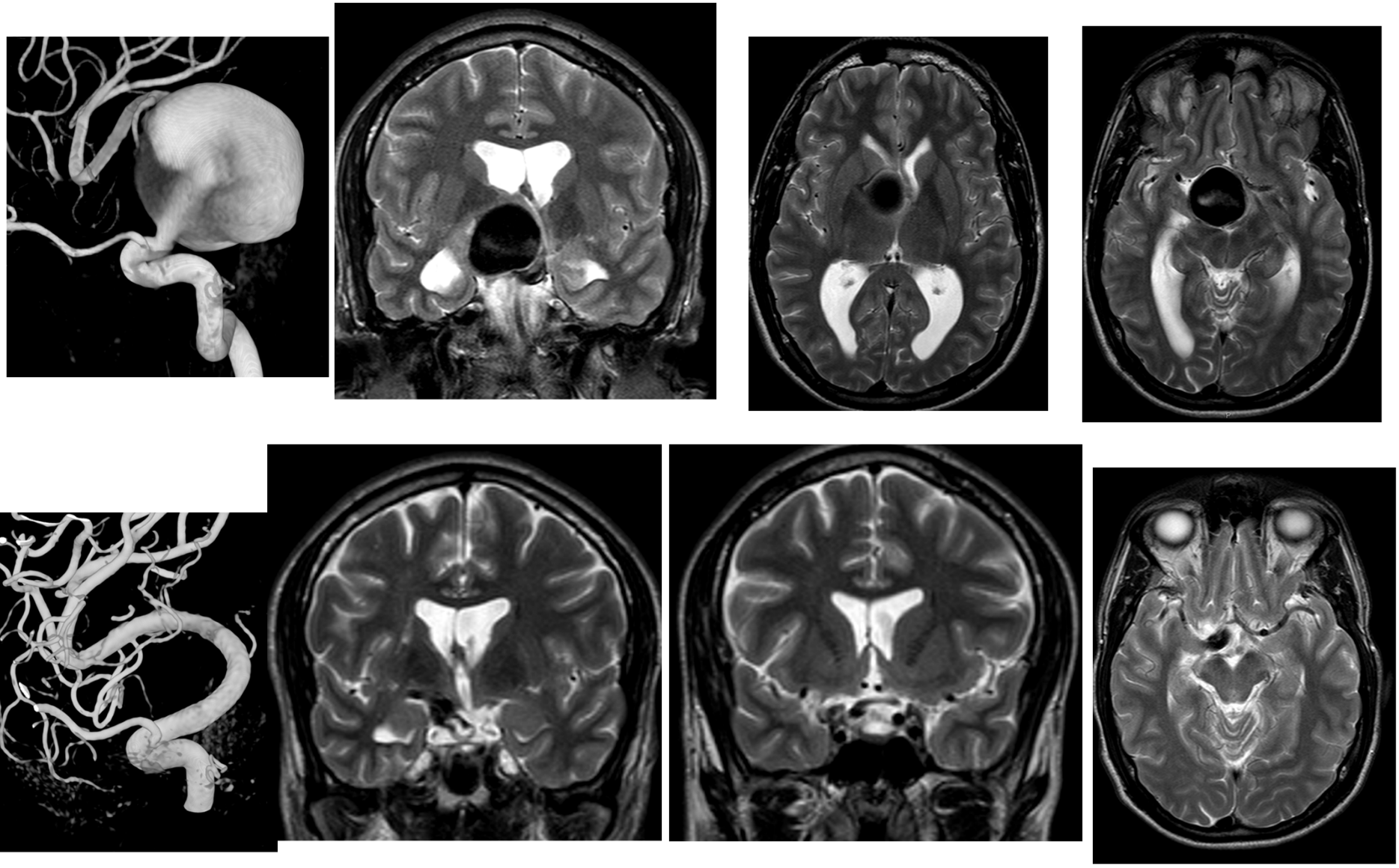

INDICACIONES

- **ANEURISMAS GRANDES O GIGANTES**
- **SINTOMAS COMPRESIVOS**

Treatment of Cavernous Sinus Aneurysms with Flow Diversion: Results in 44 Patients

R.C. Puffer, M. Piano, G. Lanzino, L. Valvassori, D.F. Kallmes, L. Quilici, H.J. Cloft, and E. Boccardi

ABSTRACT

BACKGROUND AND PURPOSE: Aneurysms of the cavernous segment of the ICA are difficult to treat with standard endovascular techniques, and ICA sacrifice achieves a high rate of occlusion but carries an elevated level of surgical complications and risk of de novo aneurysm formation. We report rates of occlusion and treatment-related data in 44 patients with cavernous sinus aneurysms treated with flow diversion.

MATERIALS AND METHODS: Patients with cavernous segment aneurysms treated with flow diversion were selected from a prospectively maintained data base of patients from 2009 to the present. Demographic information, treatment indications, number/type of flow diverters placed, outcome, complications (technical or clinical), and clinical/imaging follow-up data were analyzed.

RESULTS: We identified 44 patients (37 females, 7 males) who had a flow diverter placed for treatment of a cavernous ICA aneurysm (mean age, 57.2; mean aneurysm size, 20.9 mm). The mean number of devices placed per patient was 2.2. At final angiographic follow-up (mean, 10.9 months), 71% had complete occlusion, and of those with incomplete occlusion, 40% had minimal remnants (<3 mm). In symptomatic patients, complete resolution or significant improvement in symptoms was noted in 90% at follow-up. Technical complications (which included, among others, vessel perforation in 4 patients, groin hematoma in 2, and asymptomatic carotid occlusion in 1) occurred in approximately 36% of patients but did not result in any clinical sequelae immediately or at follow-up.

CONCLUSIONS: Our series of flow-diversion treatments achieved markedly greater rates of complete occlusion than coiling, with a safety profile that compares favorably with that of carotid sacrifice.

ABBREVIATION: PED = Pipeline Embolization Device

- 44 PACIENTES

- SINTOMAS:
  - cavernous cranial neuropathy/ diplopia in 52%
  - headache/retro-orbital pain in 30%

- DISPOSITIVOS: PIPELINE / SILK / SURPASS

- 29 PACIENTES SINTOMÁTICOS CON SEGUIMIENTO

  - RESOLUCIÓN COMPLETA O MEJORA SIGNIFICATIVA 90%
  - APARICIÓN NUEVOS SÍNTOMAS 23%
  - EN TODOS LOS CASOS, EXCEPTO 1, ESOS NUEVO STX DESAPARECIERON AL MES

- COMPLICACIONES
  TODAS ELLAS SIN REPERCUSIÓN CLÍNICA
  - HIP 2%
  - PERFORACIÓN VASCULAR 9%
  - OCLUSIÓN CARÓTIDA 2%
  - ESTENOSIS INTRASTENT 2%

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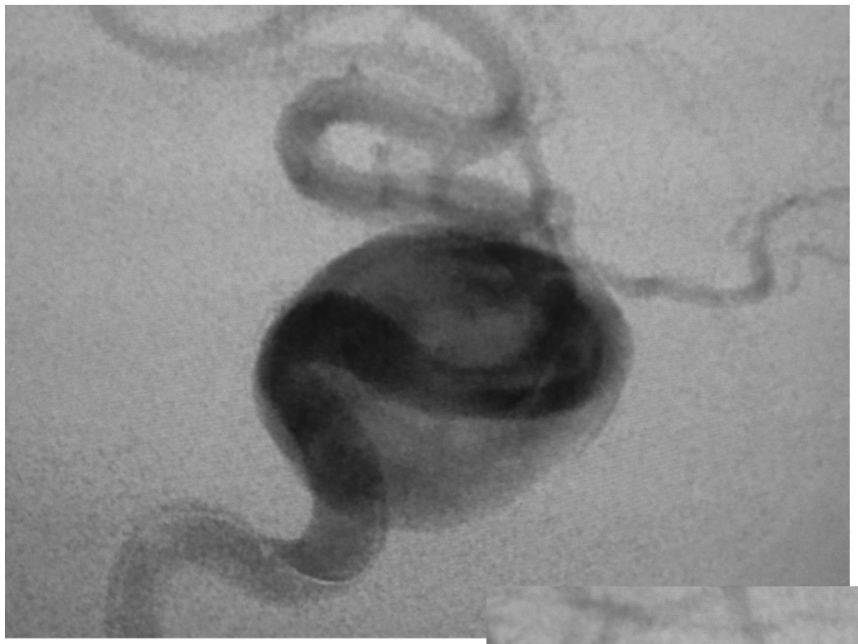

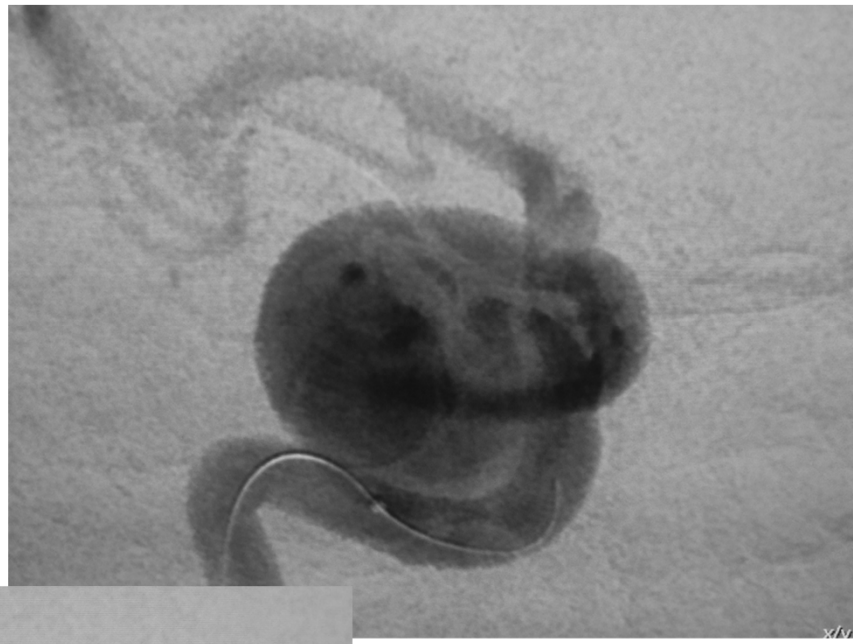

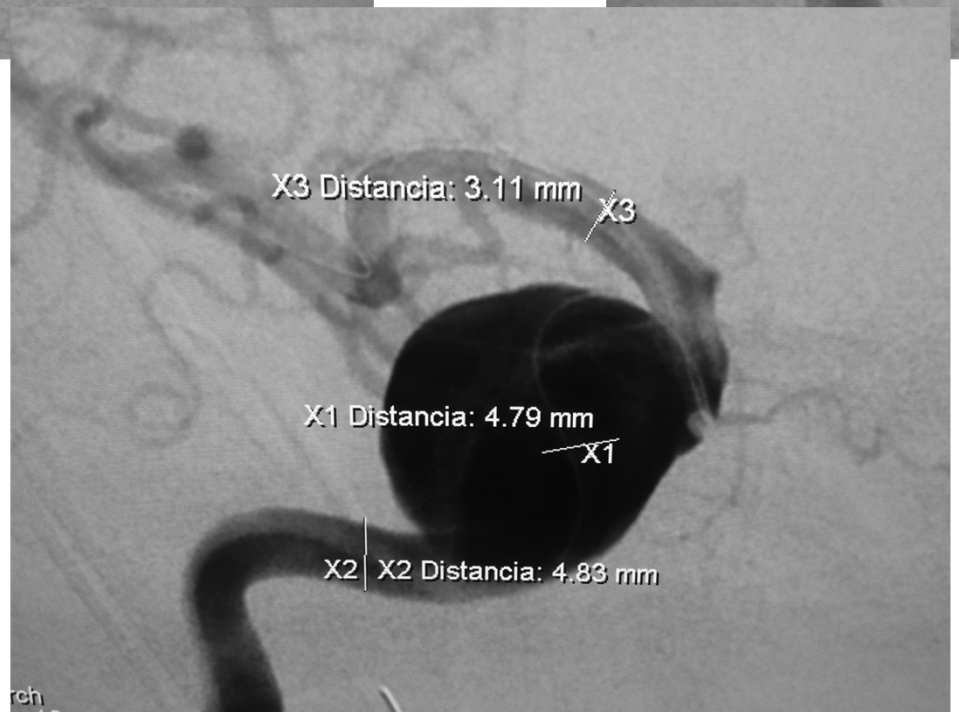

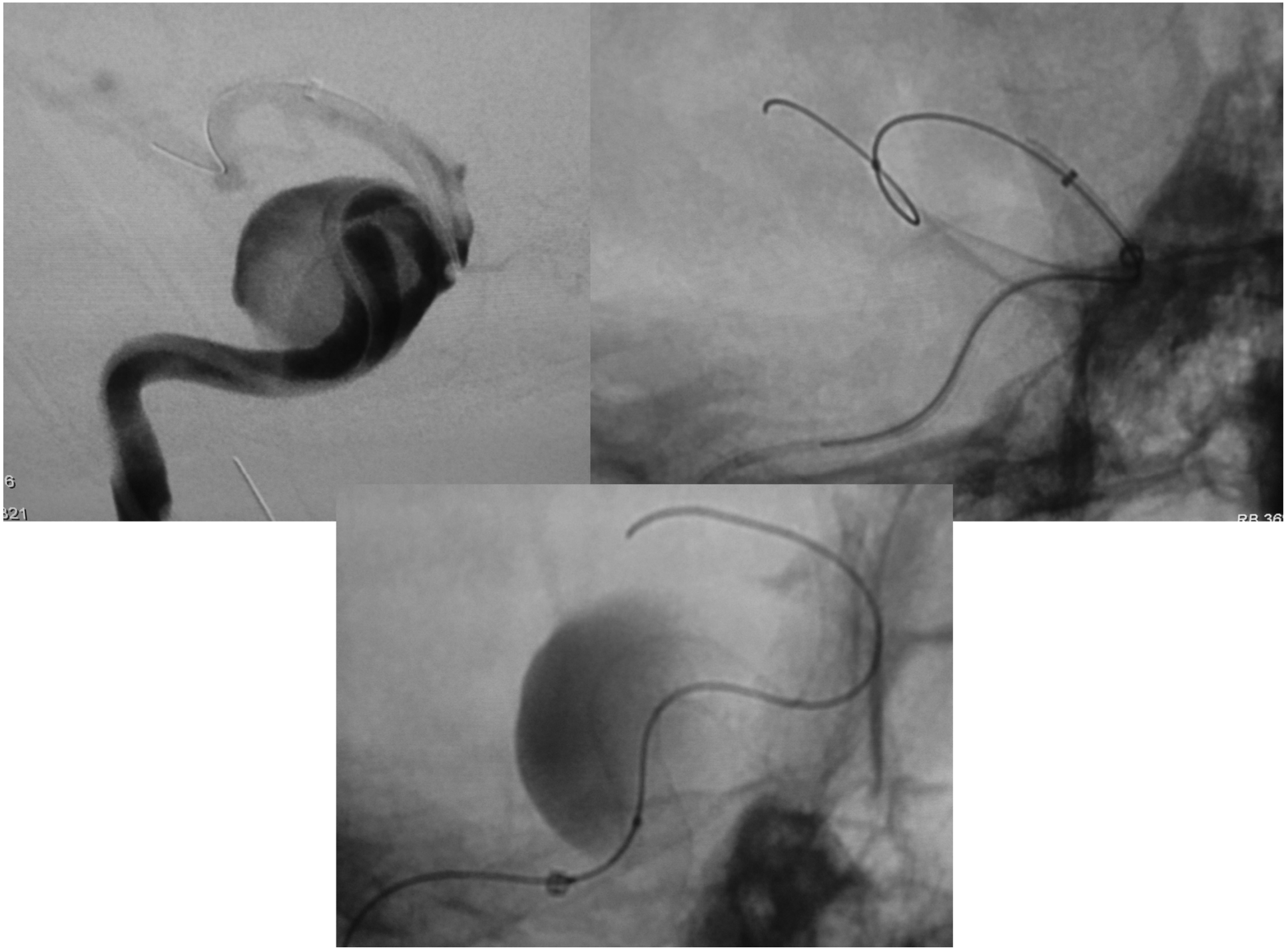

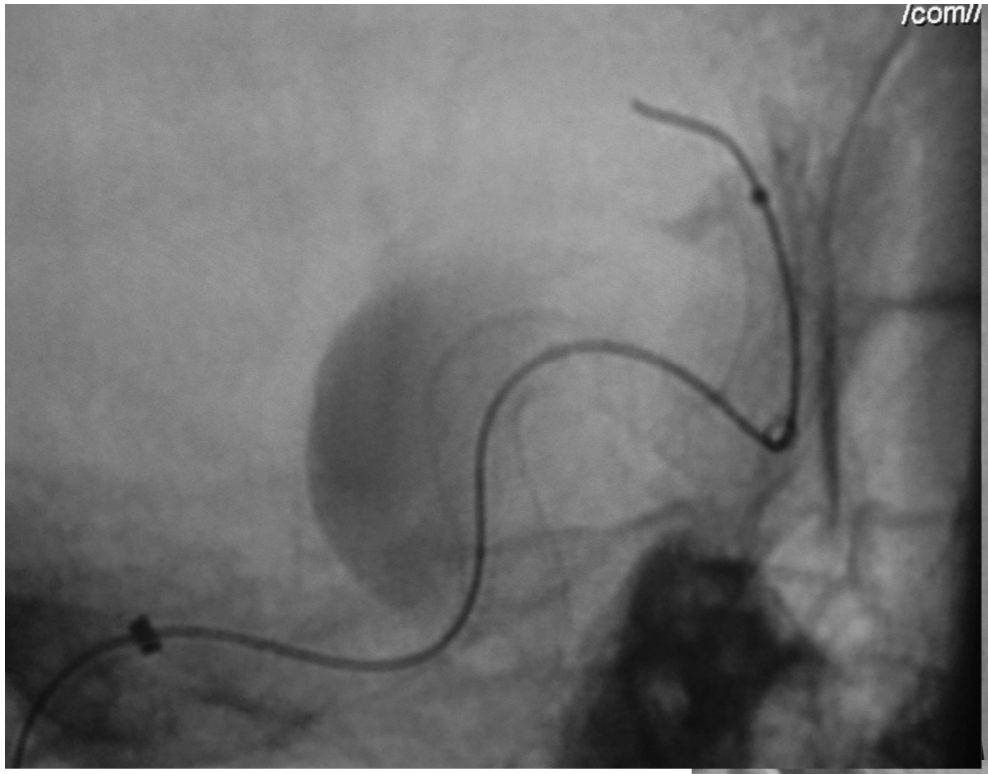
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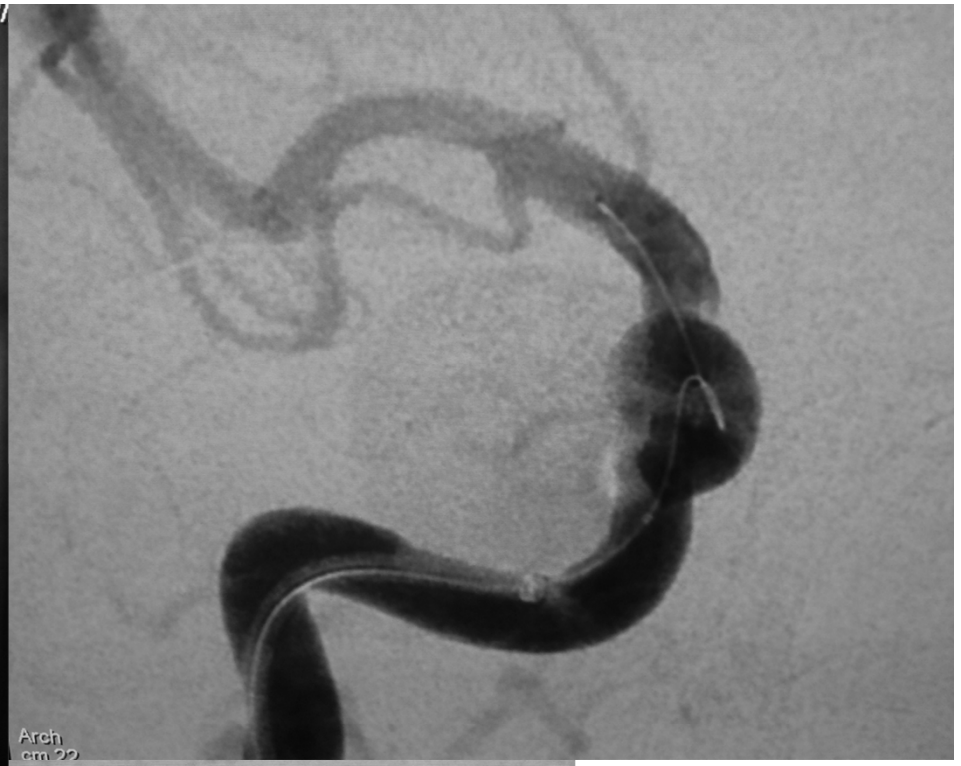
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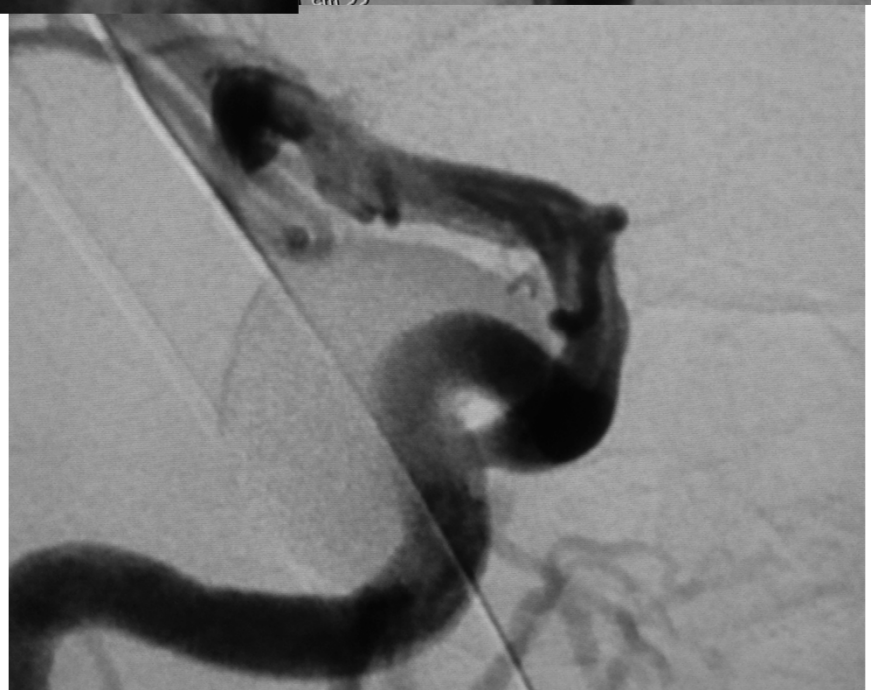

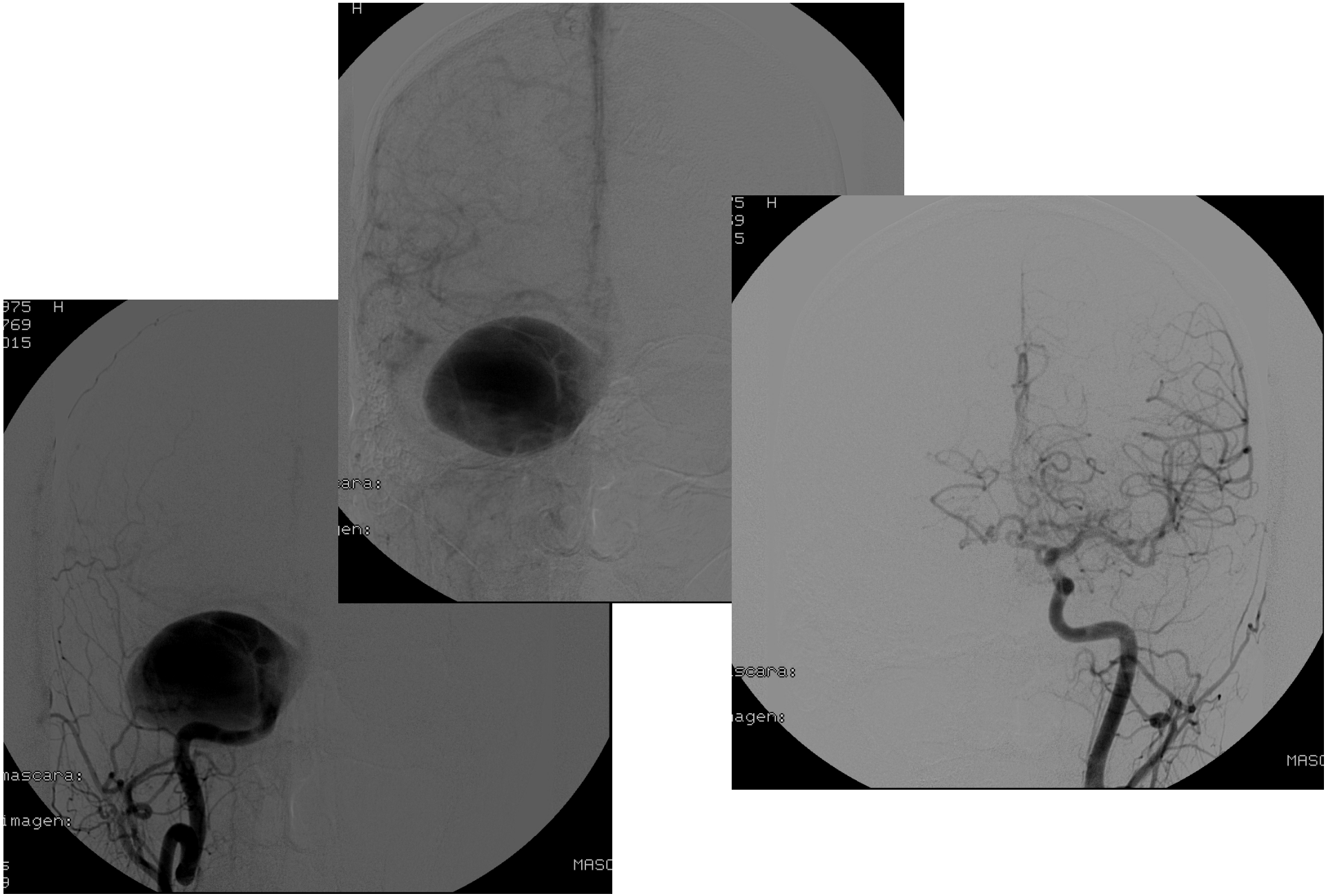
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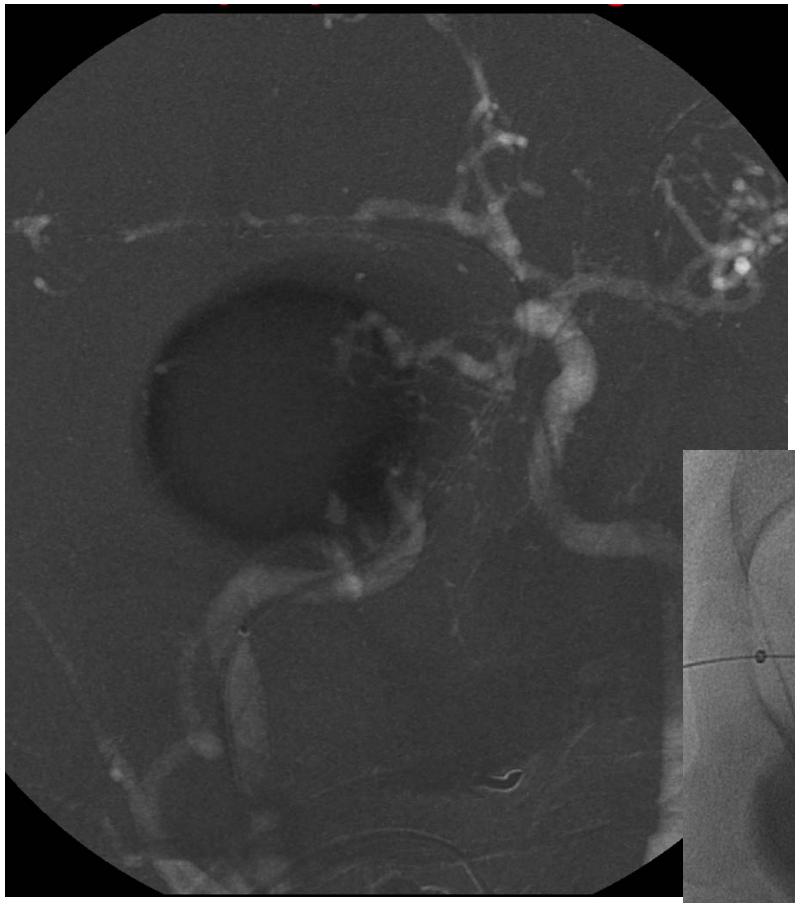

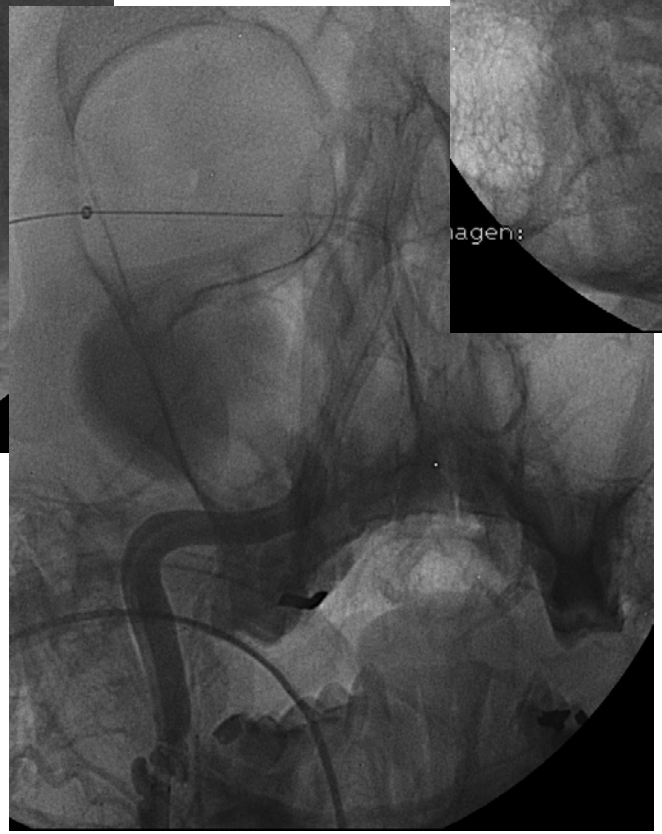

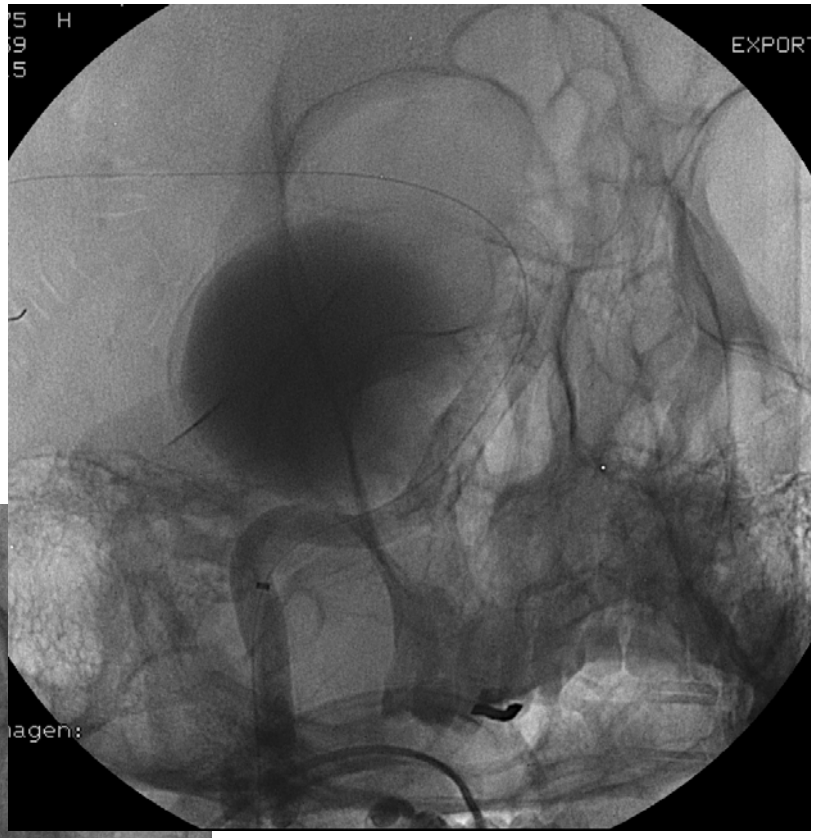
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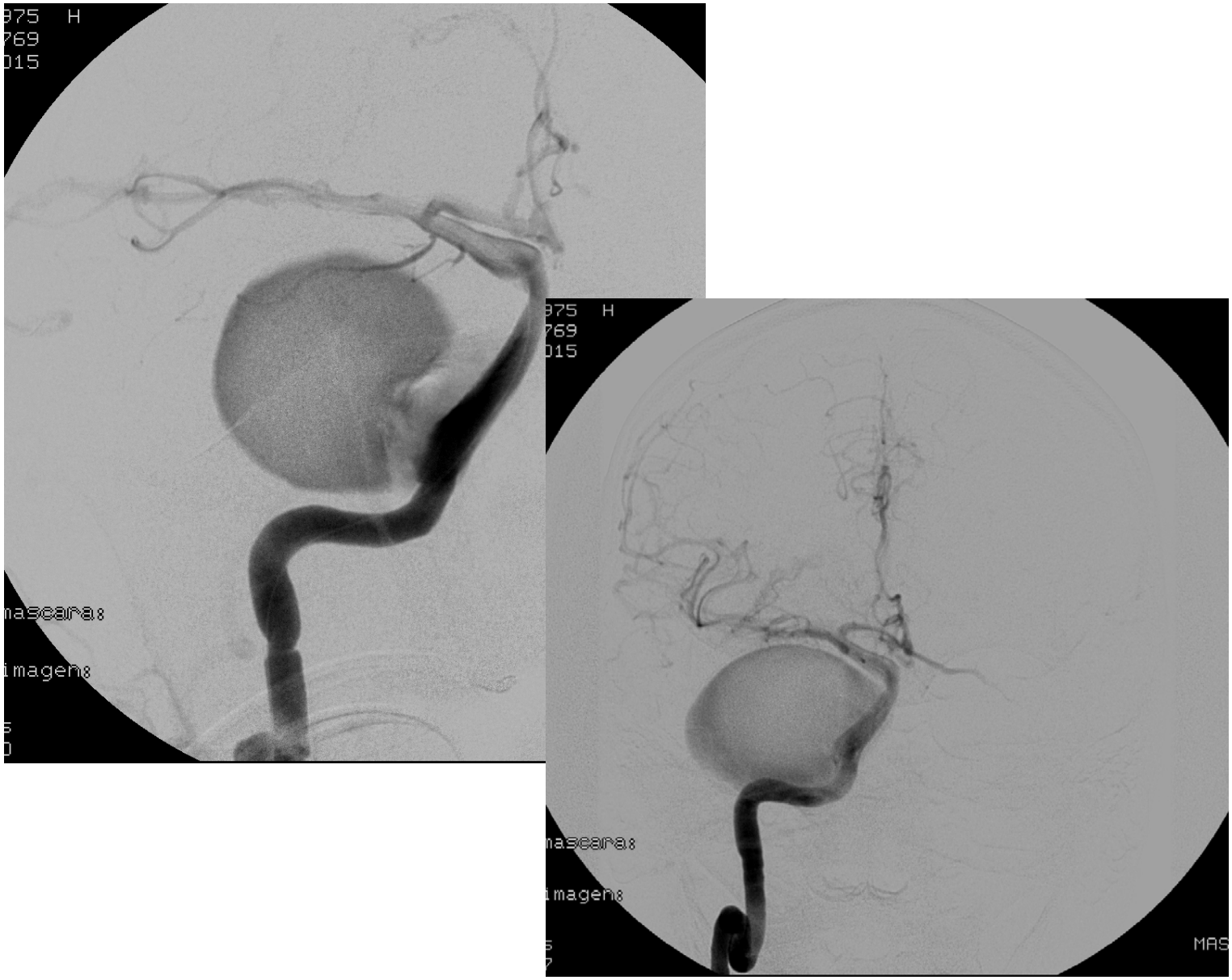

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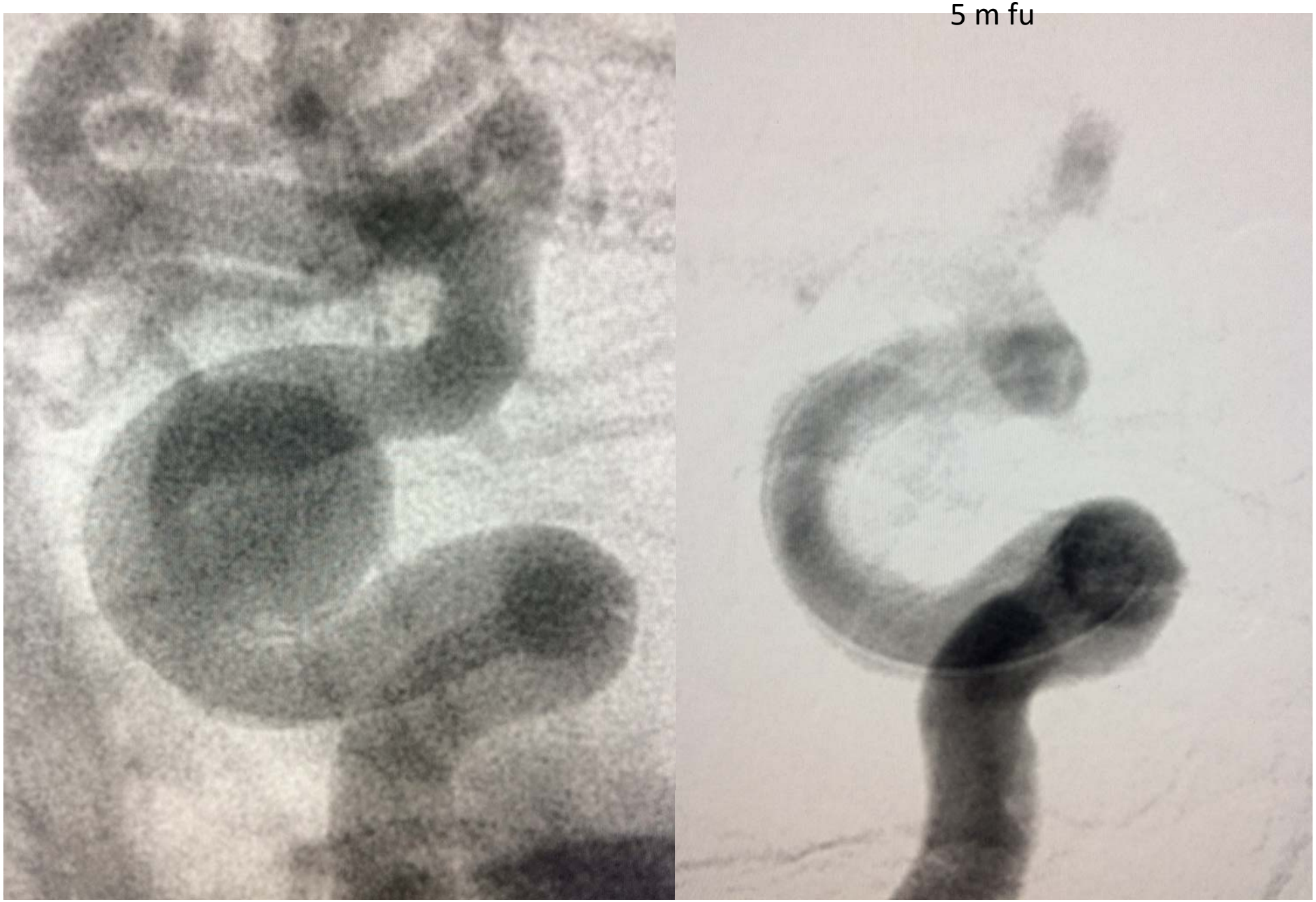

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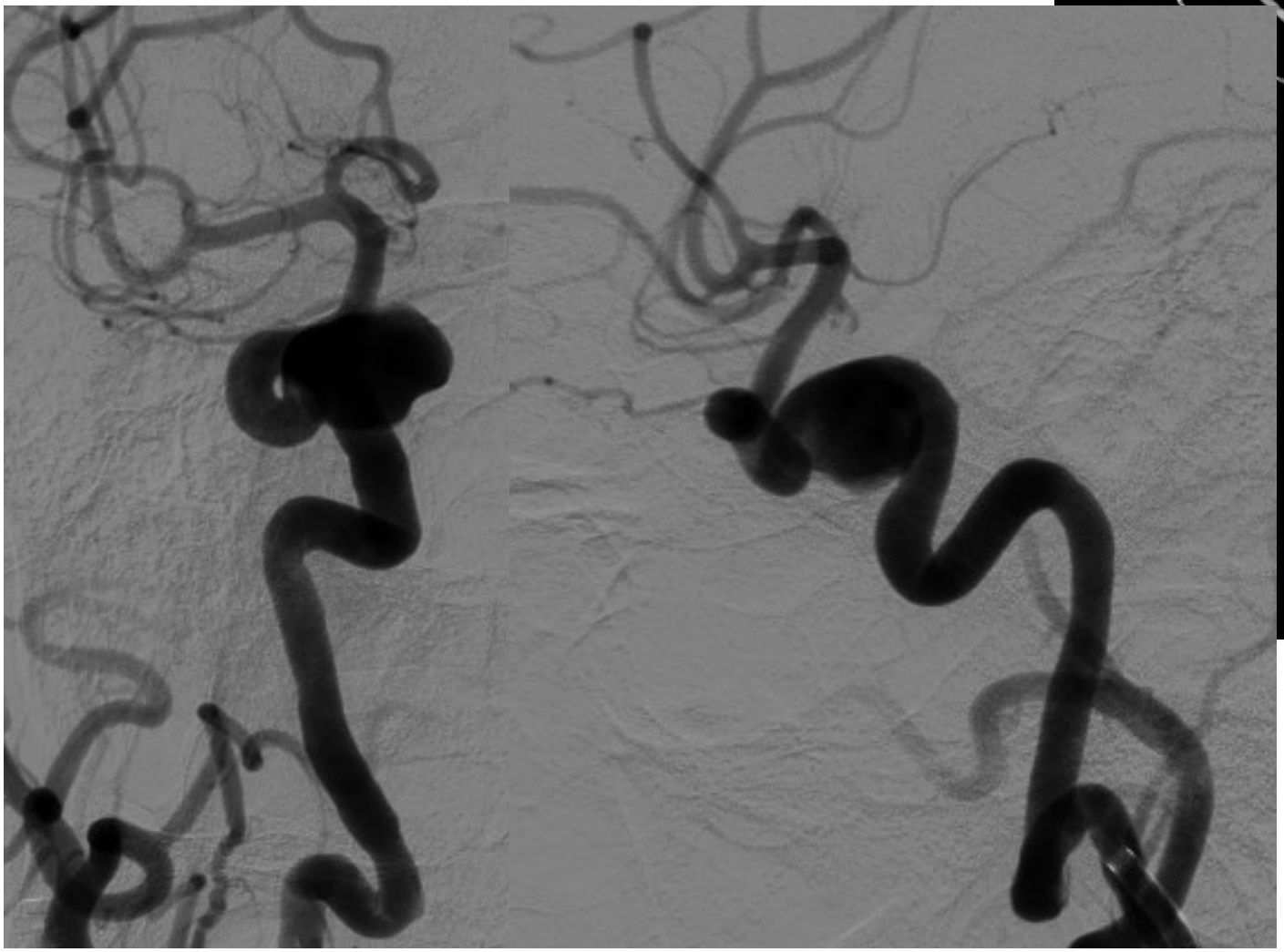

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CONCLUSIONS

Flow-diverting stents represent a highly effective treatment technique for aneurysms of the cavernous ICA and may be a safer choice than carotid sacrifice with or without surgical bypass, given the ideal vessel characteristics of the cavernous ICA for flow diversion. Technical issues are not uncommon, occurring in just more than 1 in 3 cases, some of which were serious complications, though none resulted in any permanent neurologic morbidity in this series. Nevertheless, these technical issues, combined with the often advanced age of these patients and their relative vessel fragility, require a careful analysis to choose the procedure best indicated in each individual case.

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CONCLUSIONS: The cost of initial treatment of large and giant aneurysms with PED is economically favorable compared to traditional embolization techniques. However, any potential cost benefit depends on aneurysm volume, coil type, and number of PEDs used. Accordingly, PED therapy is more expensive than coiling in aneurysms <0.9 cm^3 or when multiple devices are used.

- Aneurysm
- Coil
- Cost
- Pipeline embolization device

Abbreviations and Acronyms
PED: Pipeline embolization device
MRA: Magnetic resonance angiogram

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INTRODUCTION

Endovascular treatment of intracranial aneurysms with traditional embolic agents can be expensive. Compared with surgical clipping, endovascular treatment is associated with better clinical outcomes but higher hospital costs in both patients with

management of intracranial aneurysms. The purpose of this study was to determine whether treatment of large and giant aneurysms with the pipeline embolization device (PED) is more economical than traditional embolization strategies.

OK

ETHO… W…de…ed 30 consecutive aneurysms larger than 10 mm that …e treate…wi…t our institution. For each aneurysm treated with PED, …retical …il …bol…ion was performed by filling volume in a consistent, st…shio…until …acking density of 25% was reached. Prices of all equipment and implants were taken from price lists provided by each manufacturer.

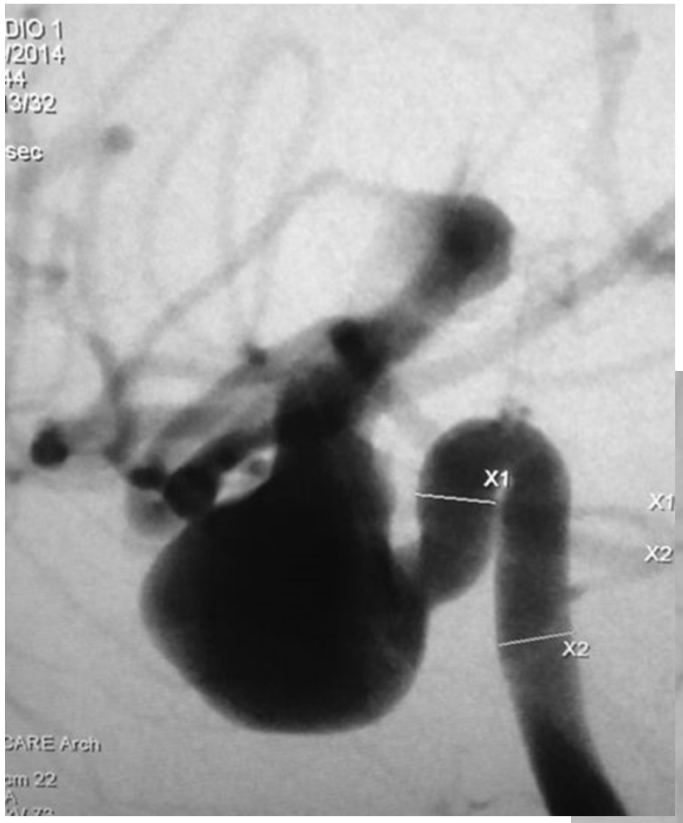
RESULTS: Median aneurysm volume was 0.90 cm^3. Overall procedure cost was lower with the PED (mean, $23,911) vs. coiling ($30,522, $P = .06$). Above the median aneurysm volume, PED treatment was significantly less expensive than coiling even if multiple PEDs were used ($P = .006$). However, below the median aneurysm volume, PED treatment was significantly more expensive than coiling ($P = .009$). Treatment with multiple PEDs was not cost-beneficial compared with coiling, even above the median aneurysm volume. Potential savings associated with the PED were highly dependent on the type of embolic agent used.

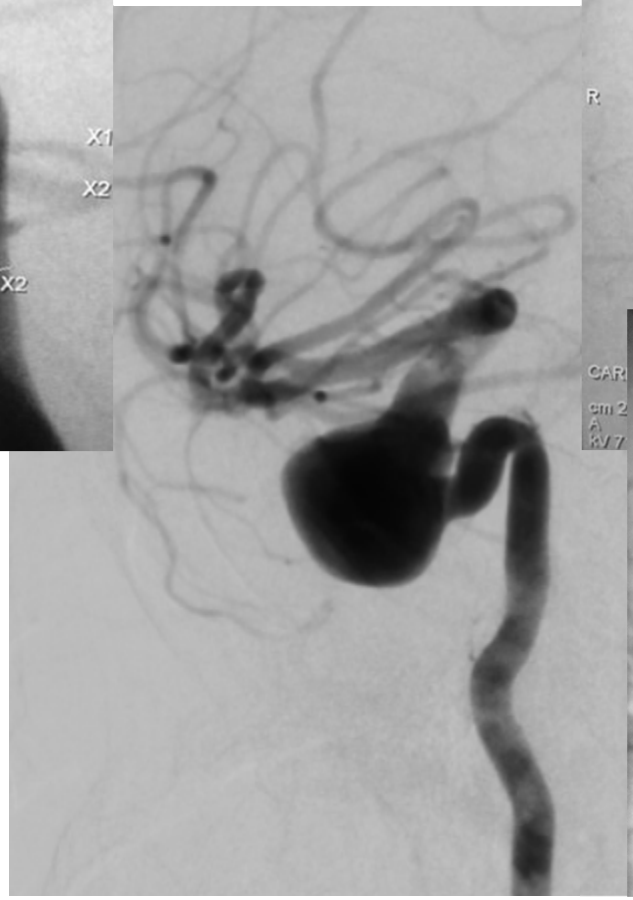
CONCLUSIONS: The cost of initial treatment of large and giant aneurysms with PED is economically favorable compared to traditional embolization techniques. However, any potential cost benefit depends on aneurysm volume, coil type, and number of PEDs used. Accordingly, PED therapy is more expensive than coiling in aneurysms <0.9 cm^3 or when multiple devices are used.

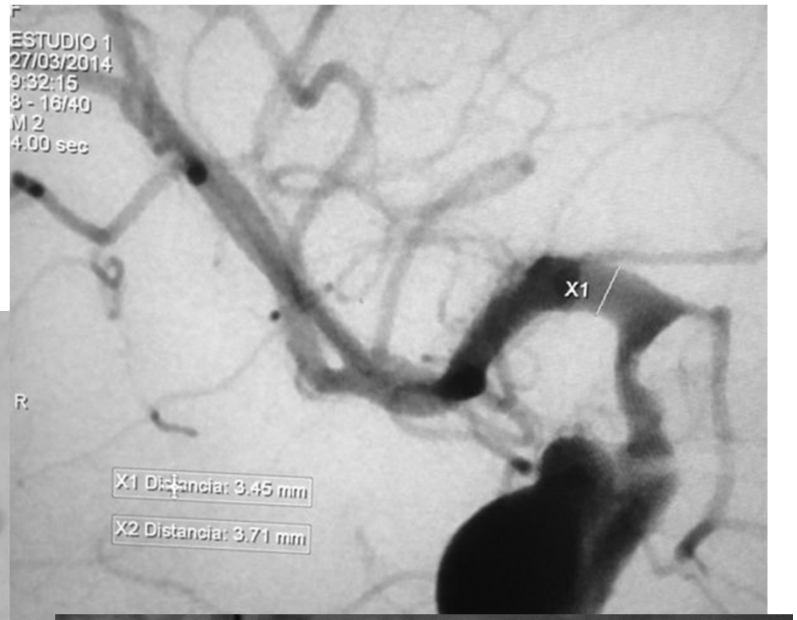
INDICACIONES

- **ANEURISMAS GRANDES O GIGANTES**
- **SINTOMAS COMPRESIVOS**
- **ANEURISMAS FUSIFORMES**

Case 22 alicante 11/04/14

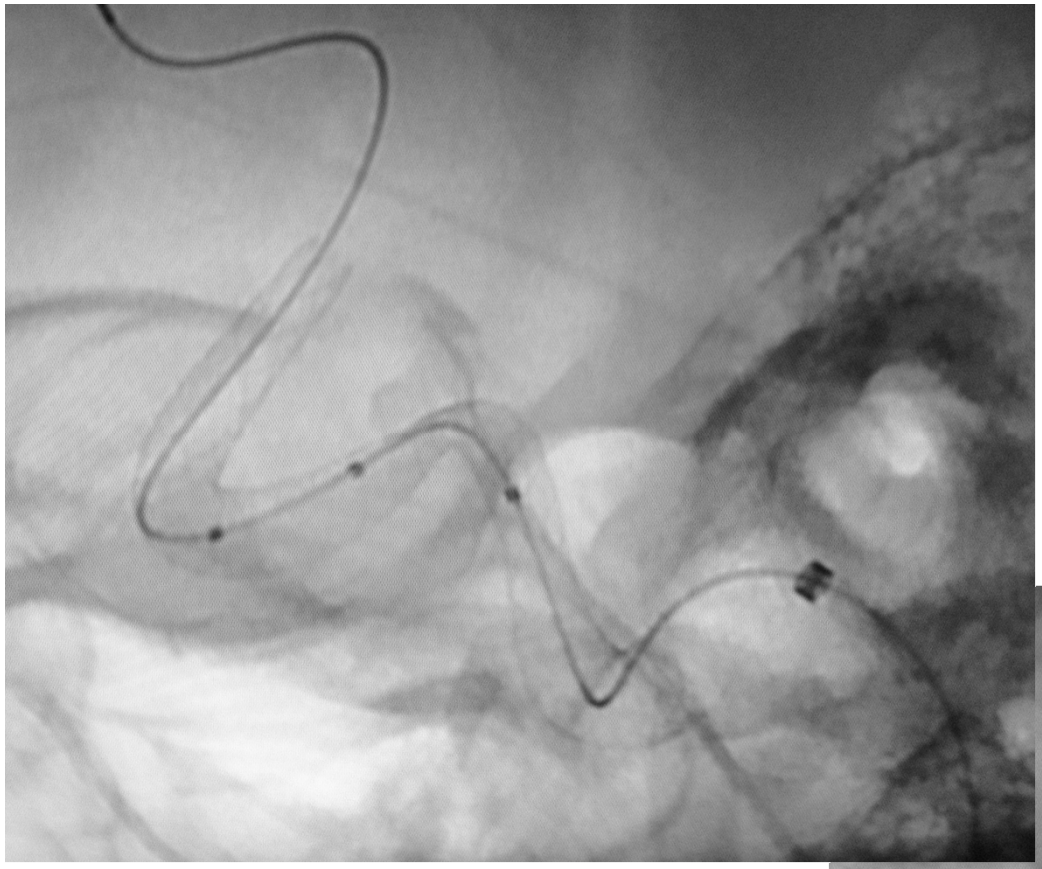


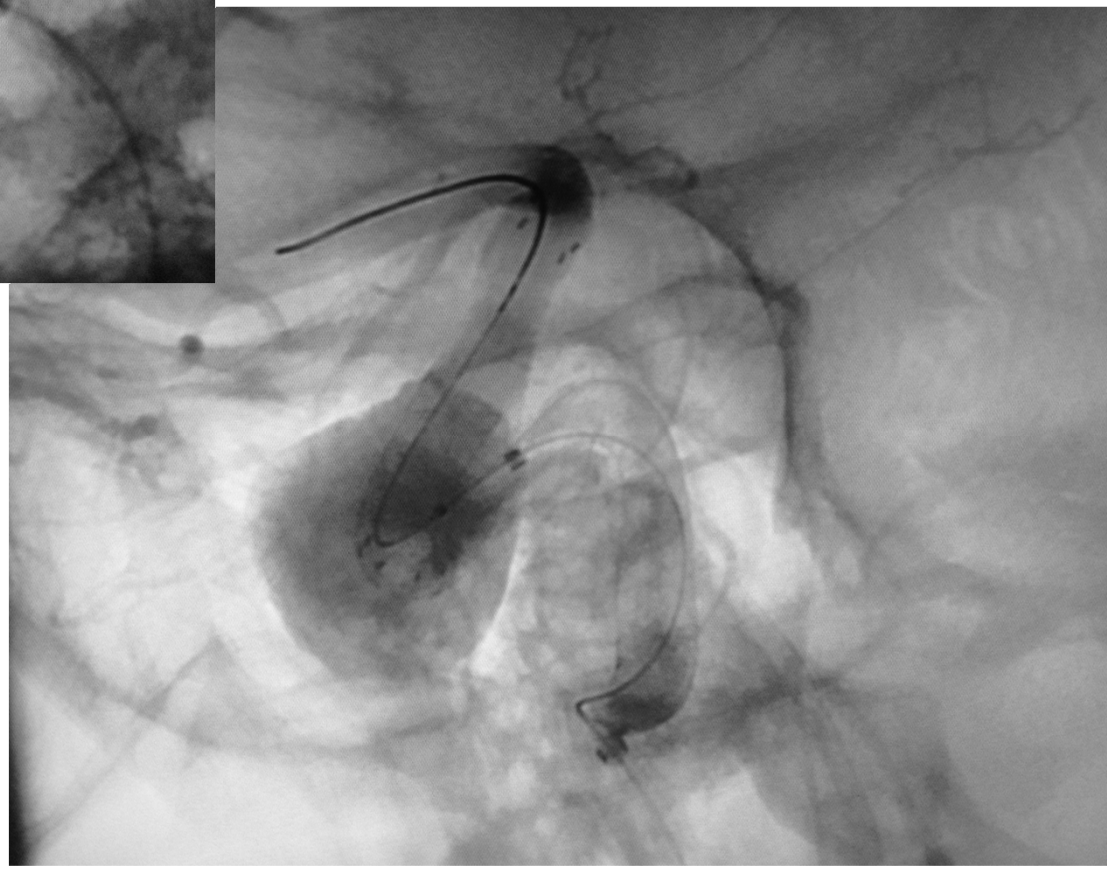




4X50
+ WINGSPAN

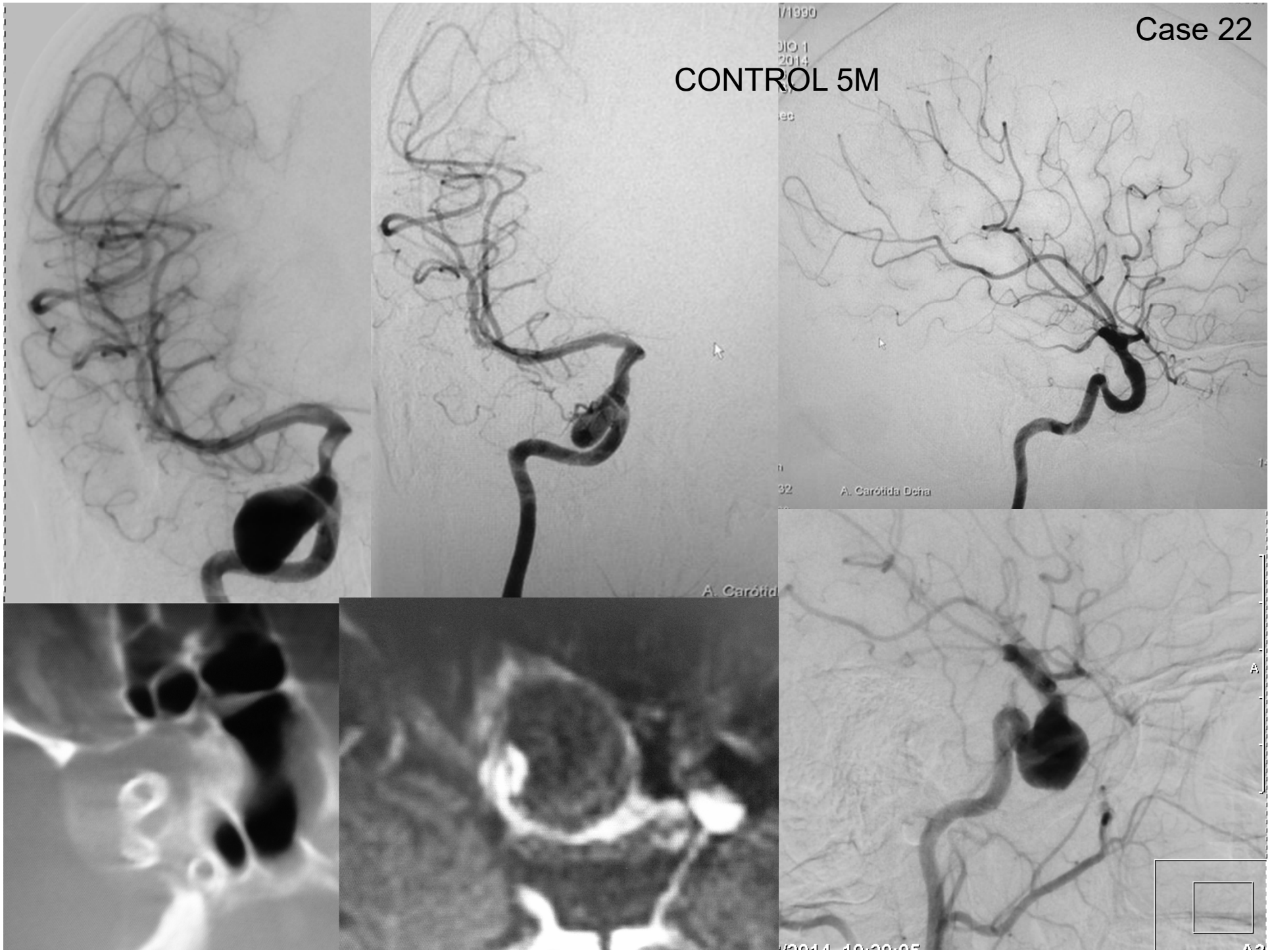
Case 22





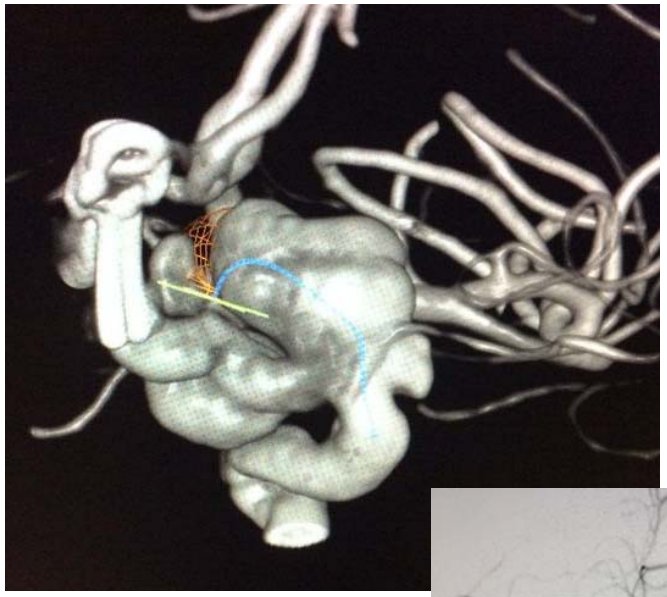
Case 22

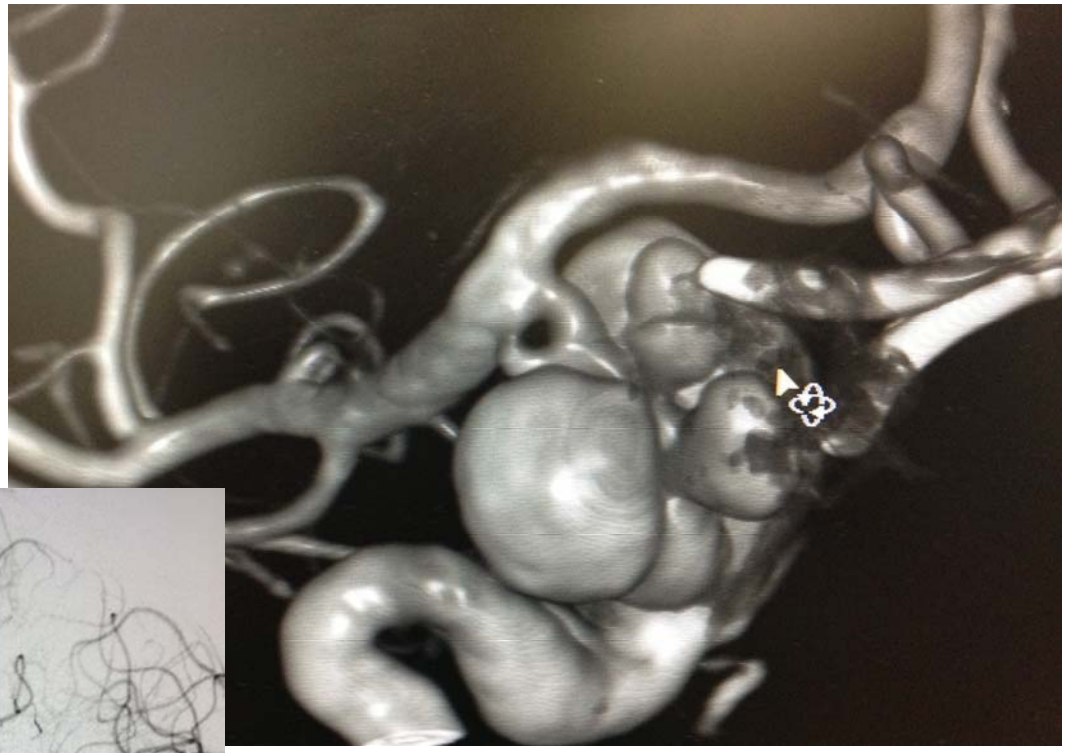
CONTROL 5M

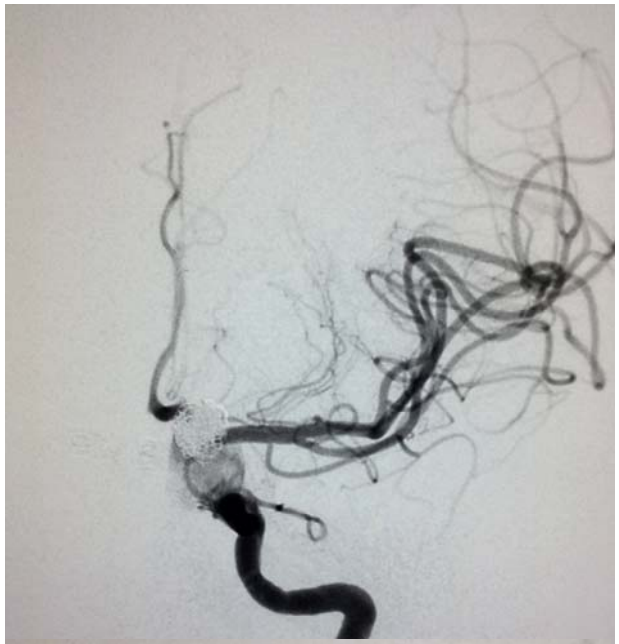


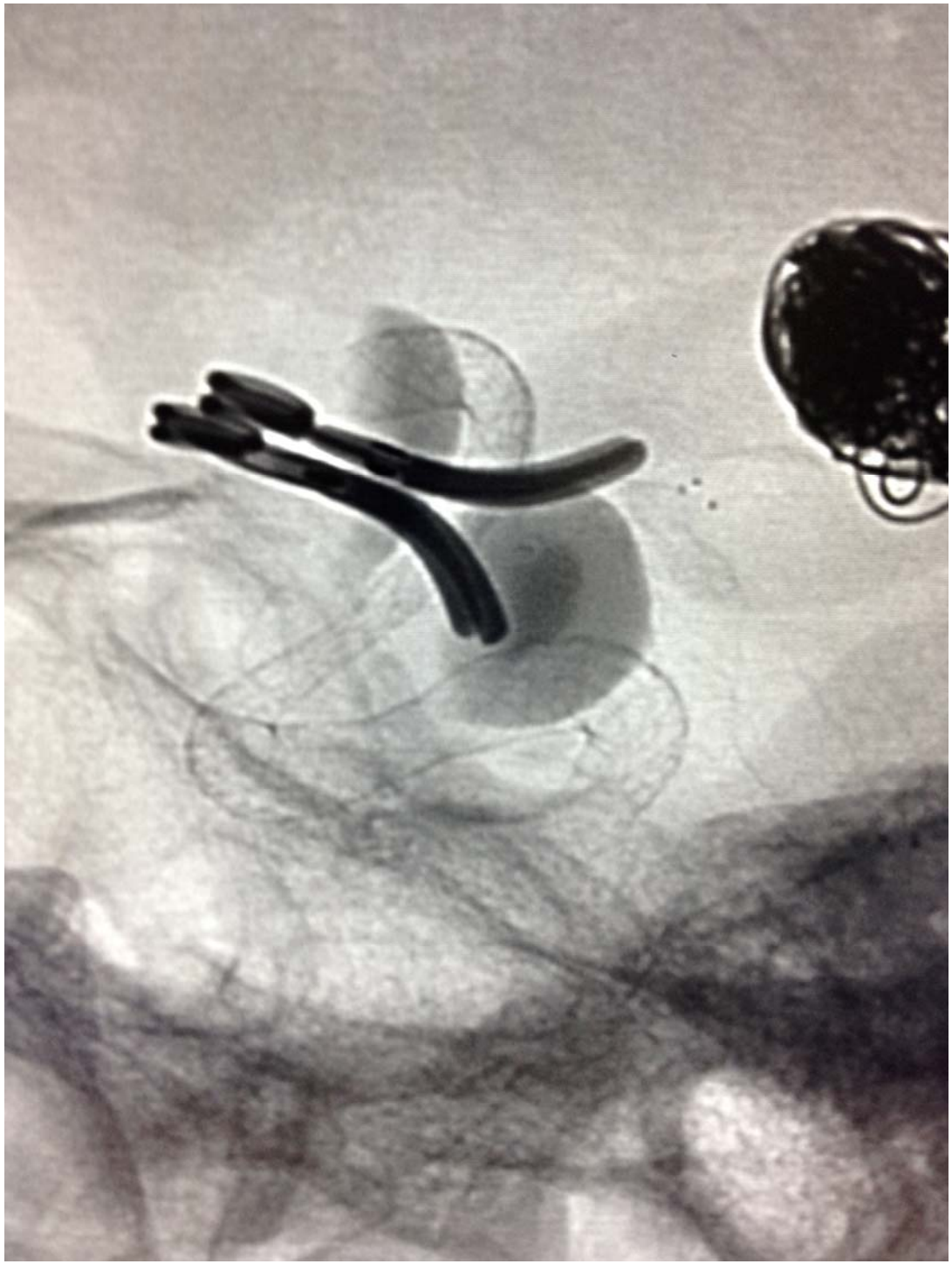
4X40

Case 31 VALENCIA FE 10/07/14

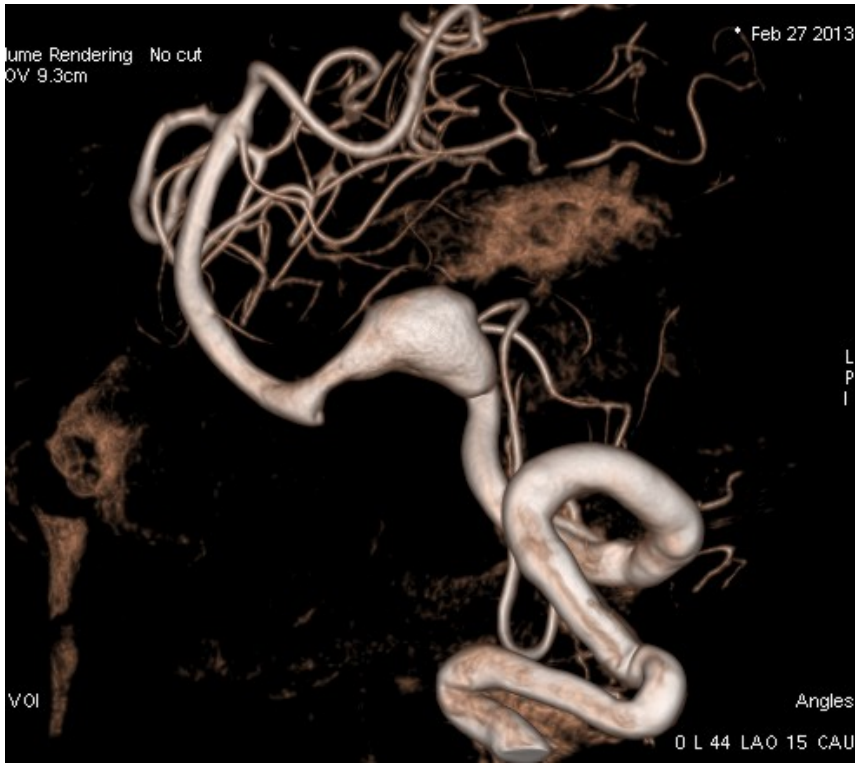








62 yo, female, Left VBJ Aneurysm: Surpass™ 5x30mm



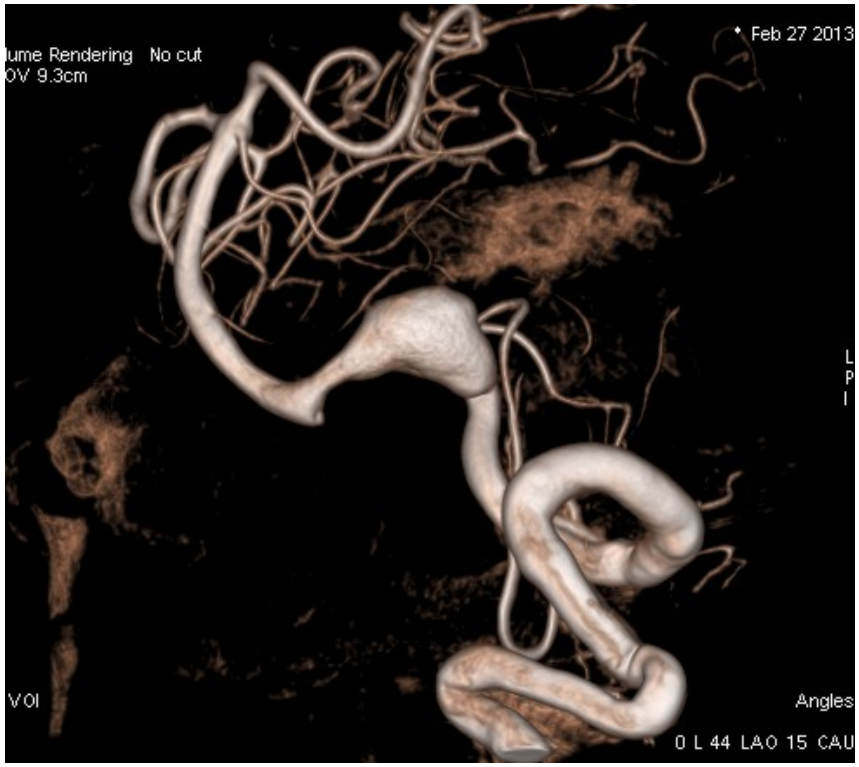
62 yo, Female, Left VBJ Aneurysm: Surpass™ 5x30 mm

Pre-Operative

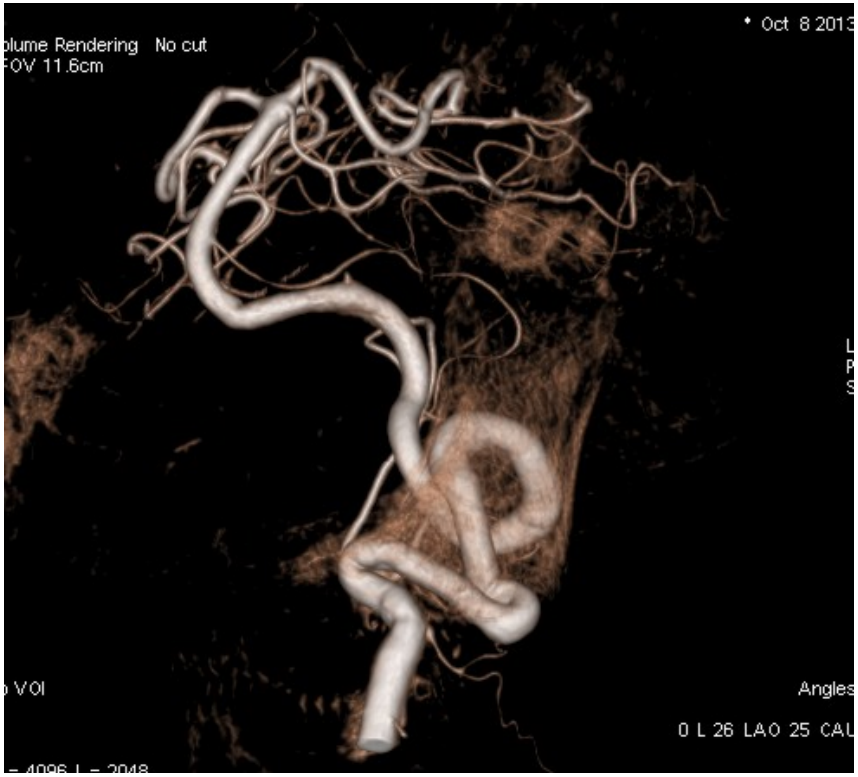
3 Months later

62 yo, female, Left VBJ Aneurysm: Surpass™ 5x30mm

Pre-Operative



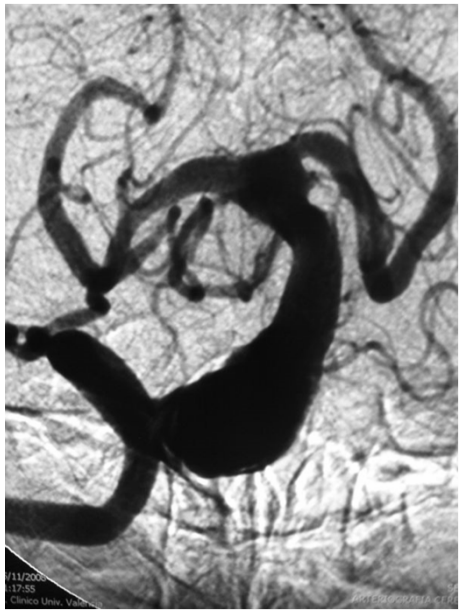
3 Months later

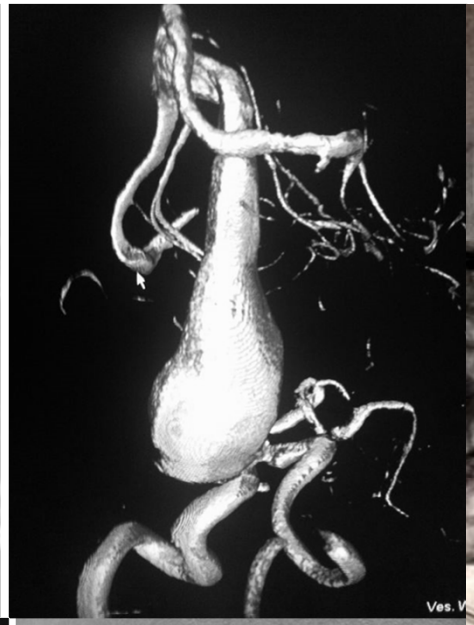


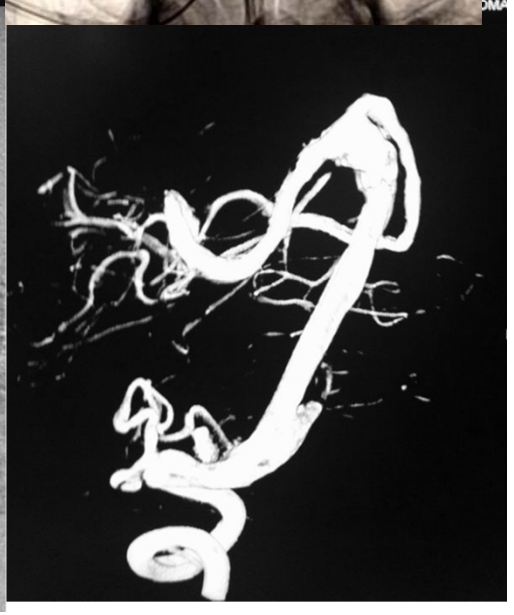
INDICACIONES

- **ANEURISMAS GRANDES O GIGANTES**
- **SINTOMAS COMPRESIVOS**
- **ANEURISMAS FUSIFORMES**
- **ANEURISMAS FOSA POSTERIOR**

Case 9 clinico valencia 29/01/14







5X50 + 5X50

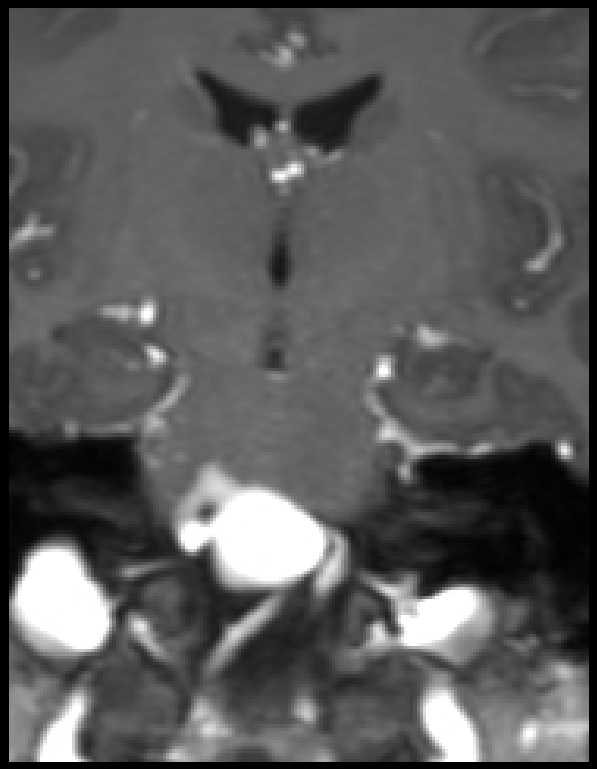
3 m fu

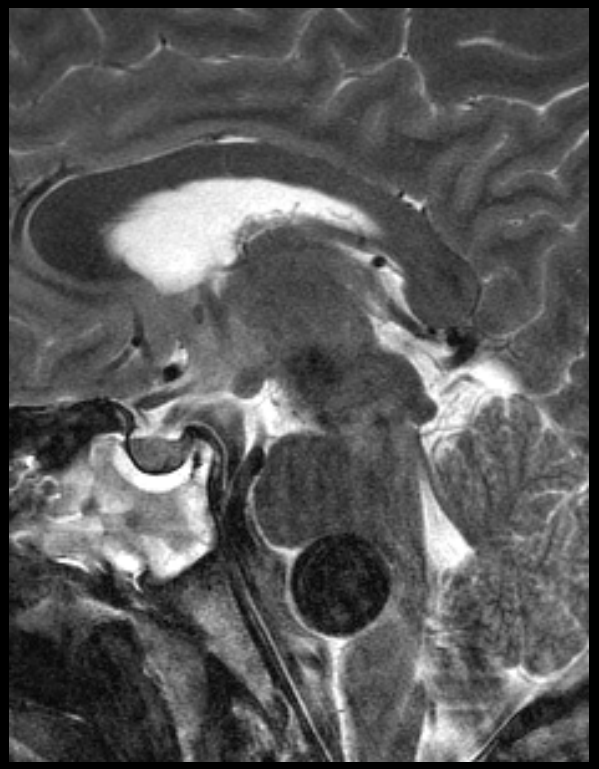
TREATMENT OF INTRACRANIAL ANEURYSMS LOCATED IN THE POSTERIOR CIRCULATION WITH THE SURPASS FLOW DIVERTER

JUAN MACHO for the Surpass Study Group
Department of Interventional Neuroradiology
Hospital Clinic de Barcelona, Spain

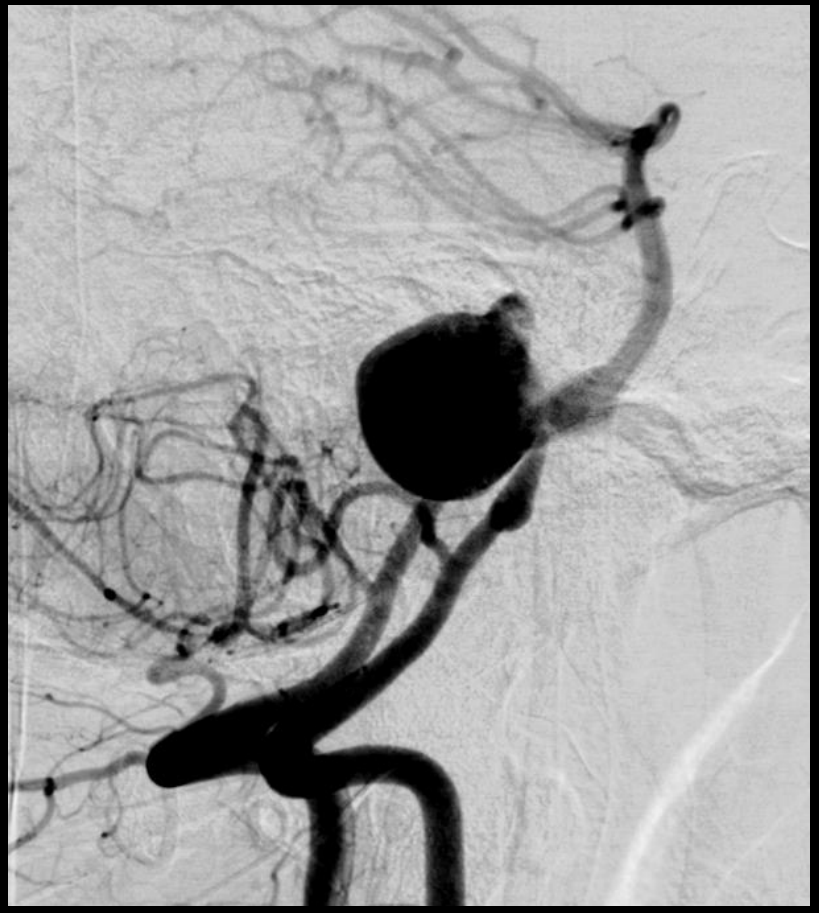
Symptomatic basilar tip aneurysm

Symptomatic basilar tip aneurysm

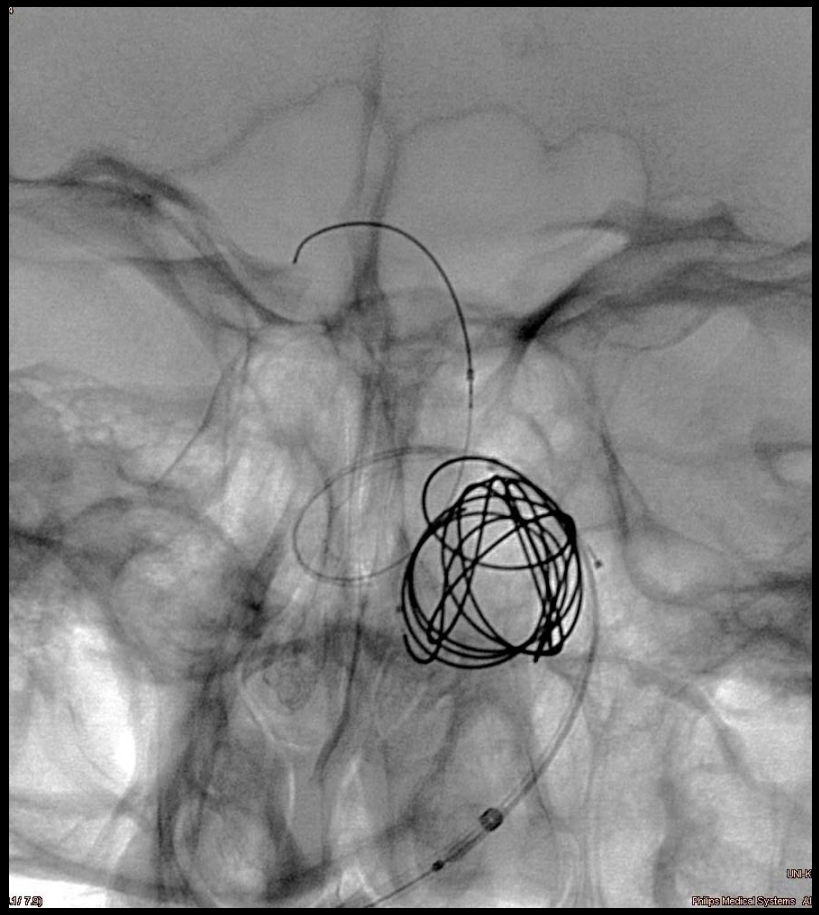




Symptomatic basilar tip aneurysm

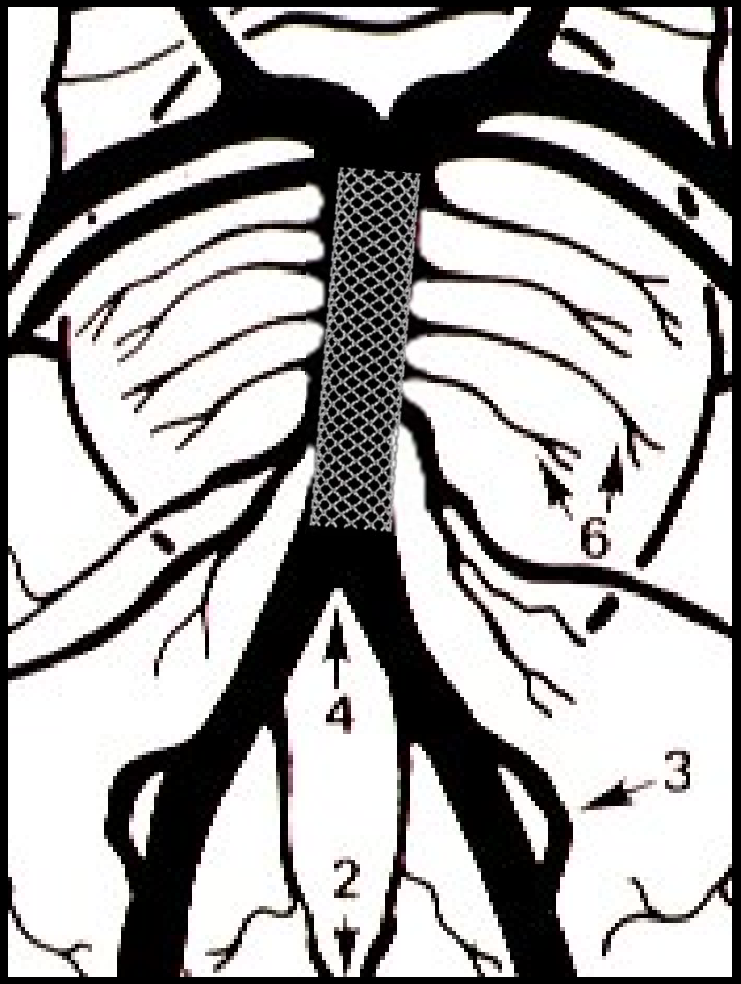


Symptomatic basilar tip aneurysm



Symptomatic basilar tip aneurysm

Objective

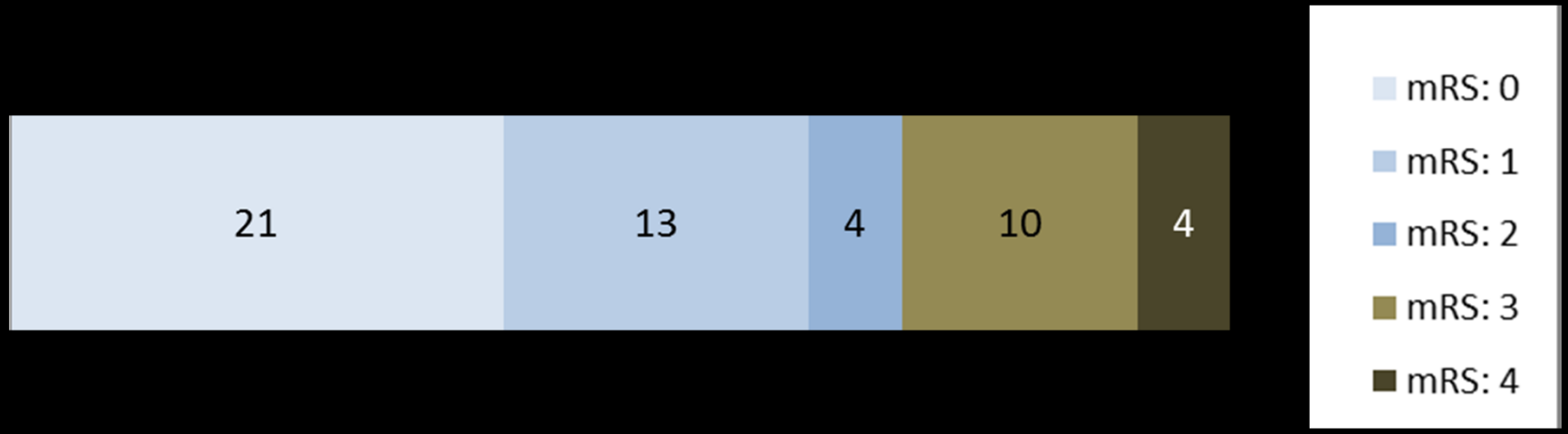


SURPASS Multicentre Registry

General information	
Patients	52
Aneurysms	52
Women (%)	22 (42%)
Mean age	55 (15-79)

General information	
SAH	7/52 (13%)
Symptomatic	25/52 (48%)

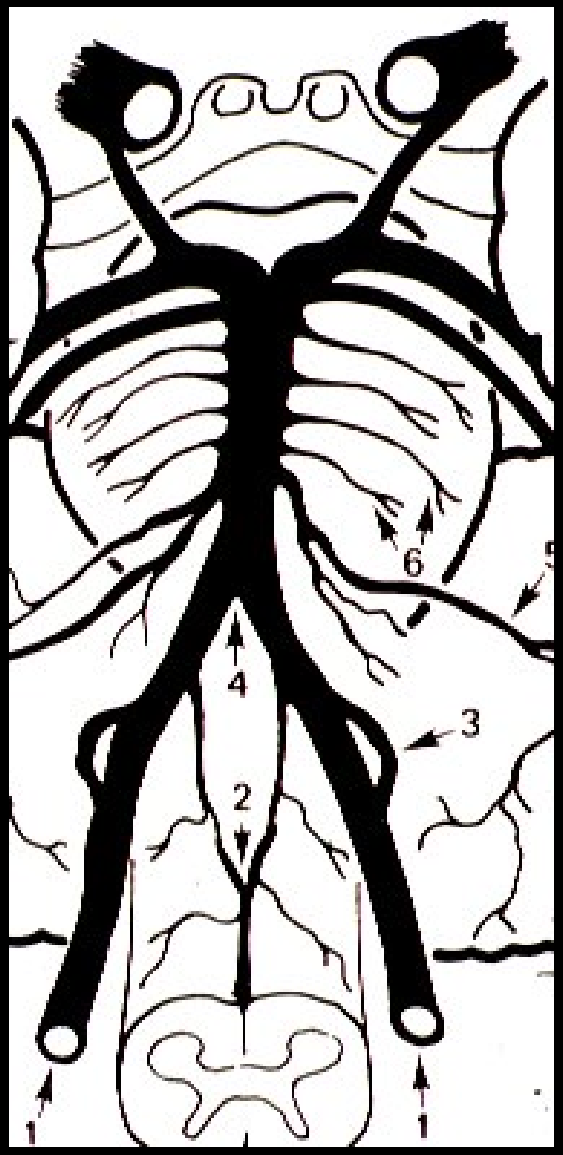
Baseline mRS (n=52)



mRS 0–2
38 (73%)

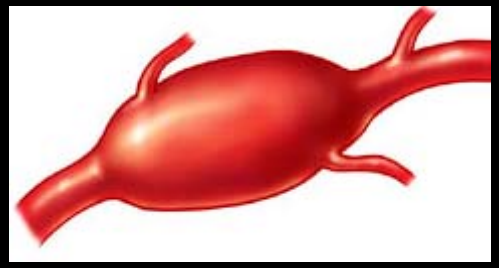
mRS 3+4
14 (27%)

Aneurysm location (n=52)



PCA	5 (10%)
Basilar trunc	17 (33%)
VB Junction	10 (19%)
Vertebral artery	20 (38%)

Aneurysm type (n=52)

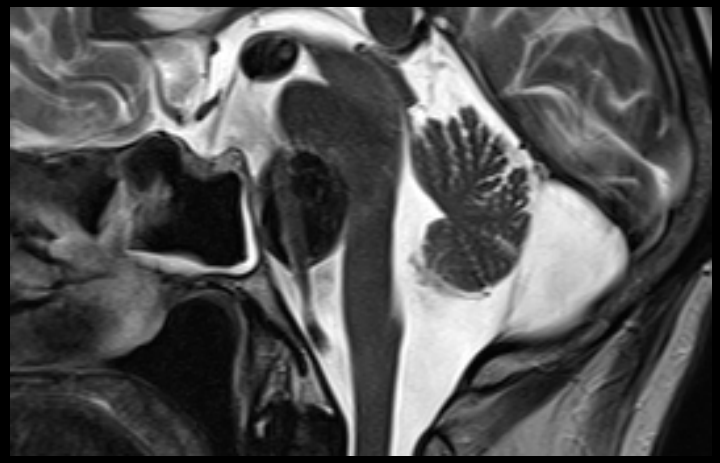
Fusiforme		37 (71%)
Saccular		14 (27%)
Blood-blister like		1 (2%)

Aneurysm characteristics

Pretreated
(Coil, Stent, Clip)

15 (29%)

Partially
thrombosed



Aneurysm treatment

< 5 mm	5 (10%)
5 – 9.9 mm	12 (23%)
10 – 20 mm	19 (37%)
> 20 mm	16 (31%)

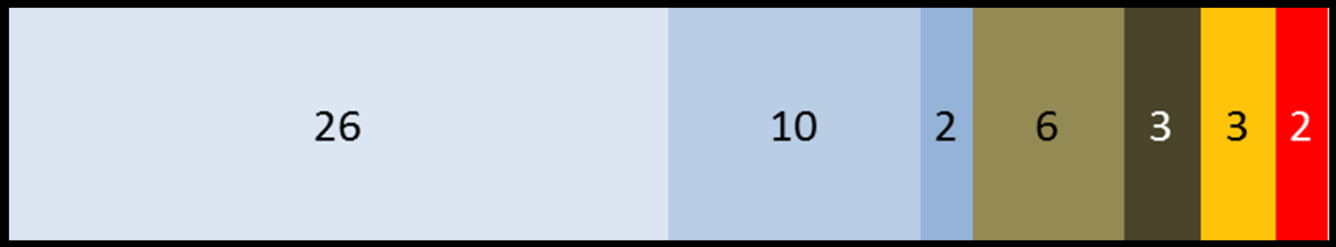
Success rate	51/52 (98%)
Average FD / case	1,4 (range 1 – 3)

Complications during hospital stay

Neuro	
Ischemia	4
Asymptomatic ICH	3
SAH	1

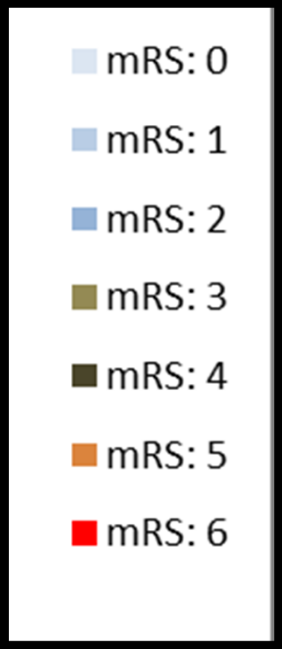
Clinical Outcome

Baseline

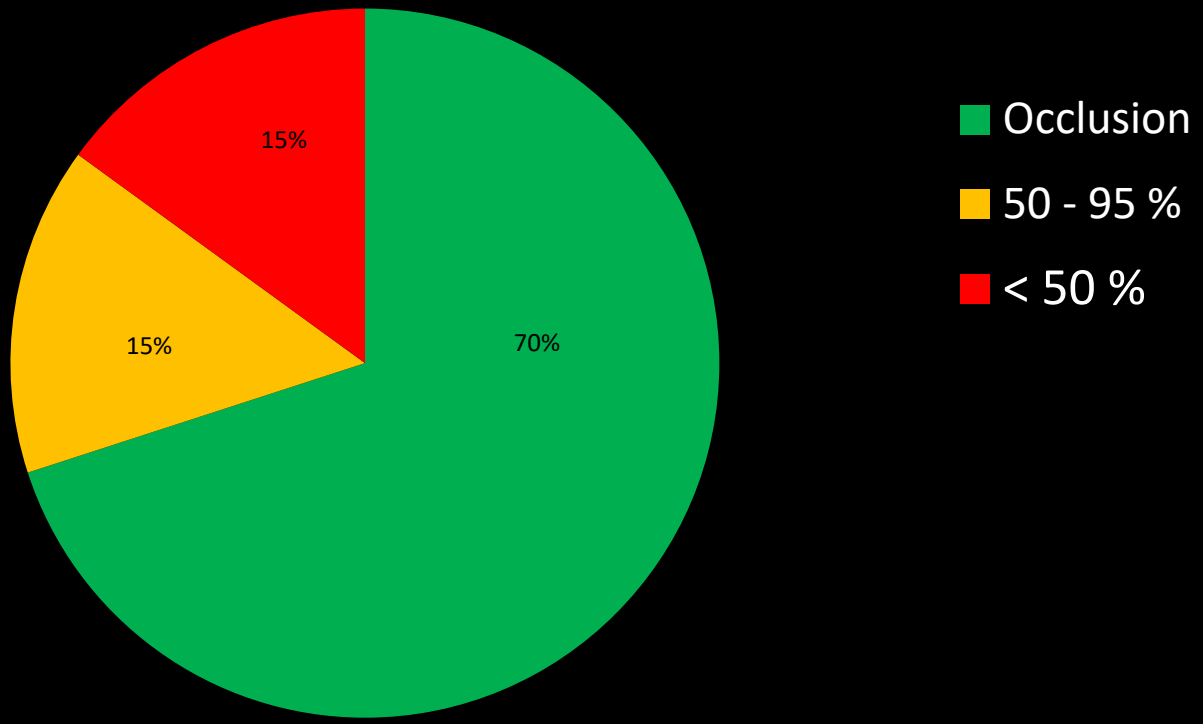


Discharge

Follow-up: mean 11 months (range 1 – 23)

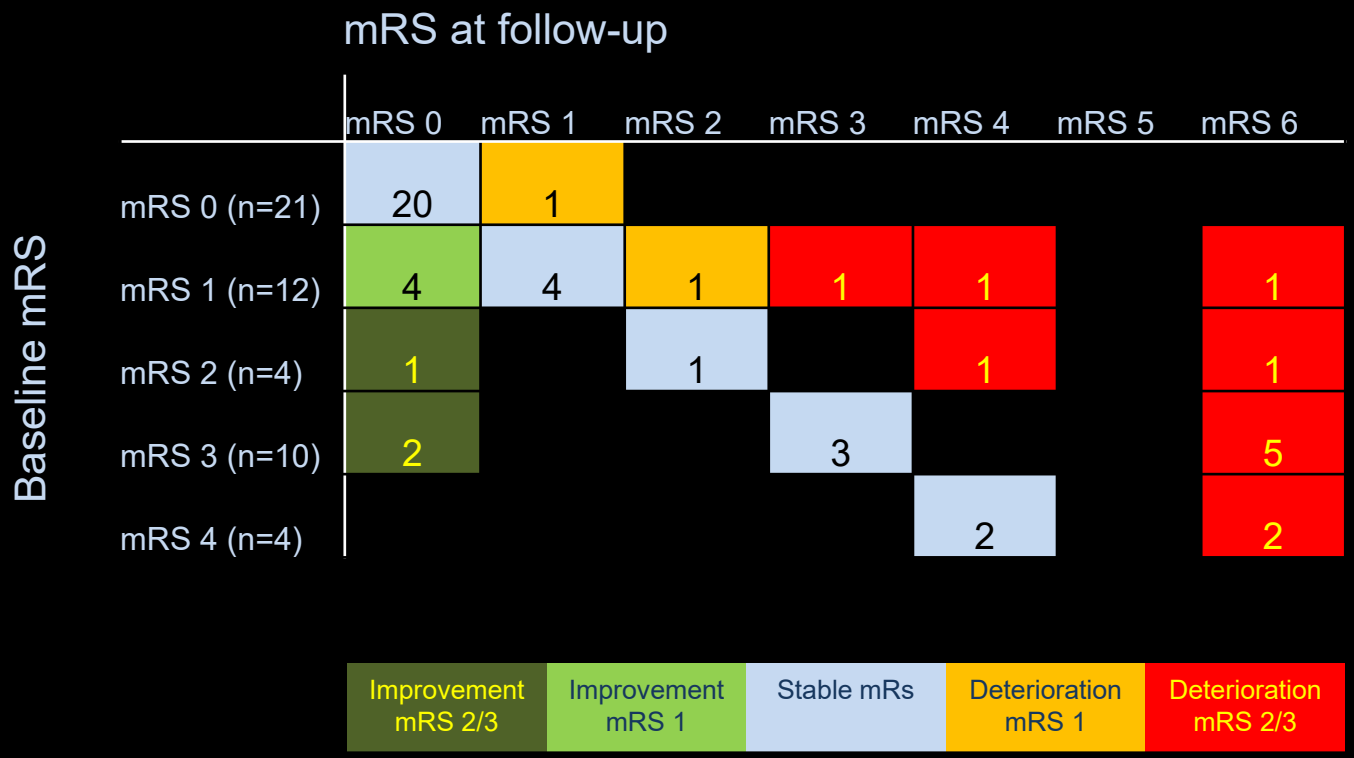


Angiographic outcome (n=39)



Follow-up: mean 11 months (range 1 – 23)

mRS shift: All patients (n=51)



Conclusion

Treatment of aneurysms located in the posterior circulation with the Surpass FD is feasible

It shows a variable safety profile

Good clinical outcomes were observed in patients bearing saccular aneurysms

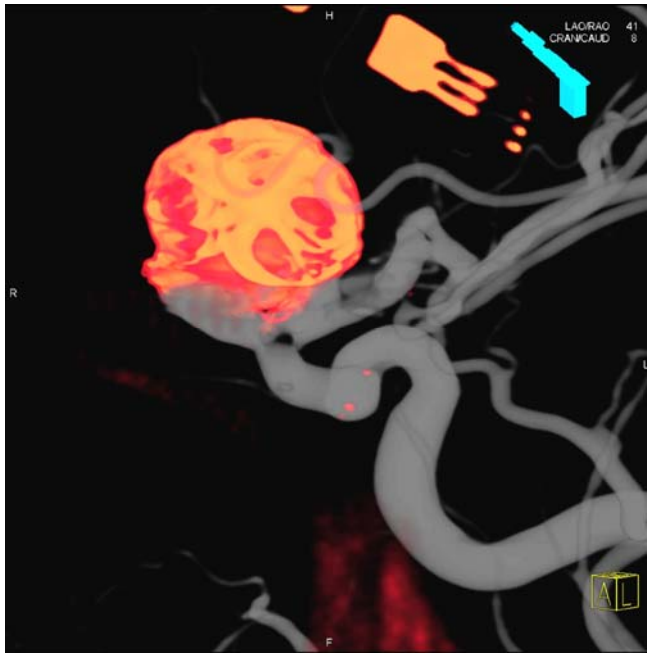
Conclusion

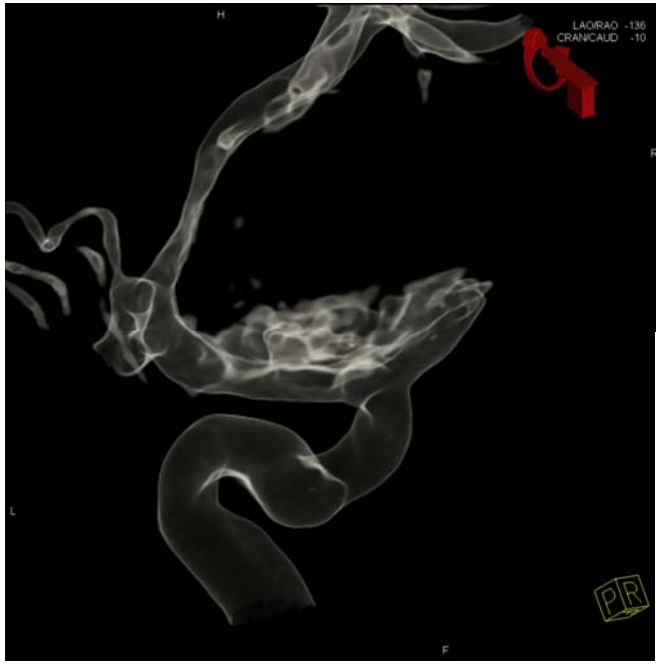
In patients with fusiforme aneurysms as well as in patients with basilar and VB junction aneurysms the clinical outcome seemed better in asymptomatic patients when compared to symptomatic patients

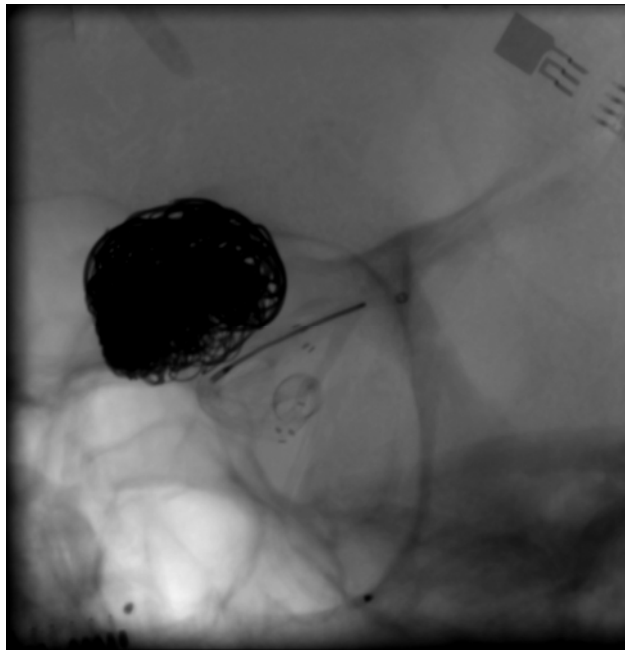
Worst outcome was observed in symptomatic patients with fusiforme aneurysms of the basilar artery and the VB junction

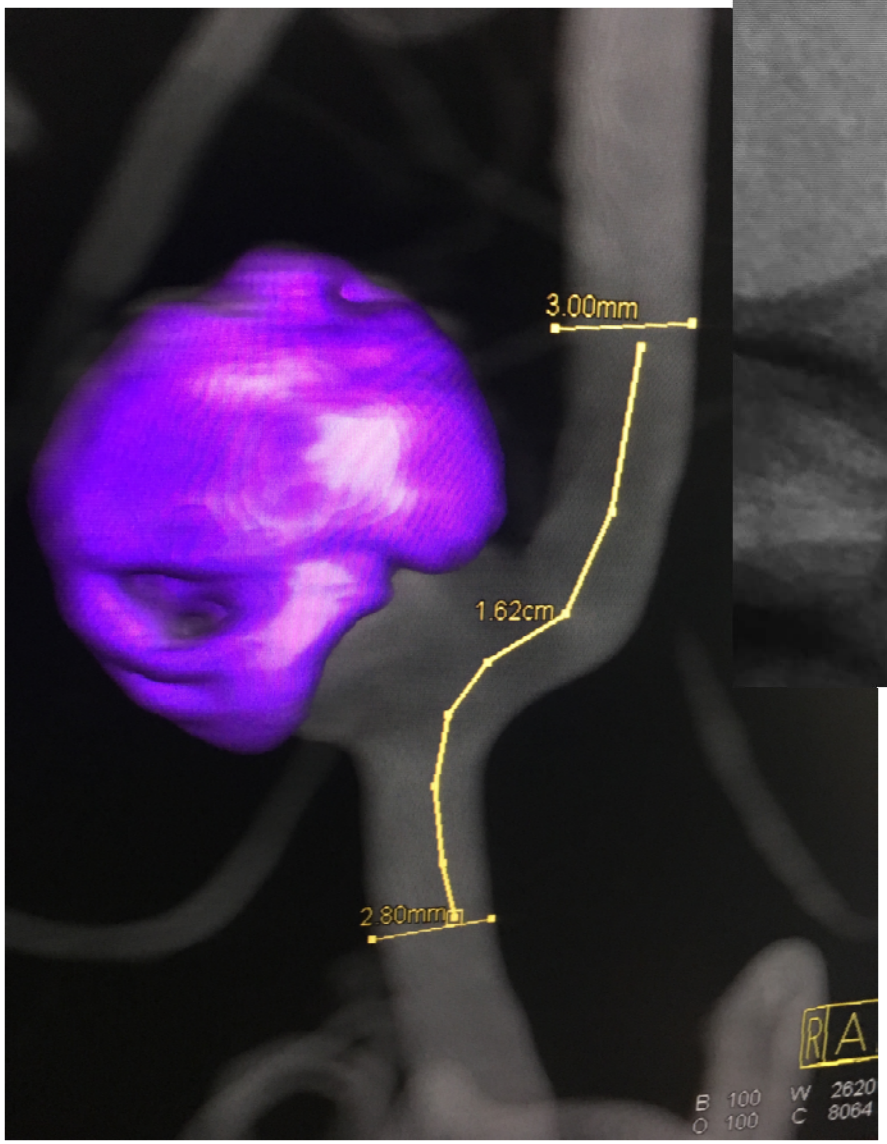
INDICACIONES

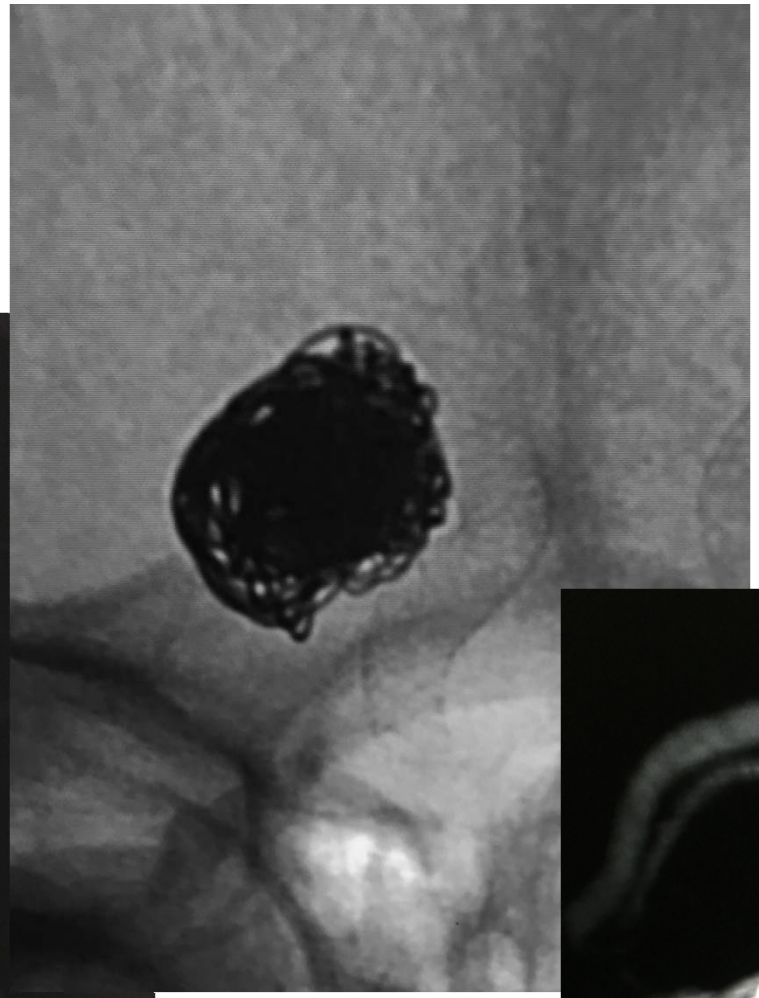
- **ANEURISMAS GRANDES O GIGANTES**
- **SINTOMAS COMPRESIVOS**
- **ANEURISMAS FUSIFORMES**
- **ANEURISMAS FOSA POSTERIOR**
- **RECURRENCIAS POST-COILING?**


H
LAO/RAO 41
CRANICAUD 8
R
F

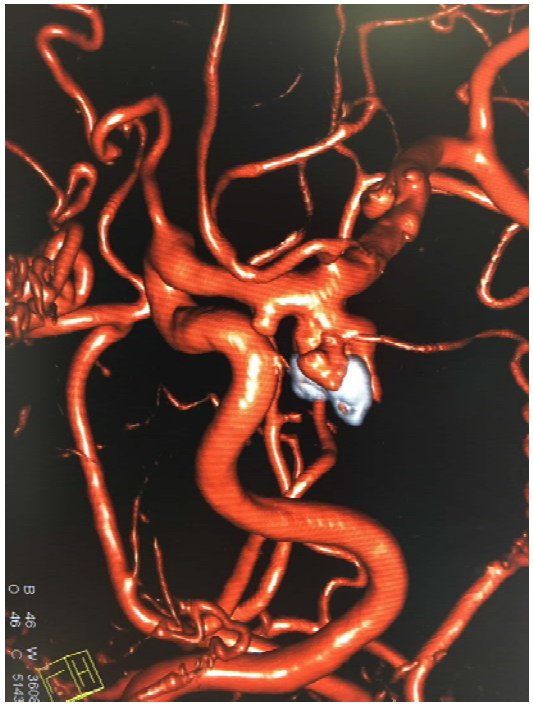

H
LAO/RAO -136
CRANICAUD -10
L
F

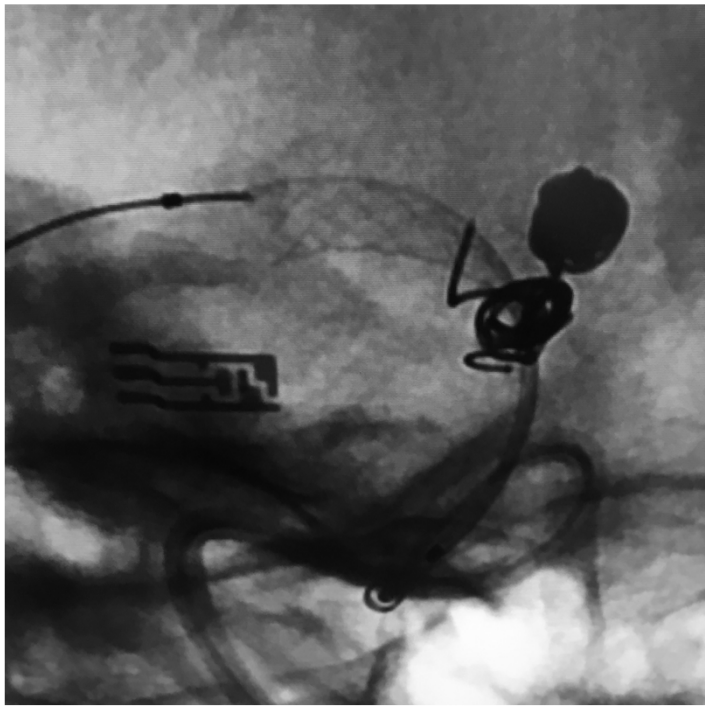


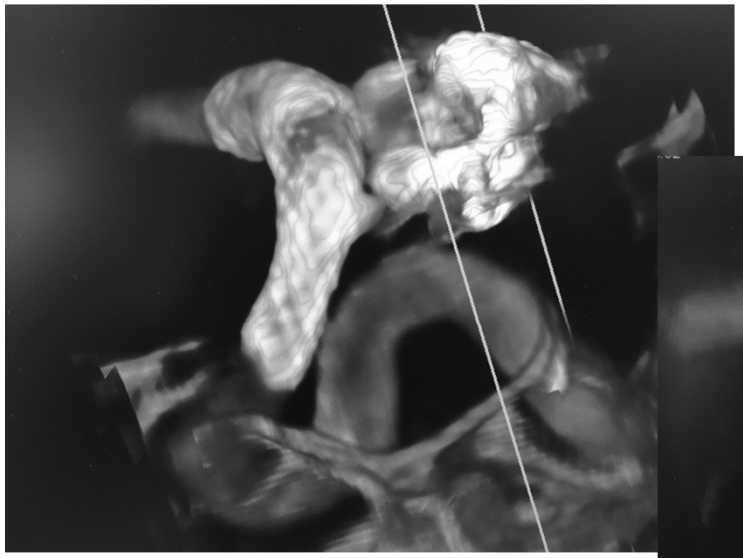

3.00mm
1.62cm
2.80mm
B 100
O 100
W 2620
C 8064

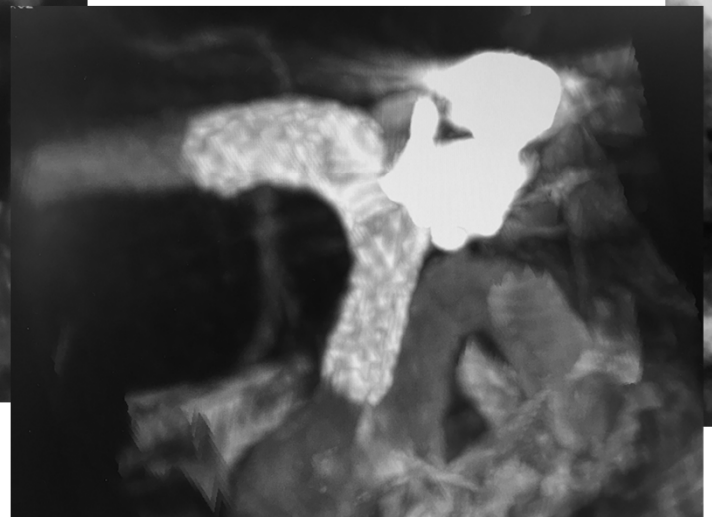


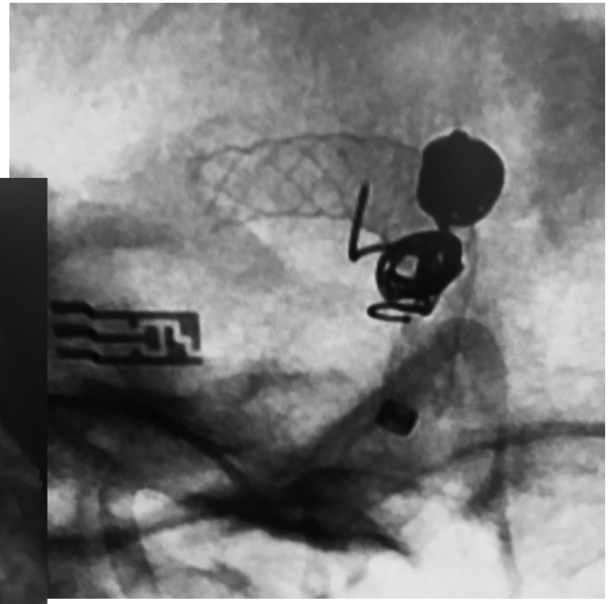

10mm
1.81 cm



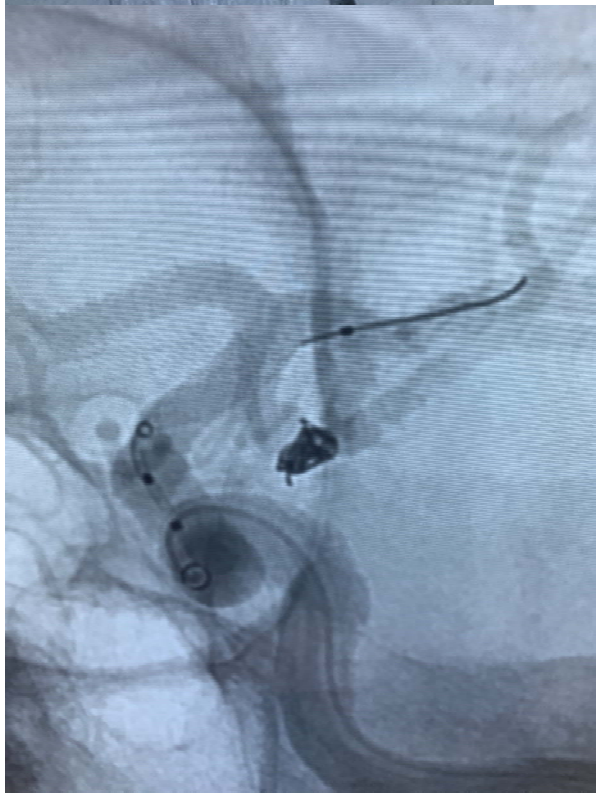


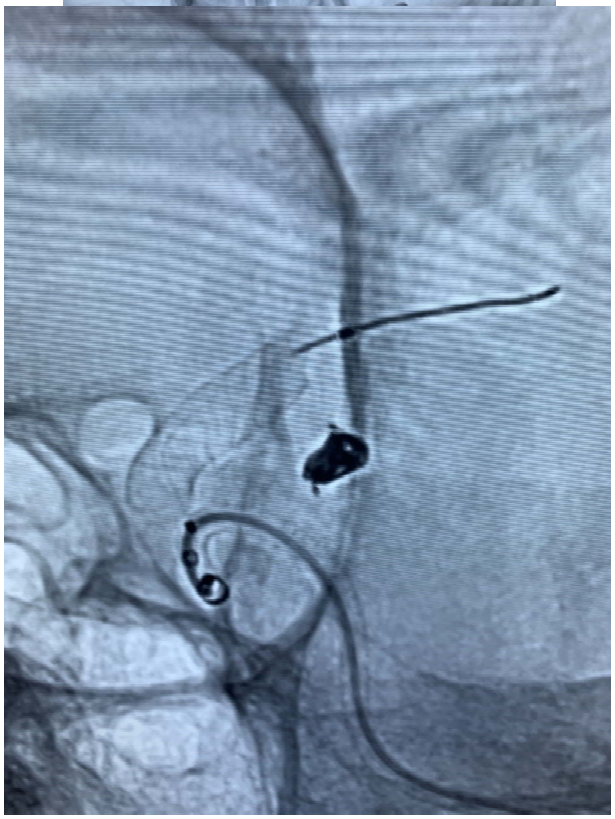


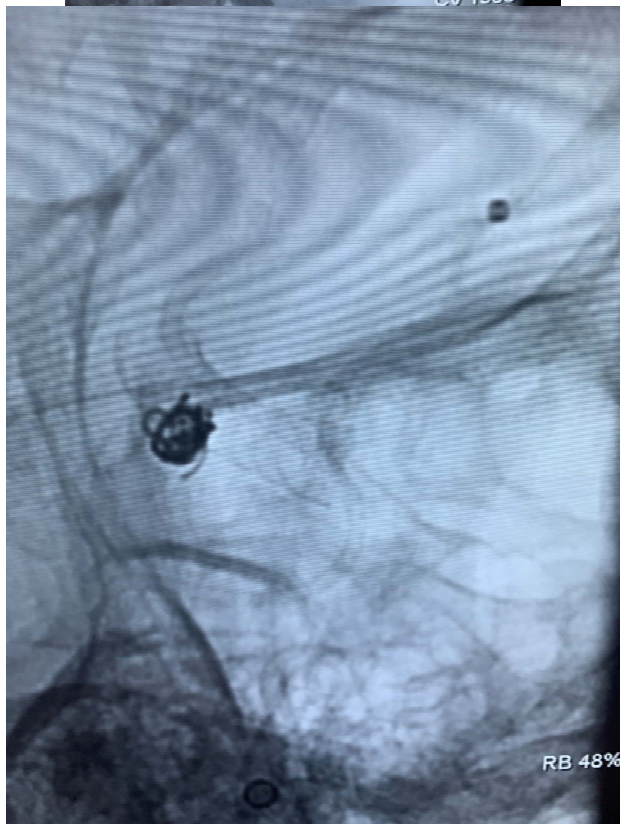


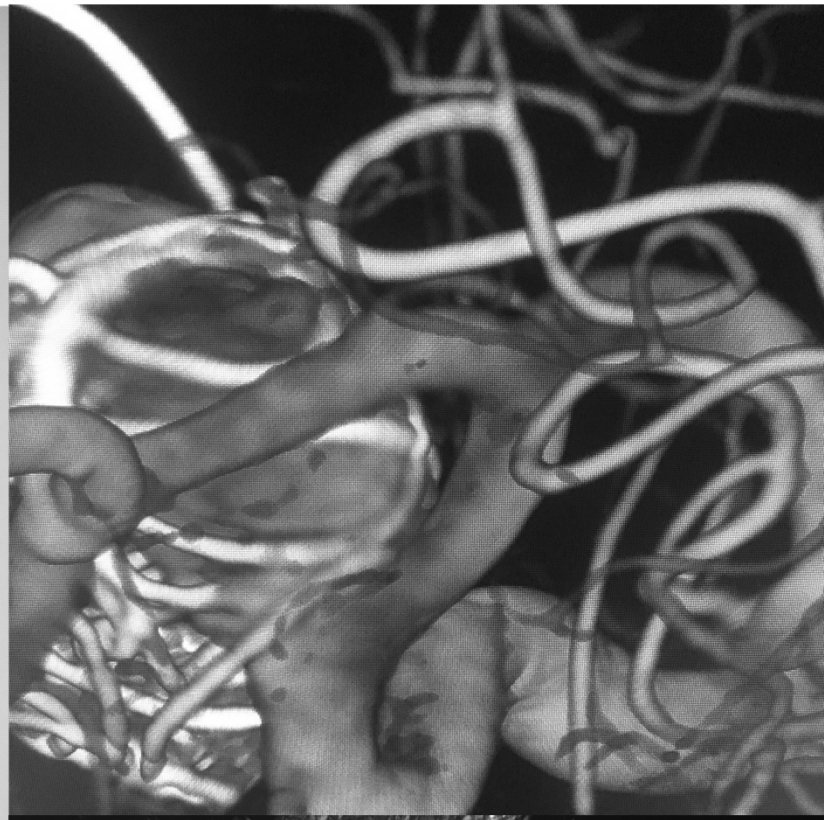


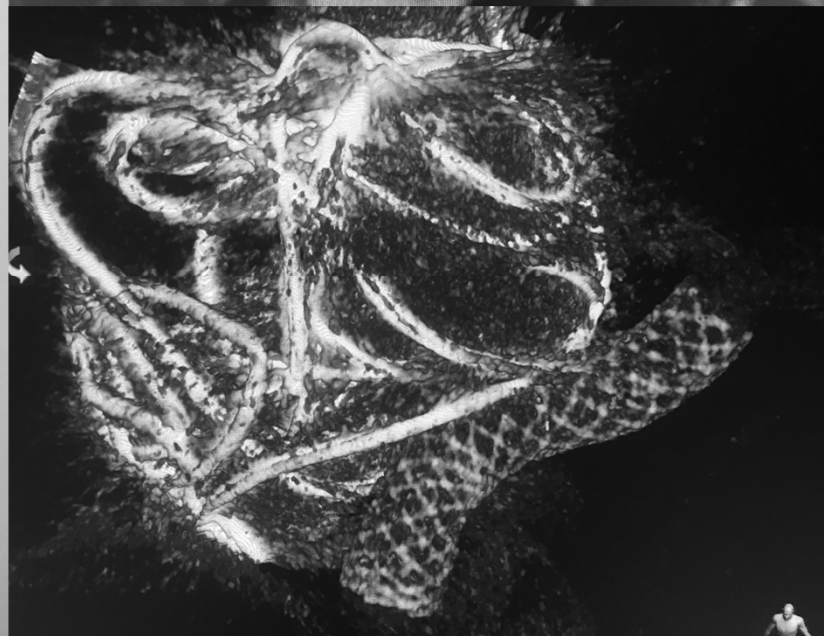

RB 27%
CV 1900






RB 48%





Comparing Retreatments and Expenditures in Flow Diversion Versus Coiling for Unruptured Intracranial Aneurysm Treatment: A Retrospective Cohort Study Using a Real-World National Database

BACKGROUND: Flow diverters (FDs) have marked the beginning of innovations in the endovascular treatment of large unruptured intracranial aneurysms, but no multi-institutional studies have been conducted on these devices from both the clinical and economic perspectives.

OBJECTIVE: To compare retreatment rates and healthcare expenditures between FDs and conventional coiling-based treatments in all eligible cases in Japan.

METHODS: We identified patients who had undergone endovascular treatments during the study period (October 2015-March 2018) from a national-level claims database. The outcome measures were retreatment rates and 1-yr total healthcare expenditures, which were compared among patients who had undergone FD, coiling, and stent-assisted coiling (SAC) treatments. The coiling and SAC groups were further categorized according to the number of coils used. Retreatment rates were analyzed using Cox proportional hazards models, and total expenditures were analyzed using multilevel mixed-effects generalized linear models.

RESULTS: The study sample comprised 512 FD patients, 1499 coiling patients, and 711 SAC patients. The coiling groups with ≥10 coils and ≥9 coils had significantly higher retreatment rates than the FD group with hazard ratios of 2.75 (1.30-5.82) and 2.52 (1.24-5.09), respectively. In addition, the coiling group with ≥10 coils and SAC group with ≥10 coils had significantly higher 1-year expenditures than the FD group with cost ratios (95% CI) of 1.30 (1.13-1.49) and 1.31 (1.15-1.50), respectively.

CONCLUSION: In this national-level study, FDs demonstrated significantly lower retreatment rates and total expenditures than conventional coiling with ≥ 9 coils.

KEY WORDS: Aneurysm, Coil embolization, Flow diverter, Real-world data, Cost-effectiveness

Neurosurgery 0:1–8, 2019 DOI:10.1093/neuros/nyz377 www.neurosurgery-online.com

Aneurysm Remnants after Flow Diversion: Clinical and Angiographic Outcomes

T.P. Madaelil, J.A. Grossberg, B.M. Howard, C.M. Cawley, J. Dion, R.G. Nogueira, D.C. Haussen, and F.C. Tong

AJNR Am J Neuroradiol ●:● ● 2019

ABSTRACT

BACKGROUND AND PURPOSE: Flow diversion is an established method to treat complex intracranial aneurysms. The natural history of flow-diversion treatment failure resulting in aneurysm remnants is not well-defined. We aimed to delineate the clinical and angiographic features of this entity.

MATERIALS AND METHODS: Review of a prospectively maintained Pipeline Embolization Device data base from inception to October 2017 was performed for aneurysms that demonstrated residual filling on follow-up imaging. Procedural and follow-up clinical details were recorded. Independent, blinded, angiographic assessment of occlusion was performed on the basis of the O'Kelly-Marotta scale. Aggregated outcomes were analyzed using the Fisher exact and Mann-Whitney *U* tests for categoric and continuous variables, respectively (statistical significance, $\alpha = .05$).

RESULTS: During the study period, 283 sequential patients were treated; 87% (246/283) were women. The median patient age was 55 years (interquartile range, 47–65 years). Six-month follow-up imaging was available in 83.7% (237/283) of patients, which showed 62.4% (148/237) complete occlusion (class D, O'Kelly-Marotta grading scale). Adjunctive coiling ($P = .06$), on-label Pipeline Embolization Device use ($P = .04$), and multiple device constructs ($P = .02$) had higher rates of complete occlusion at 6 months. Aneurysm remnants were identified in 25 cases on long-term follow-up imaging (median, 16 months; interquartile range, 12–24 months). No patient with an aneurysm remnant after flow diversion presented with delayed rupture or other clinical sequelae, with a median clinical follow-up of 31 months (interquartile range, 23–33 months).

CONCLUSIONS: Aneurysm remnants after flow diversion are infrequent with minimal clinical impact. When appropriate, the presence of overlapping devices and possibly adjunctive coiling may result in higher rates of complete occlusion.

INDICACIONES

- **ANEURISMAS GRANDES O GIGANTES**
- **SINTOMAS COMPRESIVOS**
- **ANEURISMAS FUSIFORMES**
- **ANEURISMAS FOSA POSTERIOR**
- **RECURRENCIAS POST-COILING?**
- **ANEURISMAS INCIDENTALES? CUALQUIER TAMAÑO?**
  - **EN VASOS PROXIMALES**
  - **EN VASOS DISTALES**

Stroke
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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Extending the Indications of Flow Diversion to Small, Unruptured, Saccular Aneurysms of the Anterior Circulation

Nohra Chalouhi, MD; Robert M. Starke, MD; Steven Yang, BS; Cory D. Bovenzi, BS; Stavropoula Tjoumakaris, MD; David Hasan, MD; L. Fernando Gonzalez, MD; Robert Rosenwasser, MD; Pascal Jabbour, MD

Background and Purpose—Flow diverters are currently indicated for treatment of large and complex intracranial aneurysms. The purpose of this study was to determine whether the indications of flow diversion can be safely extended to unruptured, small, saccular aneurysms (<10 mm) of the anterior circulation.

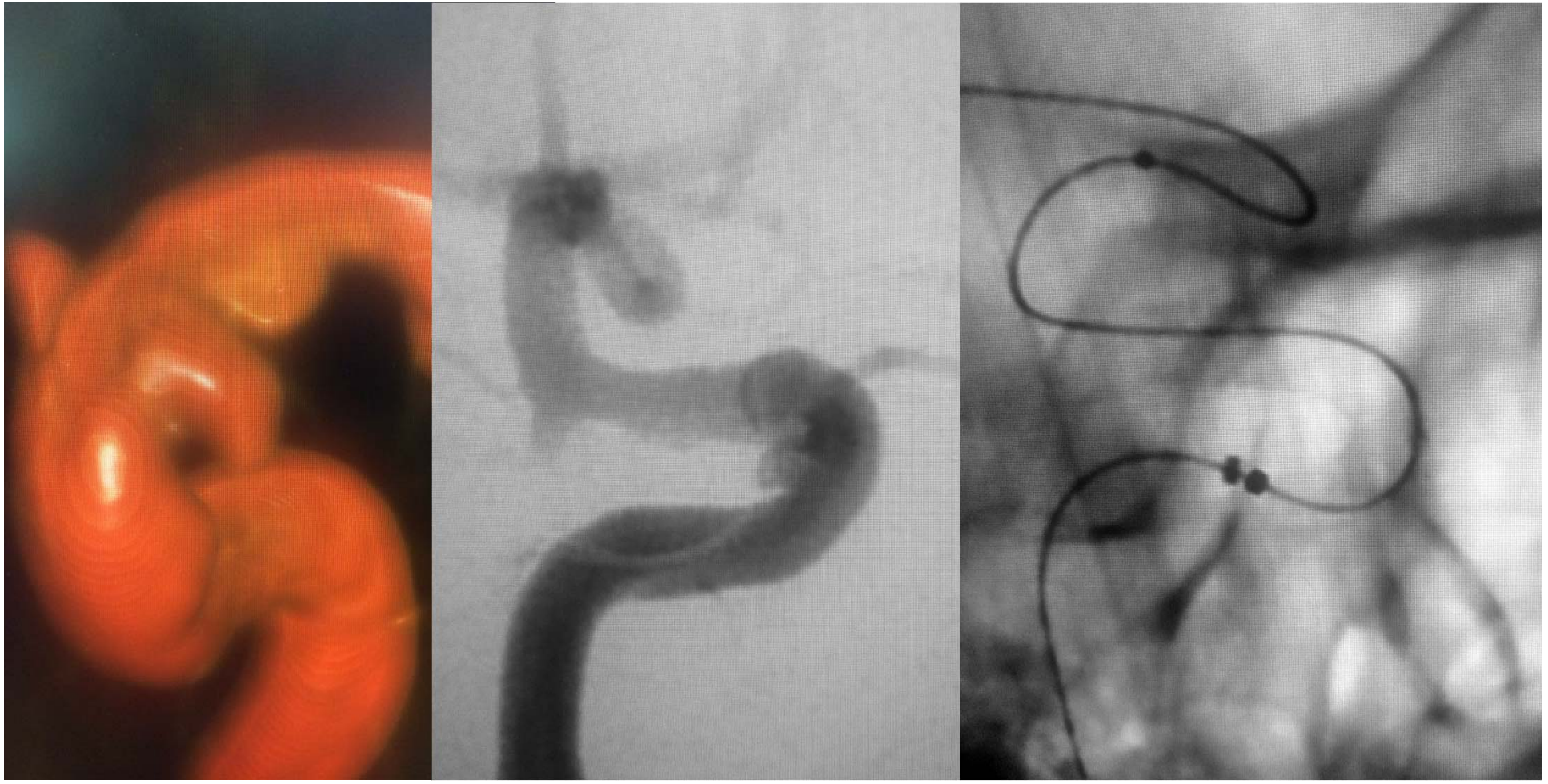
Methods—Forty patients treated with the pipeline embolization device (PED) were matched in a 1:4 fashion with 160 patients treated with stent-assisted coiling based on patient age, sex, aneurysm location, and aneurysm size. Procedural complications, angiographic results, and clinical outcomes were analyzed and compared.

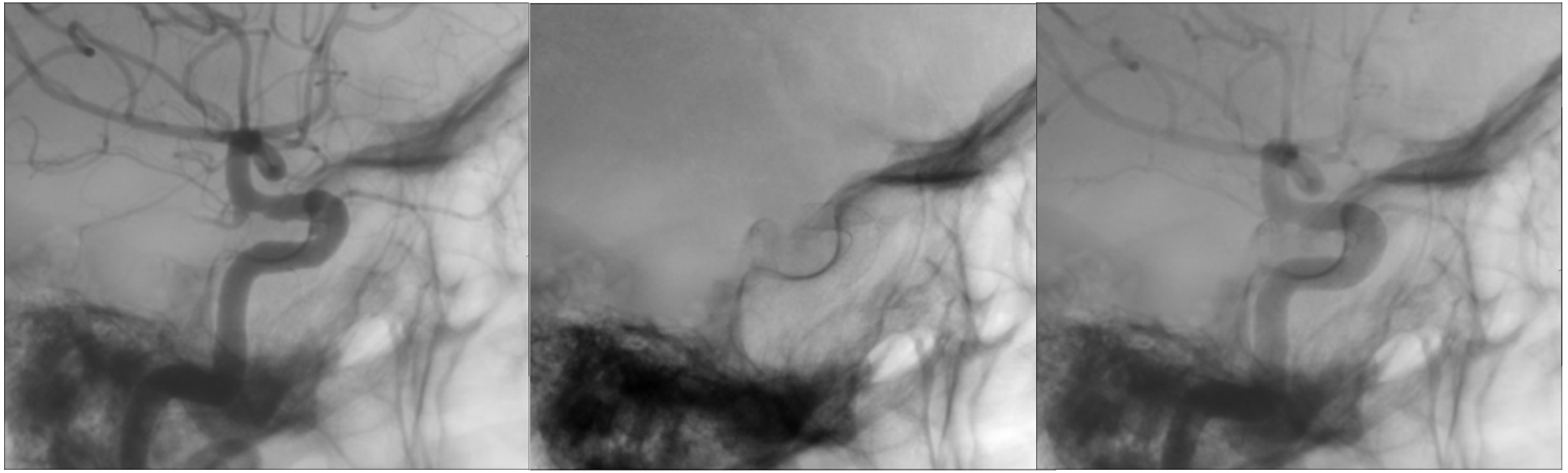
Results—The rate of periprocedural complications was 5% in the PED group and 3% in the stent-coil group (P=0.7). In multivariable analysis, increasing age was the only predictor of complications. At follow-up, a higher proportion of aneurysms treated with PED (80%) achieved complete obliteration compared with stent-coiled aneurysms (70%) but the difference did not reach statistical significance (P=0.2). In multivariable analysis, increasing aneurysm size and aneurysm location were predictors of nonocclusion. The rate of favorable outcome (modified Rankin Scale, 0–2 and modified Rankin Scale, 0–1) was similar in the PED group and the coil group.

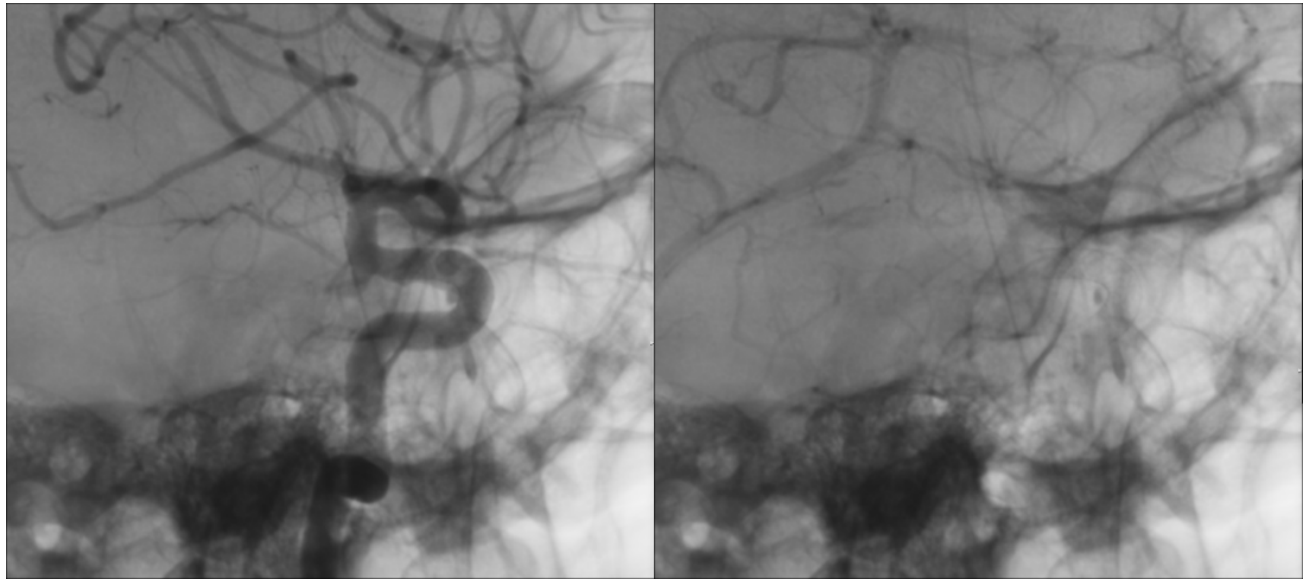
Conclusions—The PED was associated with similar periprocedural risks, clinical outcomes, and angiographic results compared with stent-assisted coiling. These findings suggest that the indications of PED can be safely extended to small intracranial aneurysms that are amenable to conventional endovascular techniques. Larger studies with long-term follow-up are necessary to determine the optimal treatment that leads to the highest rate of obliteration and best clinical outcomes. **(*Stroke*. 2014;45:54-58.)**

Case 37 CLINIC 16/10/14

3X20 STREMLINE





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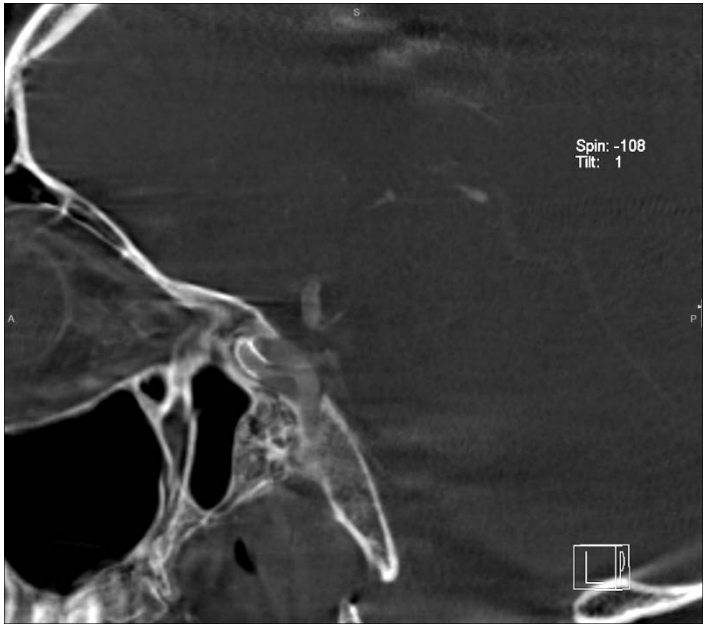
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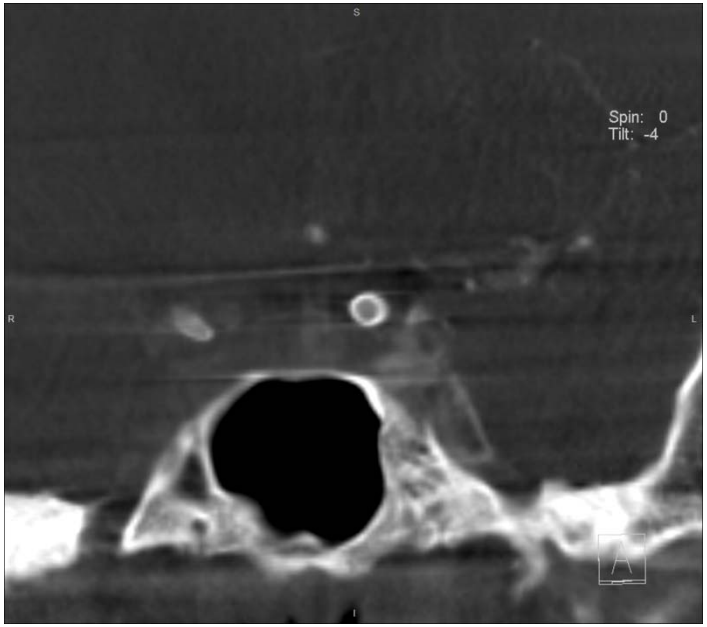
S
Spin: 0
Tilt: -4
R
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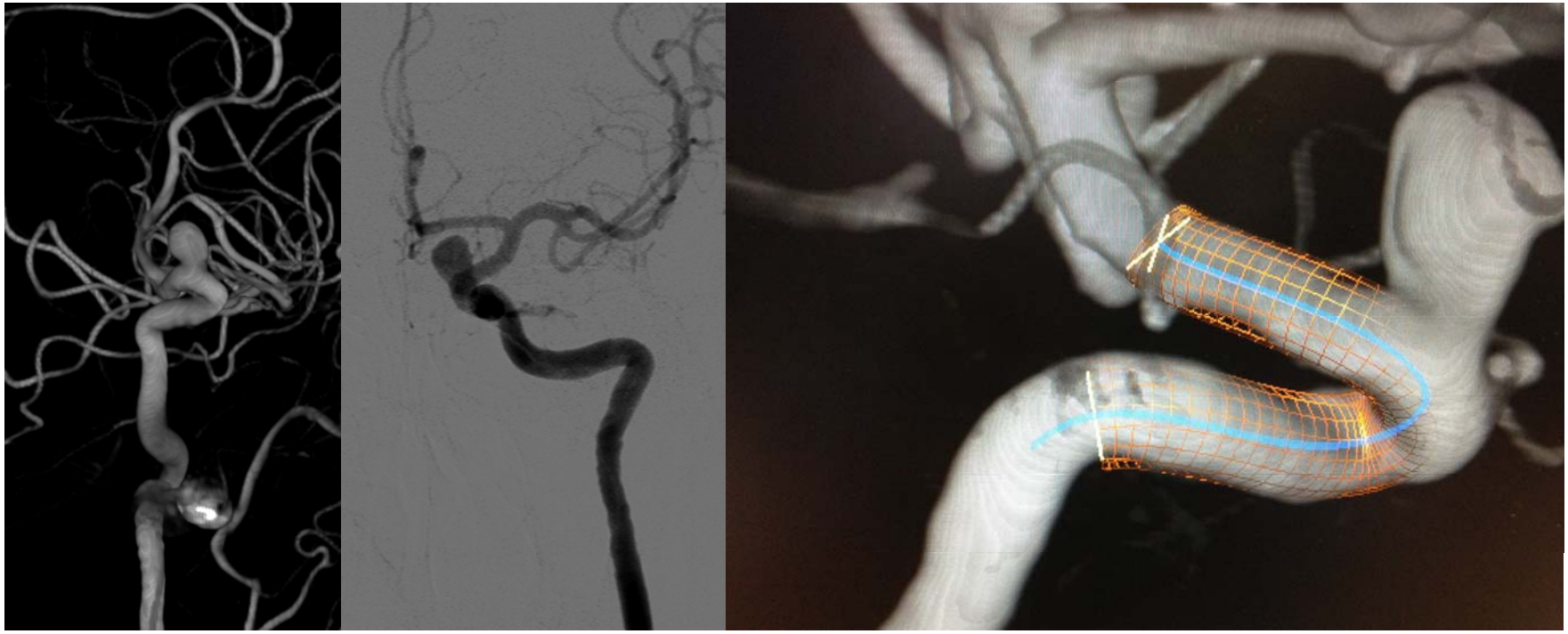
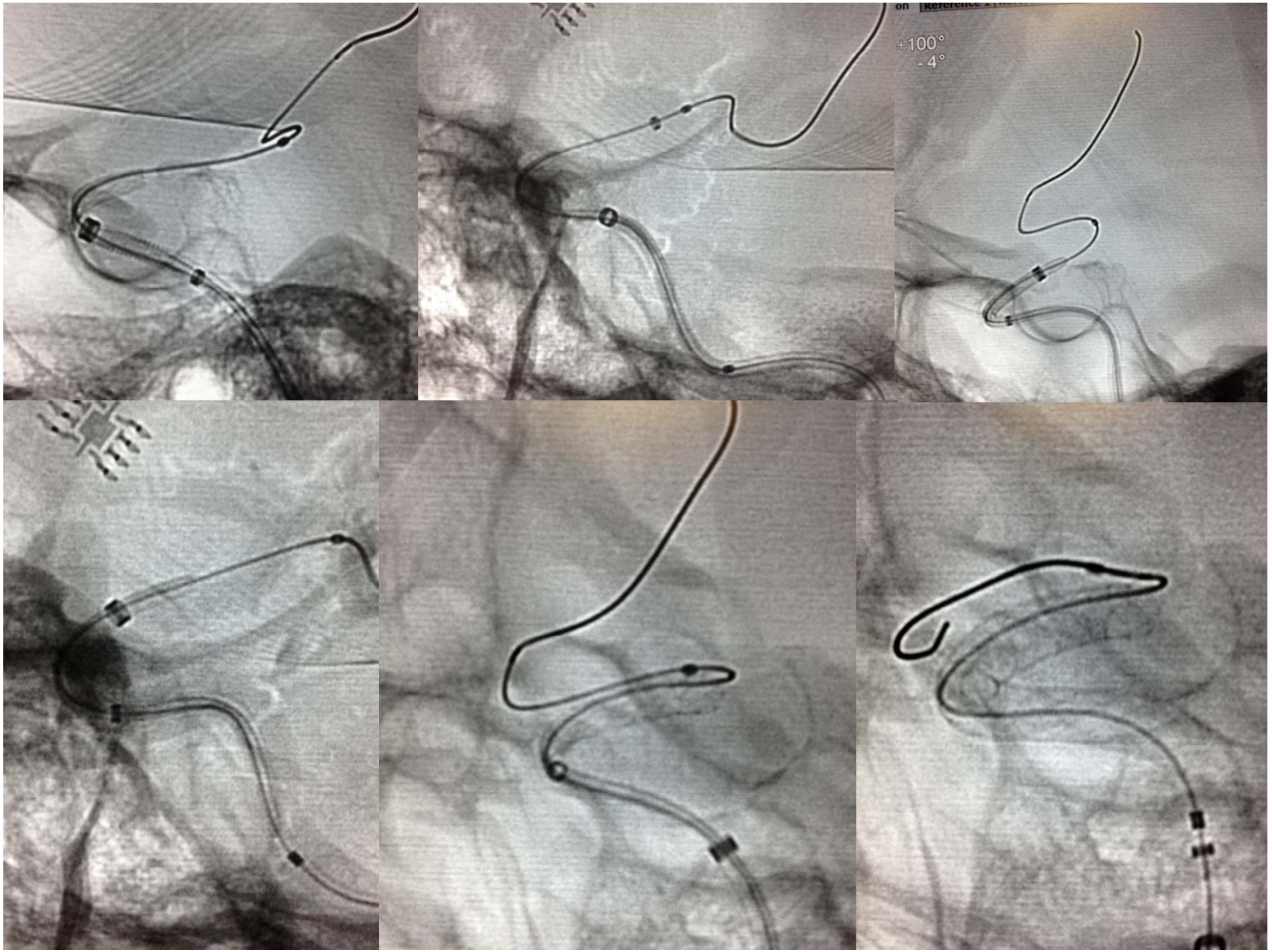
4X25

Case 39 MURCIA 21/10/14

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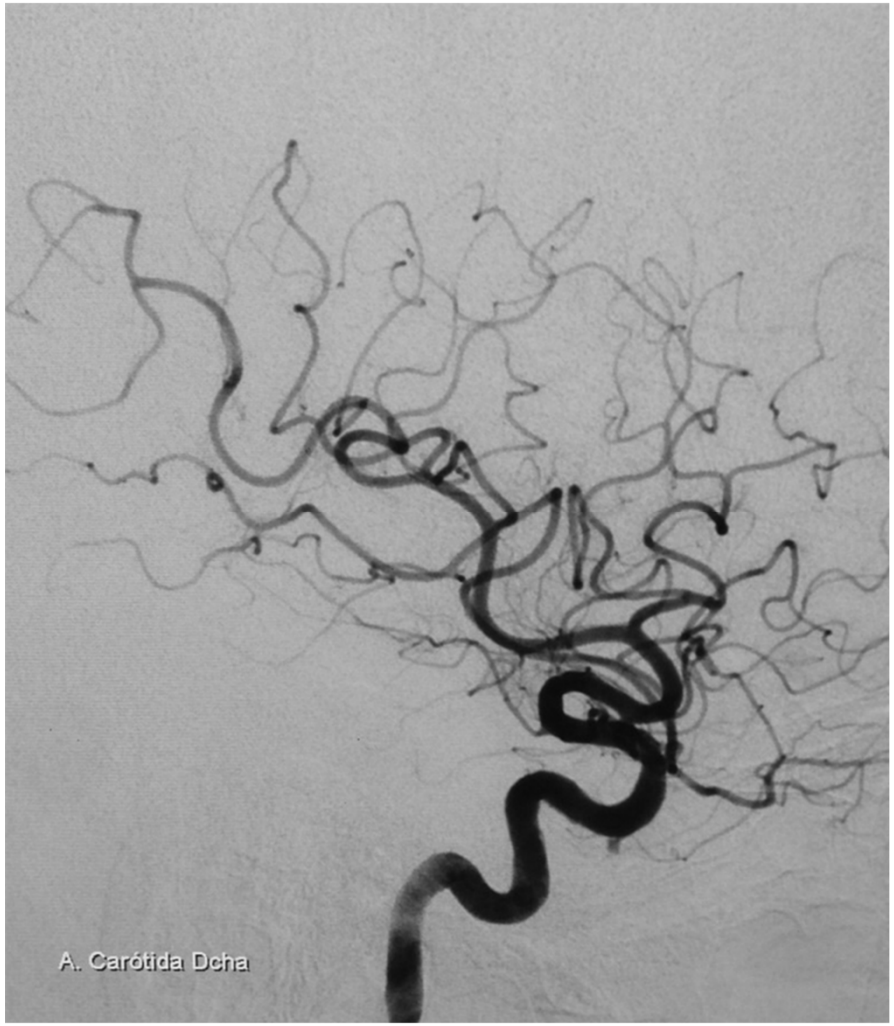
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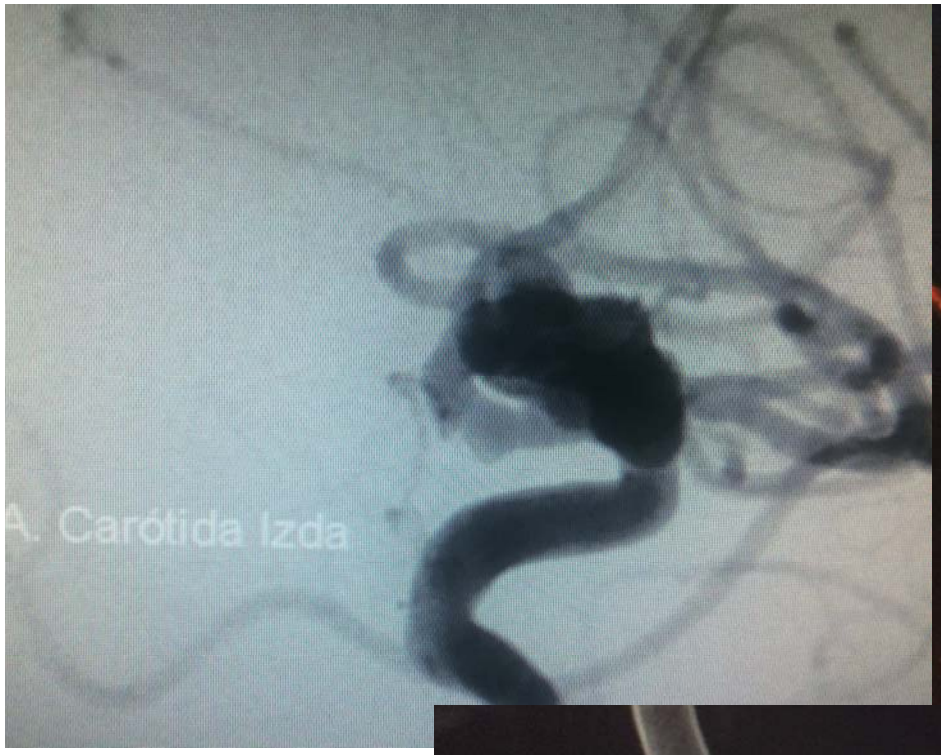
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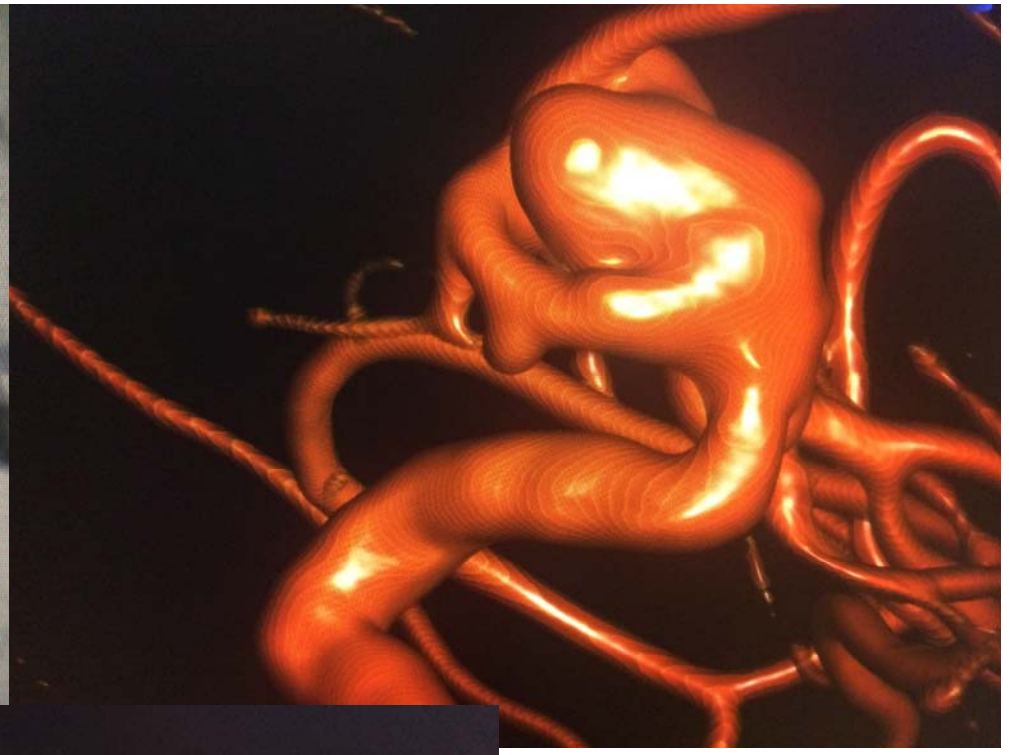

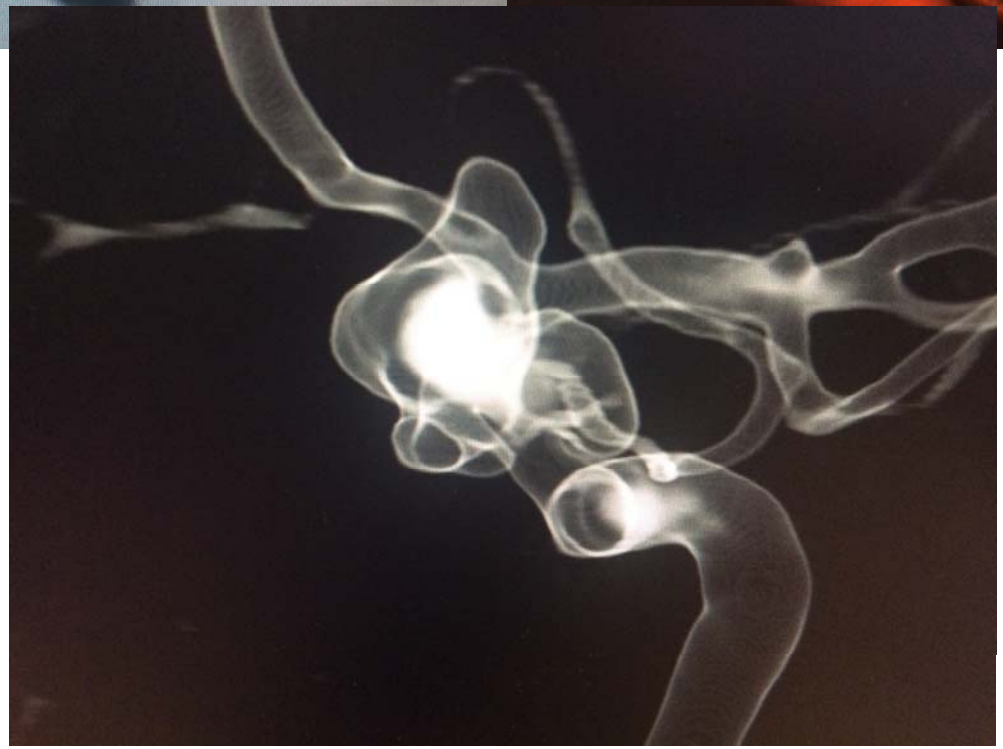

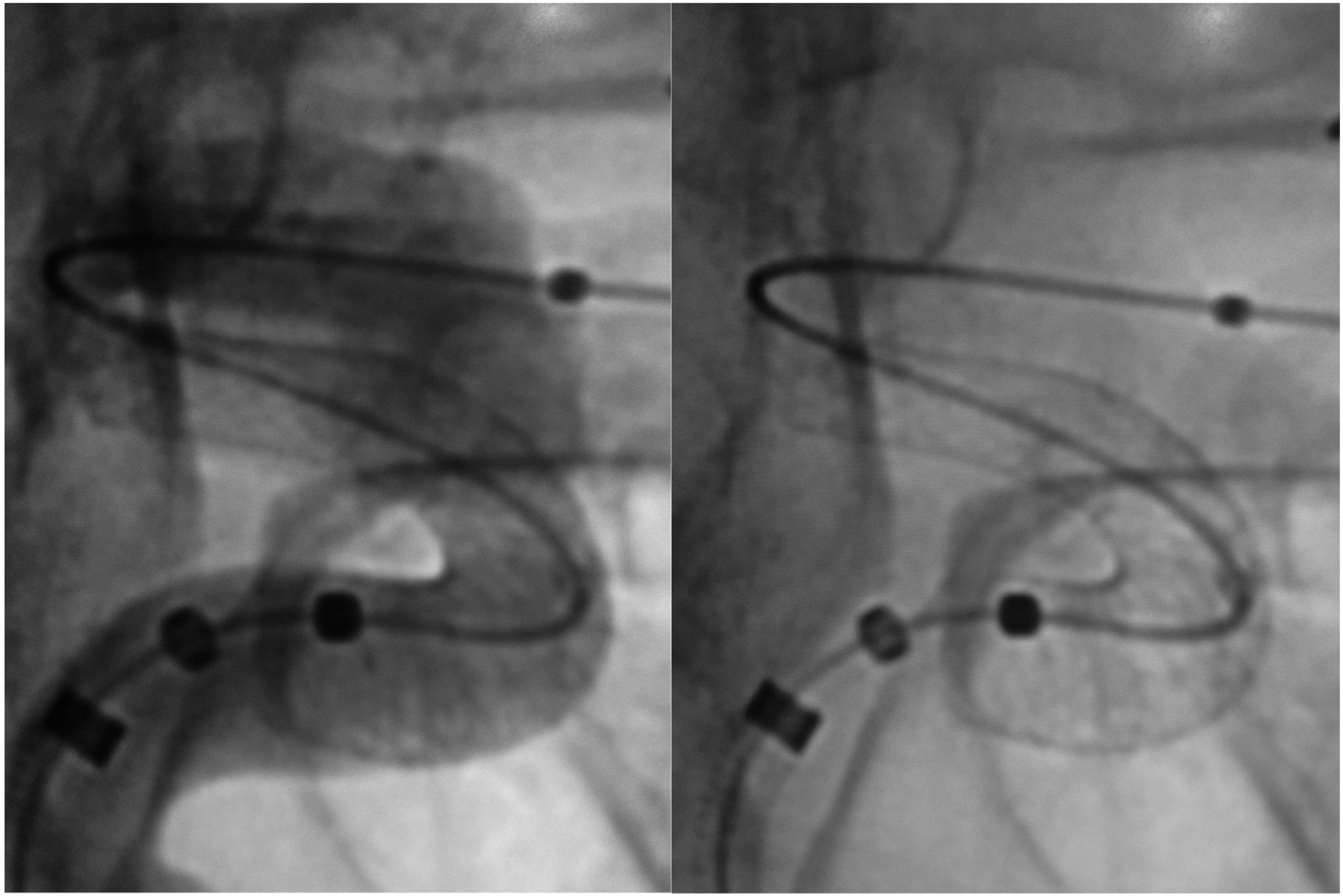

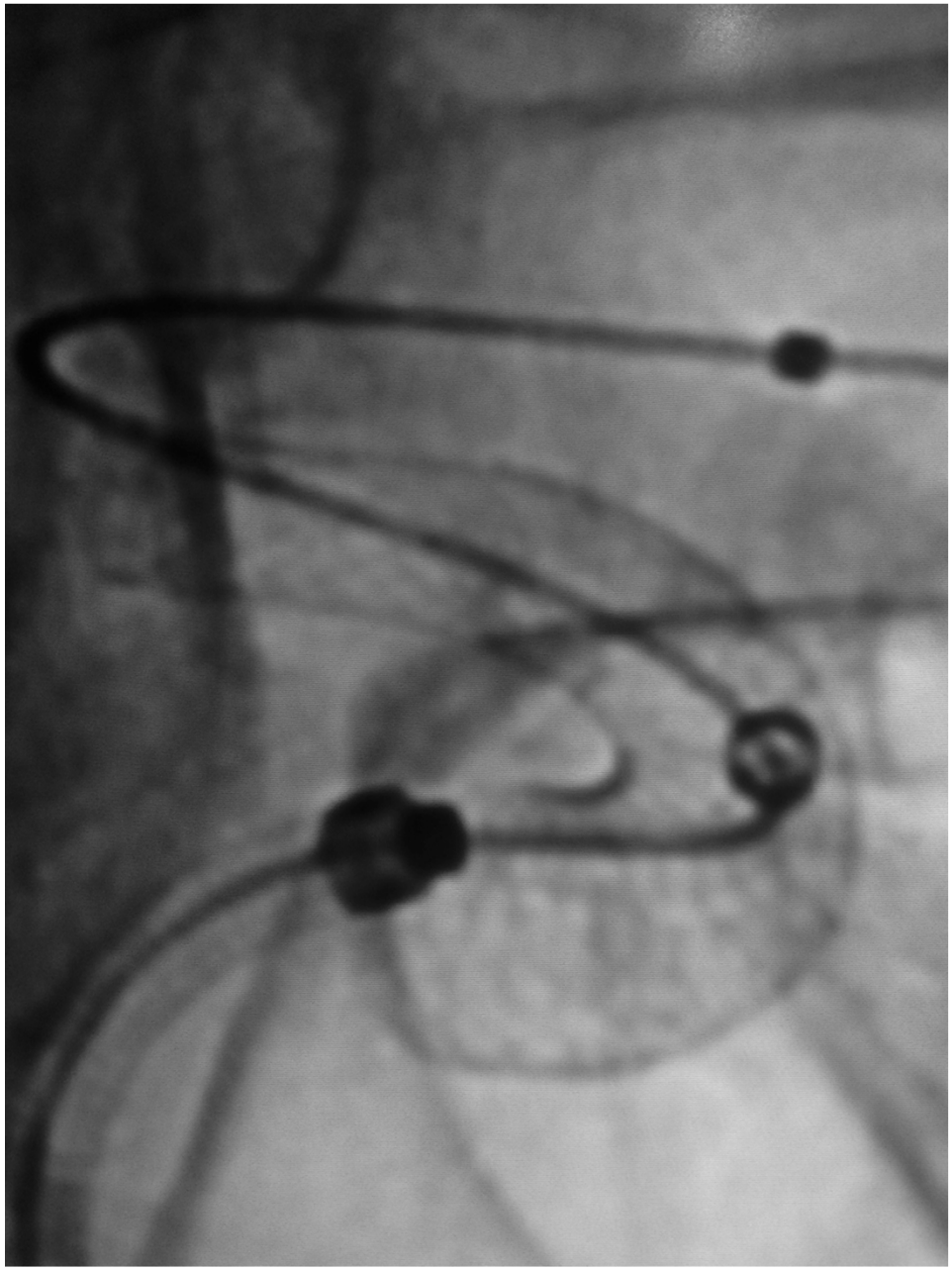

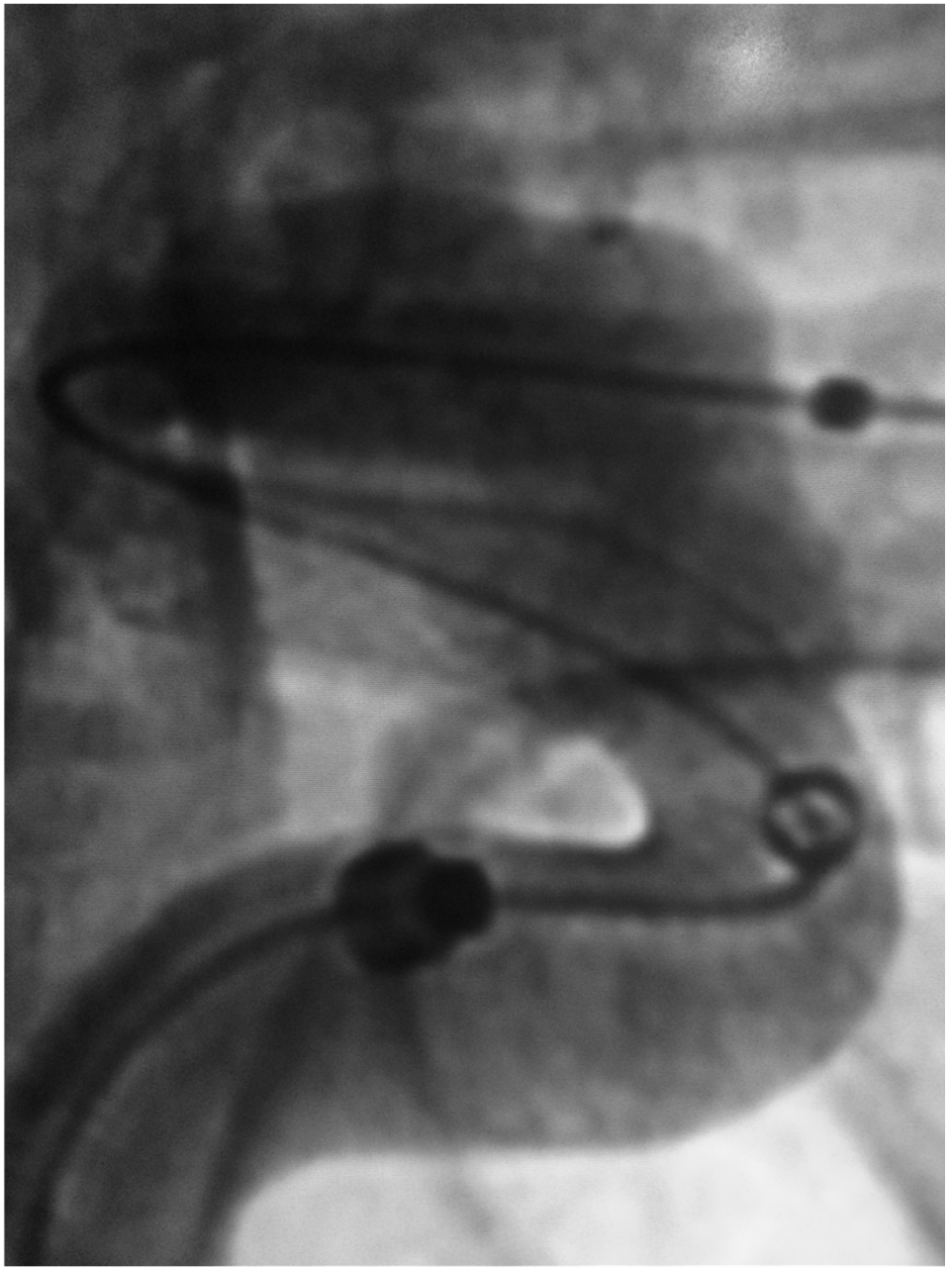

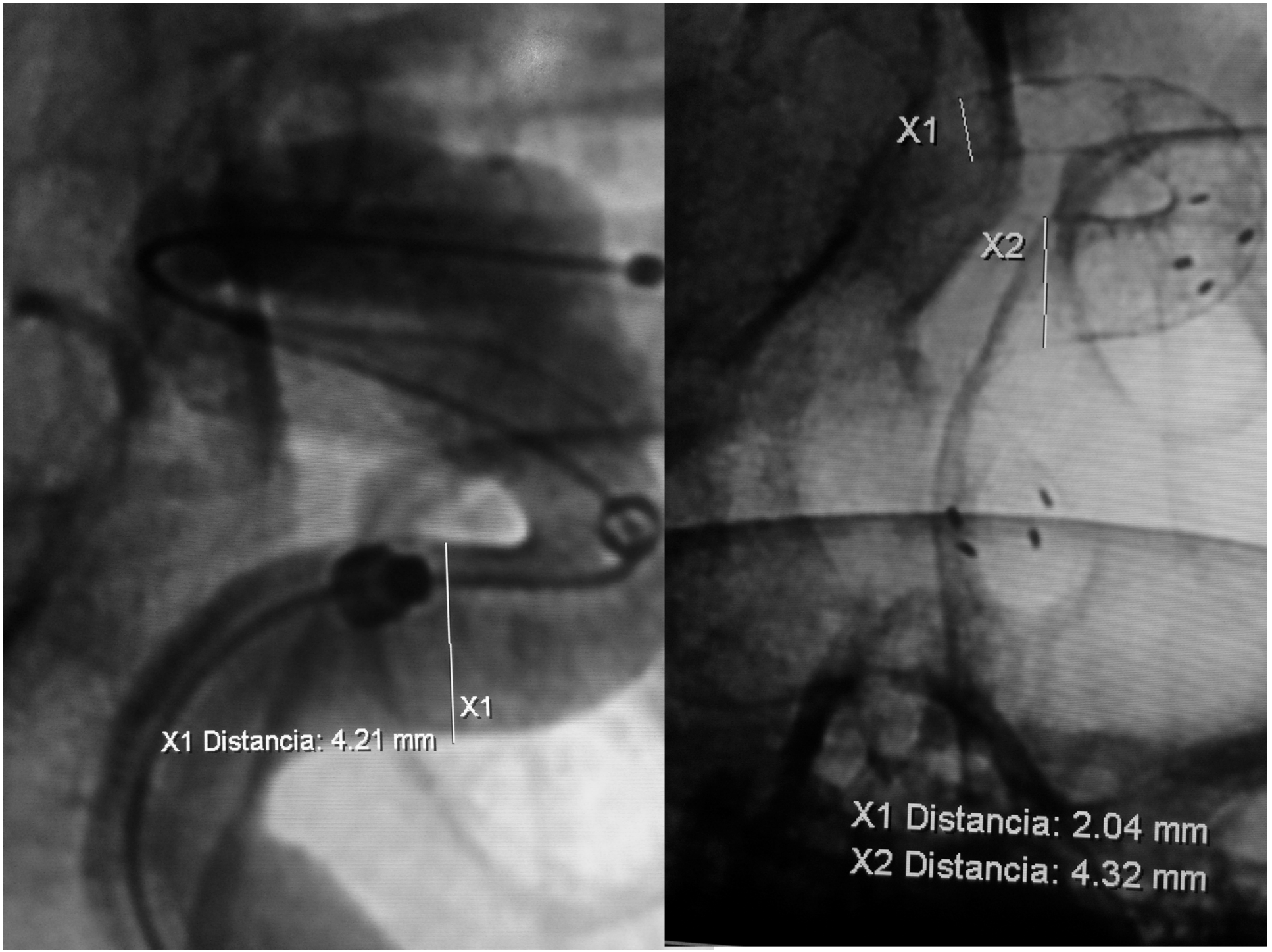
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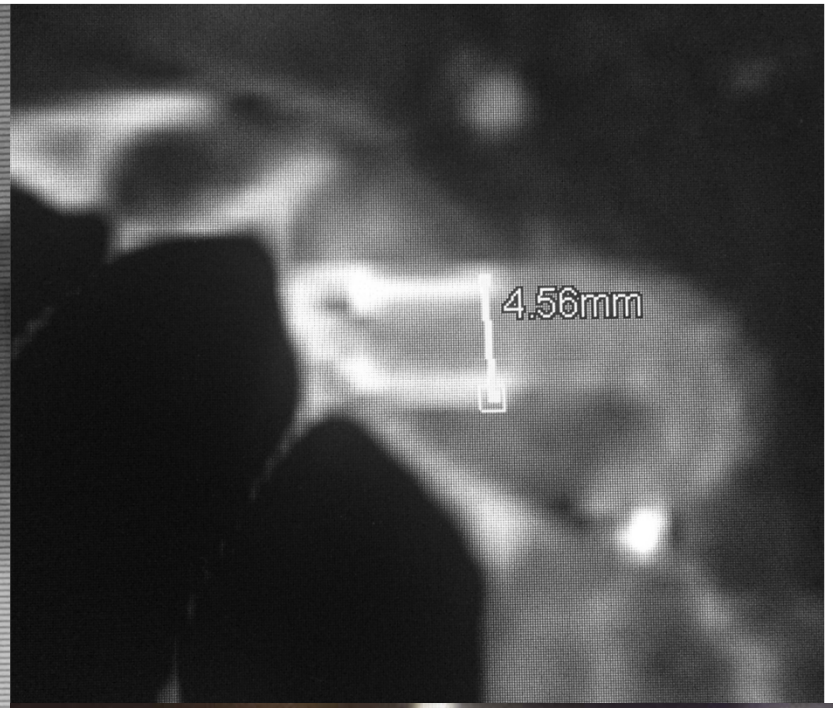
X1
X2
X1 Distancia: 2.04 mm
X2 Distancia: 4.32 mm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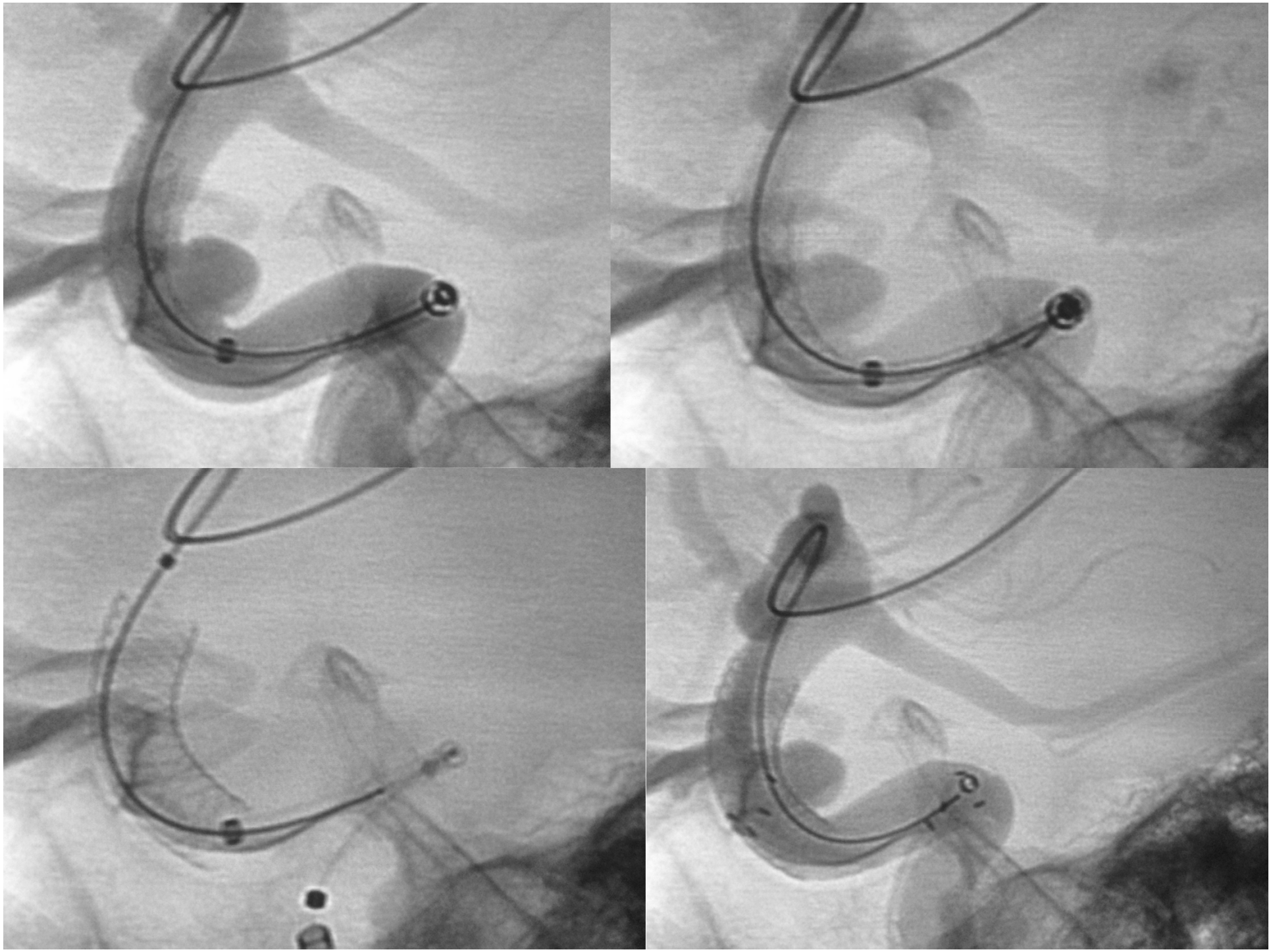


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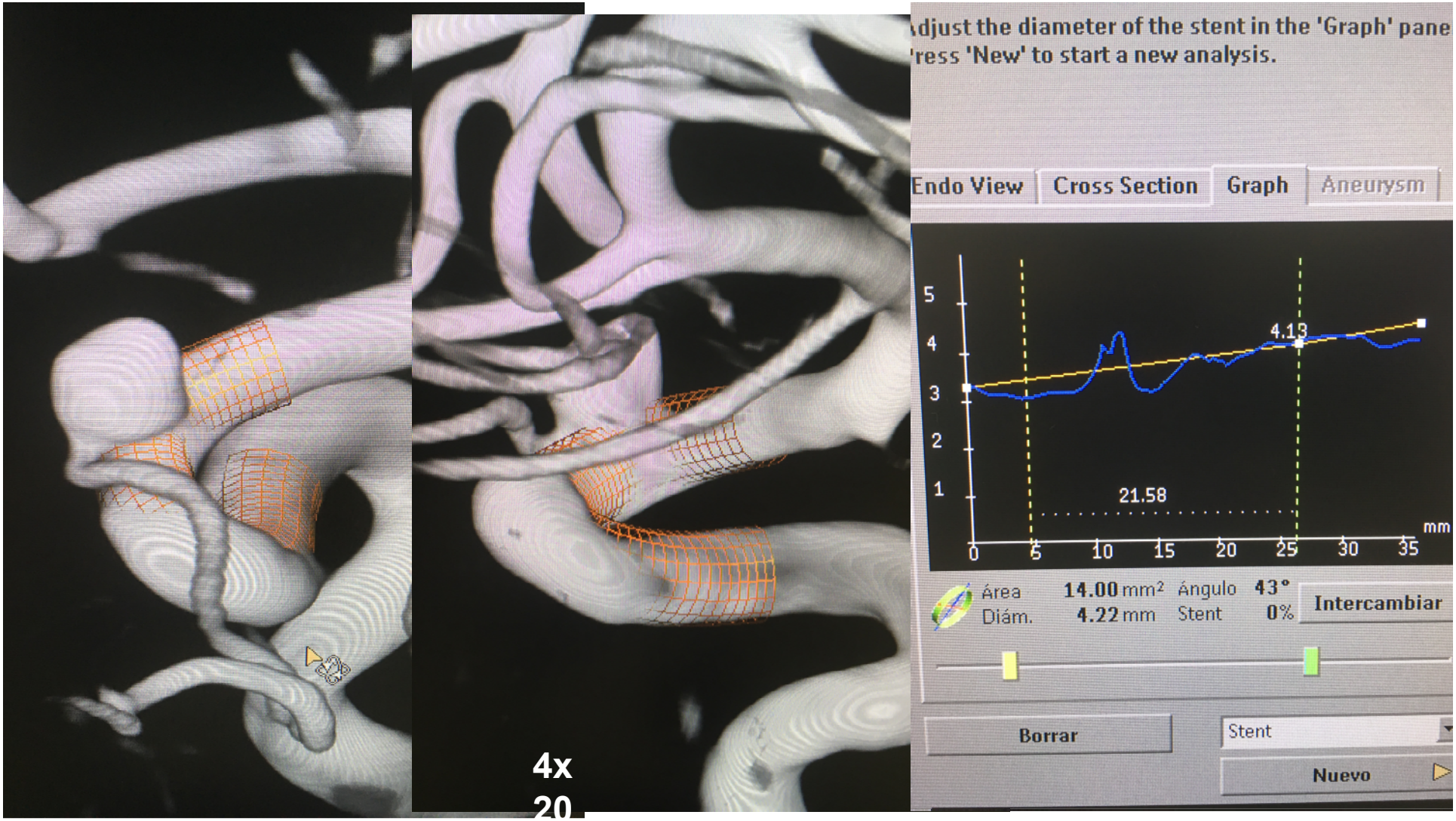
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Endo View
Cross Section
Graph
Aneurysm
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mm
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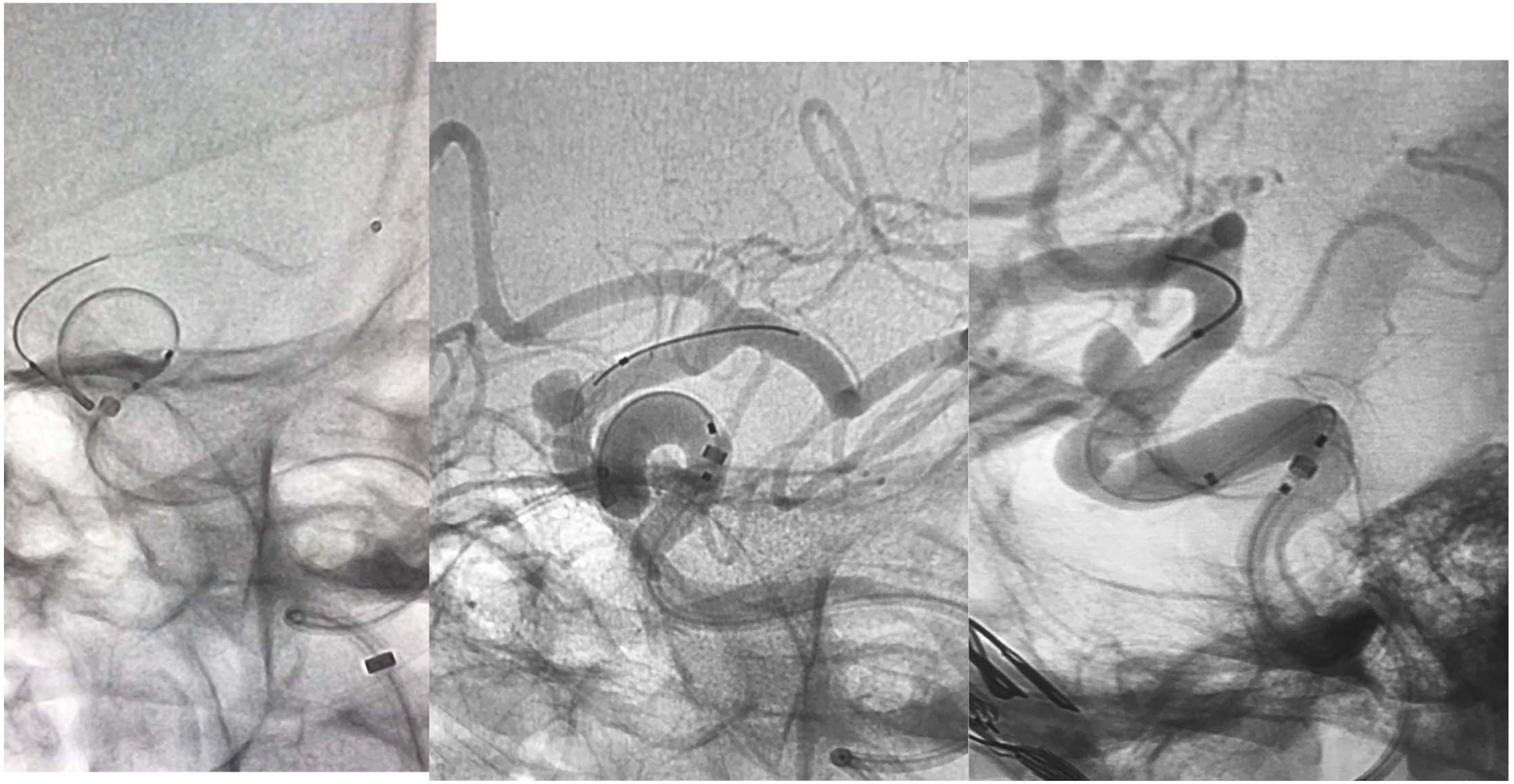
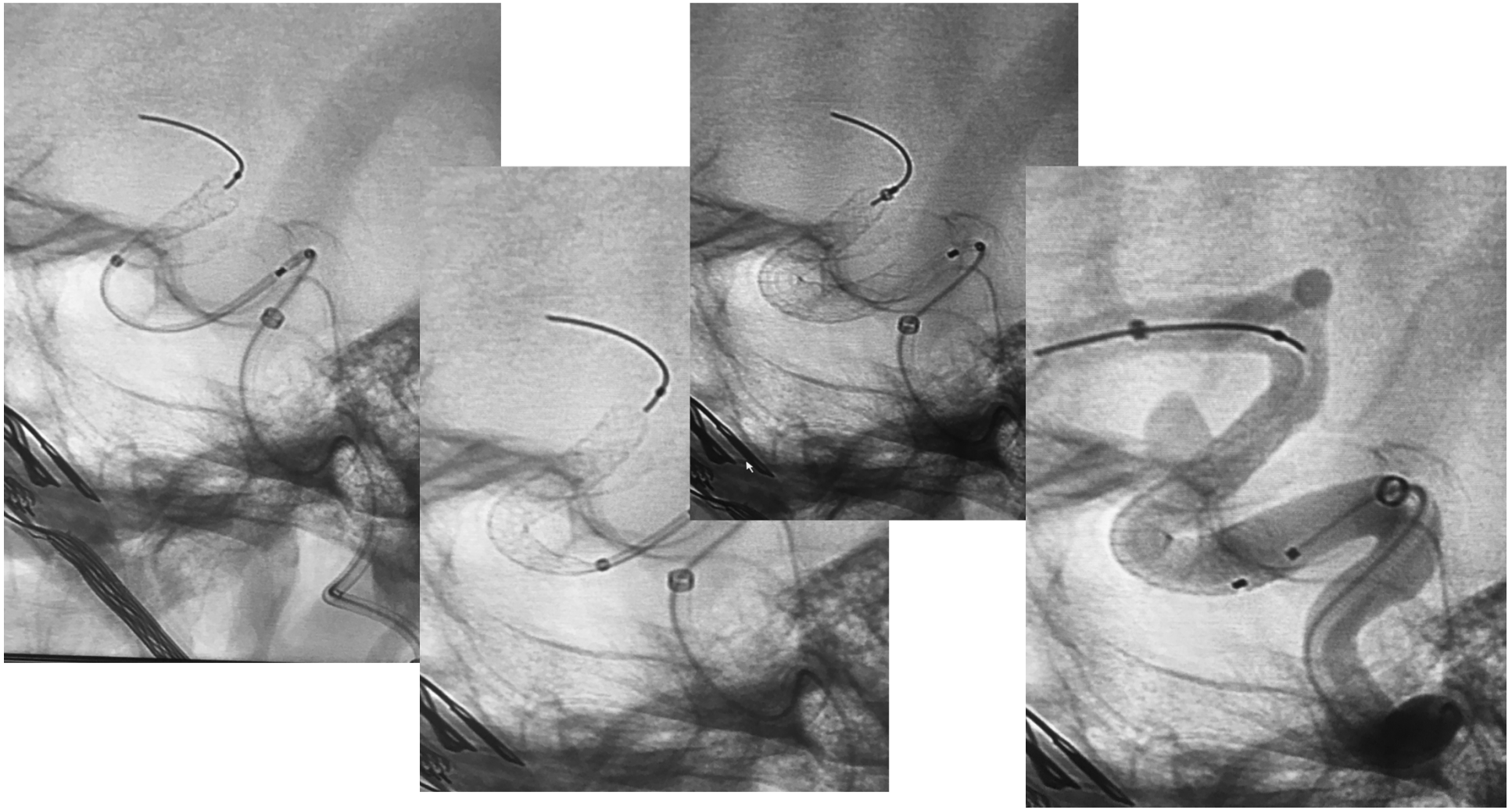
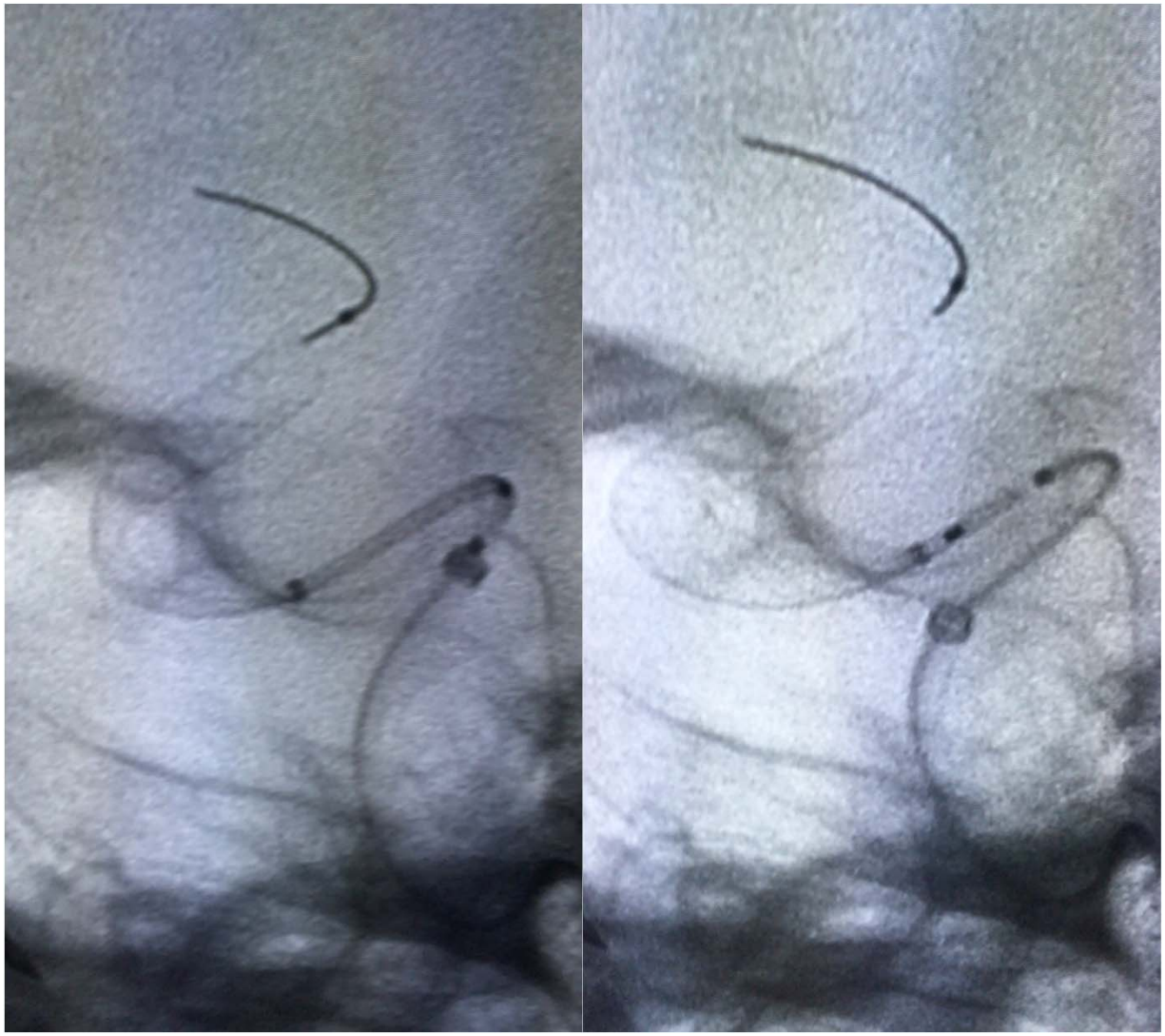
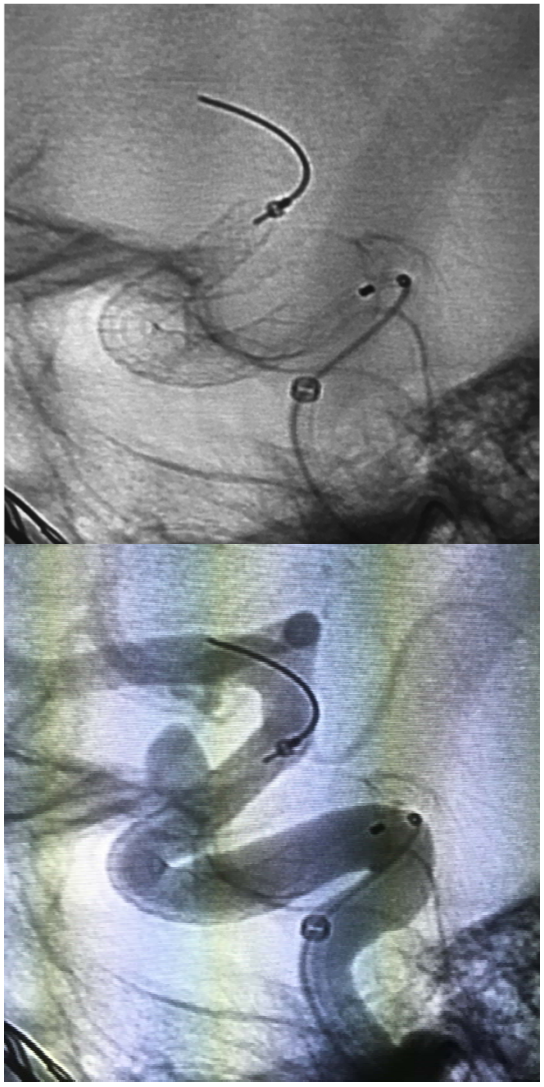
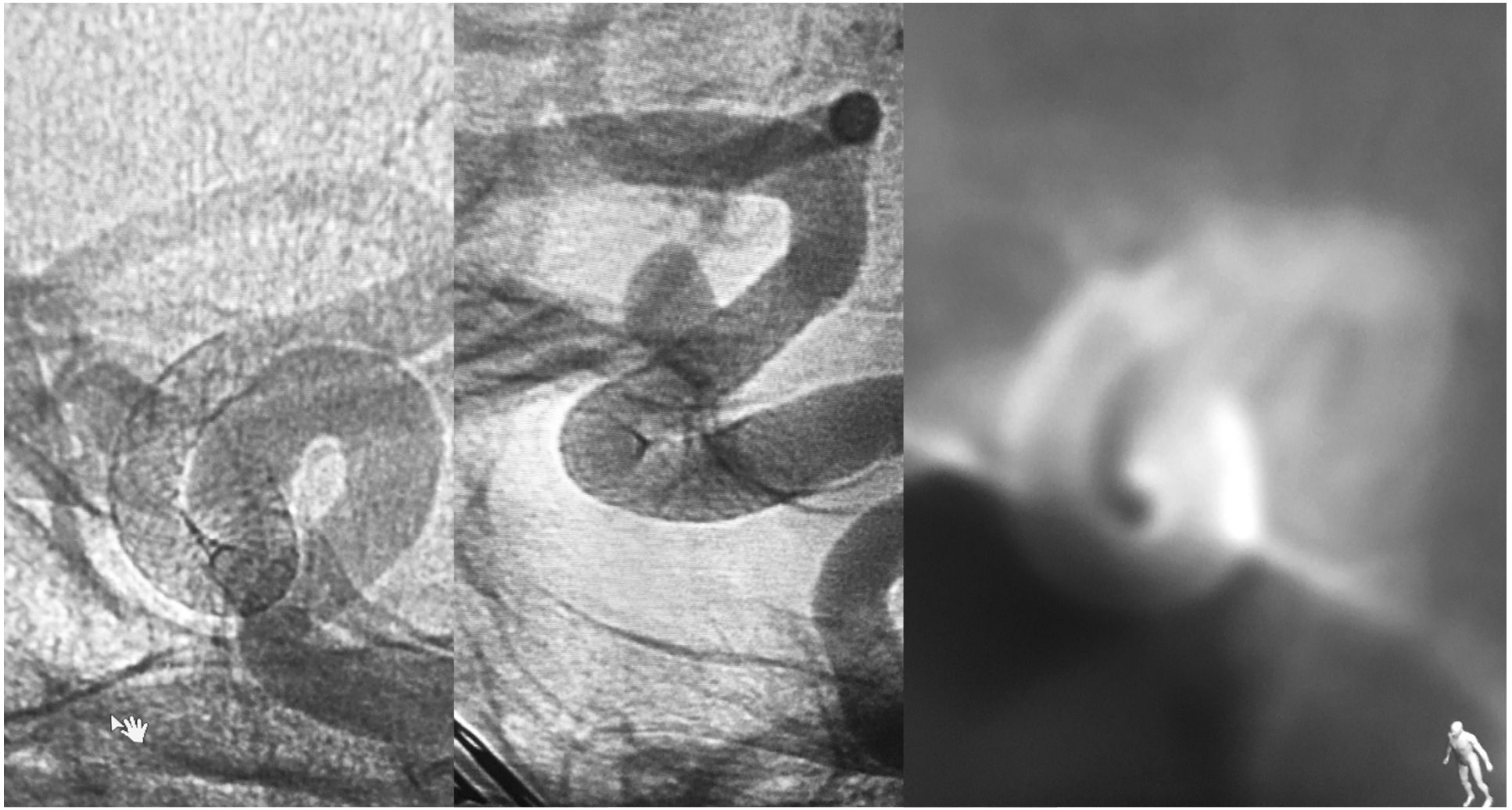


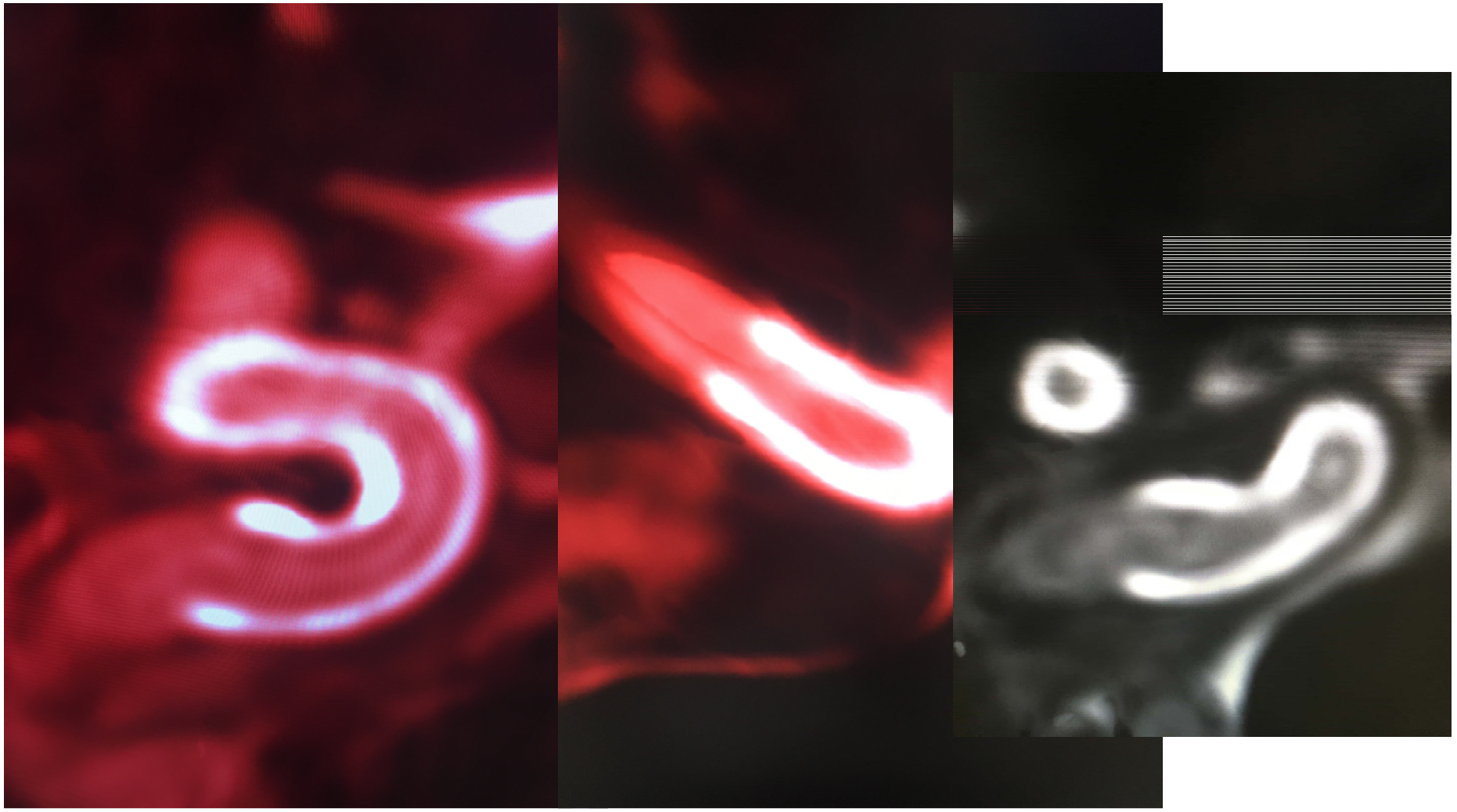
Video empuje cat 5video











INDICACIONES

- ANEURISMAS GRANDES O GIGANTES
- SINTOMAS COMPRESIVOS
- ANEURISMAS FUSIFORMES
- ANEURISMAS FOSA POSTERIOR
- RECURRENCIAS POST-COILING?
- ANEURISMAS INCIDENTALES? CUALQUIER TAMAÑO?
  - EN VASOS PROXIMALES
  - EN VASOS DISTALES

INDICACIONES

- ANEURISMAS GRANDES O GIGANTES
- SINTOMAS COMPRESIVOS
- ANEURISMAS FUSIFORMES
- ANEURISMAS FOSA POSTERIOR
- RECURRENCIAS POST-COILING?
- ANEURISMAS INCIDENTALES? CUALQUIER TAMAÑO?
  - EN VASOS PROXIMALES
  - EN VASOS DISTALES
    - FUSIFORMES
    - LATERALES
    - DE BIFURCACION


4912
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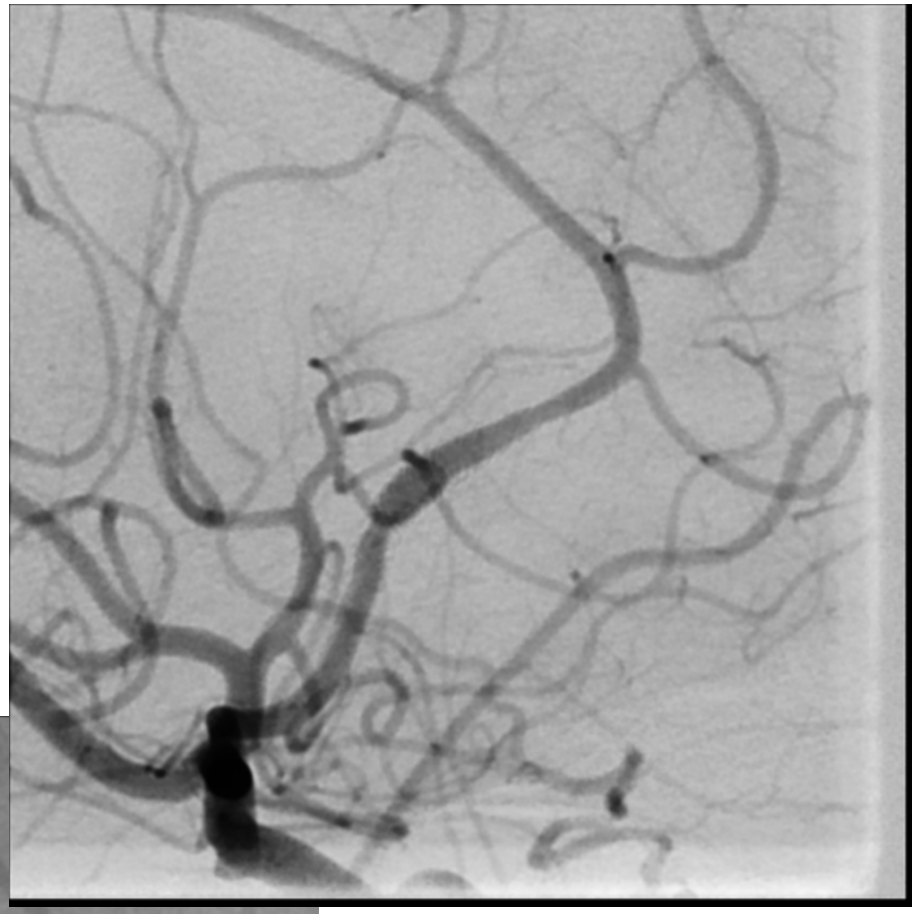
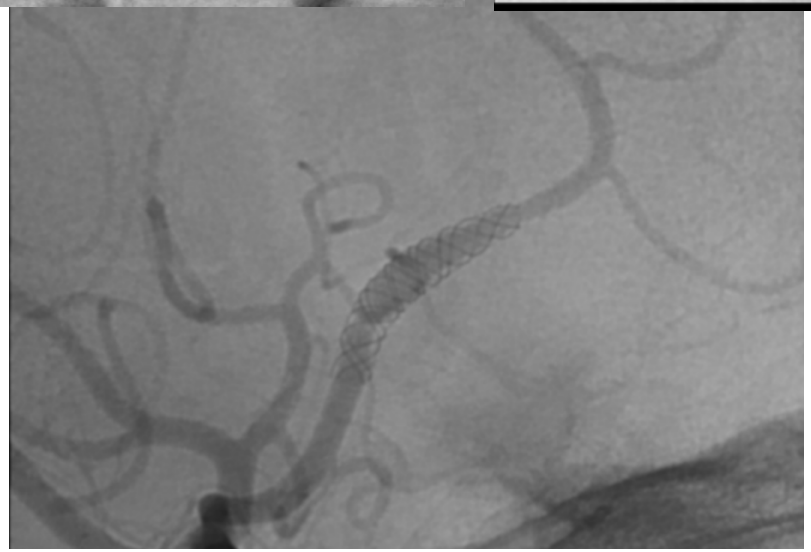
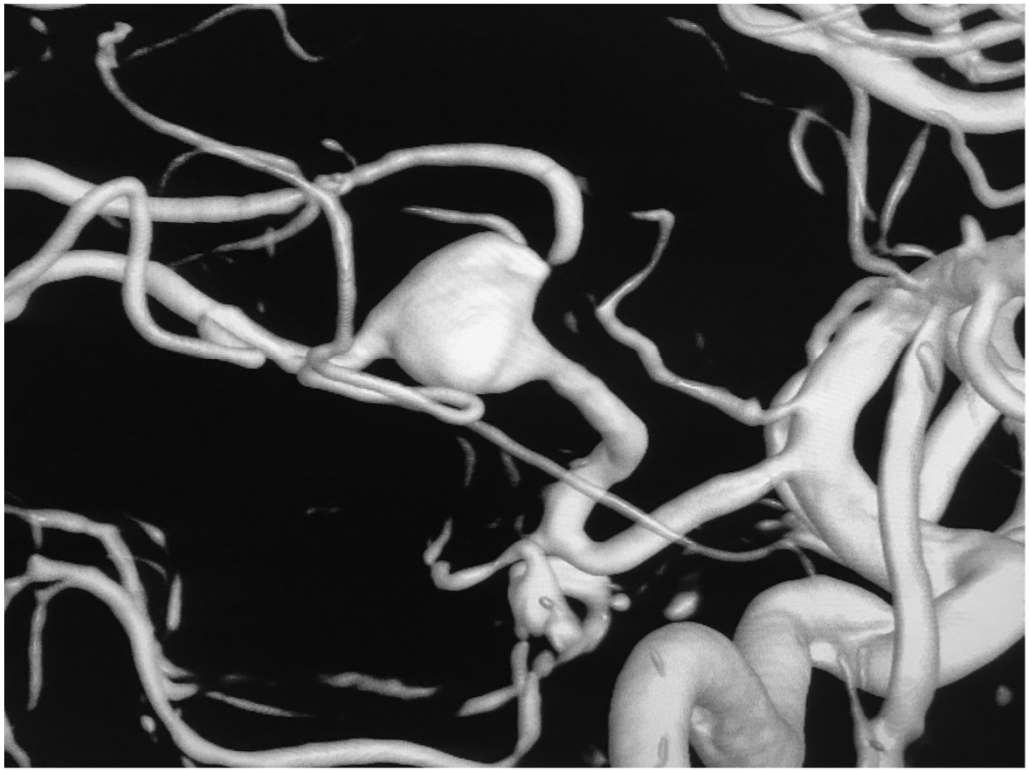
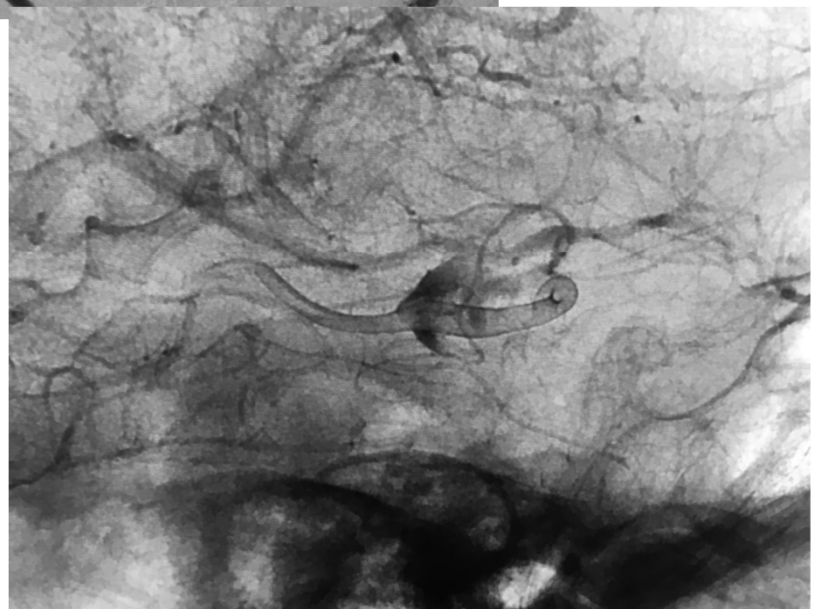
I: 15/22
FLTR: 40%
W-C: 68
X: 0.0
Y: 1.5
RAO: 107 CRAN: 2









frontiers in Neurology

ORIGINAL RESEARCH
published: 07 August 2019
doi: 10.3389/fneur.2019.00838

Patency of Branch Vessels After Pipeline Embolization: Comparison of Various Branches

*Xinzhi Wu, Zhongbin Tian, Wenqiang Li, Jian Liu, Yisen Zhang, Ying Zhang, Yangyang Zhou, Xinjian Yang and Shiqing Mu**

Department of Interventional Neuroradiology, Beijing Neurosurgical Institute, Beijing Tiantan Hospital, Capital Medical University, Beijing, China

Conclusion: Branch occlusion rate after PED deployment was low and most occlusions was asymptomatic. Branches with rich collateral supply were more likely to occlude, especially the ACA. Smaller PED diameter, branches arising from the aneurysm, and ACA involvement were significant predictors of branch occlusion after PED treatment.

The Role of Collateral Circulation in Branch Vessel Occlusion After Flow Diversion

Scott B. Raymond[1], Matthew J. Koch[2], James D. Rabinov[2], Thabele M. Leslie-Mazwi[2,3], Collin M. Torok[4], Christopher J. Stapleton[2], Aman B. Patel[2]

BACKGROUND: Flow diversion for treatment of intracranial aneurysms frequently necessitates covering adjacent branch vessels. Although branch vessel occlusion is common, associated clinical deficits are rare. It has been hypothesized that clinically silent branch vessel occlusion is due to underlying collateral circulation. To study the role of collateral circulation in covered branch vessel occlusion, we assessed collateral vessels and altered branch vessel flow on transfemoral catheter angiography in patients undergoing flow diversion of intracranial aneurysms.

METHODS: Angiograms obtained before treatment, immediately after treatment, and during follow-up were evaluated for branch vessel flow patterns and associated collateral circulation in a consecutive retrospective cohort of 84 patients from 2011 to 2017 with branch vessel coverage related to aneurysm flow diversion using the Pipeline embolization device.

RESULTS: We identified 142 branch vessels covered by the Pipeline device construct for treatment of 89 aneurysms, predominately in the anterior circulation (>90%). Collateral circulation was observed in approximately one third of these vessels and was associated with diminished ($P < 0.001$) or absent ($P < 0.001$) flow on follow-up angiography. Only 2 of 80 terminal branch vessels (no collaterals) were occluded, and these occurred in a patient with Pipeline device construct thrombosis. Altered branch vessel flow was not associated with vascular risk factors, treatment technique, or outcome measures, including new or worsening neurologic deficit.

CONCLUSIONS: Altered flow in branch vessels covered during flow diversion reflects underlying collateral circulation and is not associated with downstream ischemic deficits.

INTRODUCTION

Flow diversion is often the preferred technique for treatment of paraclinoid internal carotid artery aneurysms, and the technique is increasingly being applied in treatment of other types of intracranial aneurysms.[1] Because aneurysms often arise at or near the origin of vessels, a flow diverting stent placed across the aneurysm neck will frequently cover the adjacent branch vessels. Historically, branch vessel coverage was avoided when possible because of the concern for occlusion. However, a growing number of studies have shown that clinical deficits are exceedingly rare despite moderate rates of branch vessel occlusion.[2-5]

One explanation for the lack of clinical deficits is that collateral circulation provides blood supply to covered branch vessel territories. For example, rich external carotid artery to ophthalmic artery collaterals may provide retinal artery supply in the setting of ophthalmic artery occlusion after flow diversion. Ophthalmic artery occlusion is common after flow diversion (7%–25% long term occlusion), but associated visual symptoms are rare.[6-9] In contrast to the ophthalmic artery, some branch vessels, such as the anterior choroidal artery, do not commonly have collateral supply and are considered terminal branches. Although it is unclear if redundant branch vessels (vessels with collaterals) behave differently than terminal branch vessels after flow diversion, prior studies have suggested that true terminal branch vessels rarely demonstrate angiographic occlusion.[2,10-12] In this study, we examined the relationship of collateral circulation and altered angiographic flow in branch vessels covered during flow diversion. We hypothesized that branch vessel occlusion is in most cases

JNS

CLINICAL ARTICLE

J Neurosurg March 30, 2018

Predictors of cerebral aneurysm persistence and occlusion after flow diversion: a single-institution series of 445 cases with angiographic follow-up

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[1]Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, Maryland; [2]Department of Neurosurgery, University of California, Los Angeles; and [3]Department of Neurosurgery, University of California, Irvine, California

OBJECTIVE Flow diversion requires neointimal stent overgrowth to deliver aneurysm occlusion. The existing literature on aneurysm occlusion is limited by heterogeneous follow-up, variable antiplatelet regimens, noninvasive imaging modalities, and nonstandard occlusion assessment. Using a large, single-center cohort with low attrition and standardized antiplatelet tapering, the authors evaluated outcomes after flow diversion of anterior circulation aneurysms to identify predictors of occlusion and aneurysm persistence.

METHODS Data from a prospective, IRB-approved database was analyzed for all patients with anterior circulation aneurysms treated by flow diversion with the Pipeline embolization device (PED) at the authors' institution. Follow-up consisted of catheter cerebral angiography at 6 and 12 months postembolization. Clopidogrel was discontinued at 6 months and aspirin was reduced to 81 mg daily at 12 months. Occlusion was graded as complete, trace filling, entry remnant, or aneurysm filling. Multivariate logistic regression was performed to identify predictors of aneurysm persistence.

RESULTS Follow-up catheter angiography studies were available for 445 (91%) of 491 PED procedures performed for anterior circulation aneurysms between August 2011 and August 2016. Three hundred eighty-seven patients accounted for these 445 lesions with follow-up angiography. The population was 84% female; mean age was 56 years and mean aneurysm size was 6.6 mm. Aneurysms arose from the internal carotid artery (83%), anterior cerebral artery (13%), and middle cerebral artery (4%). Morphology was saccular in 90% of the lesions, and 18% of the aneurysms has been previously treated. Overall, complete occlusion was achieved in 82% of cases at a mean follow-up of 14 months. Complete occlusion was achieved in 72%, 78%, and 87% at 6, 12, and 24 months, respectively. At 12 months, adjunctive coiling predicted occlusion (OR 0.260, $p = 0.036$), while male sex (OR 2.923, $p = 0.032$), aneurysm size (OR 3.584, $p = 0.011$), and incorporation of a branch vessel (OR 2.206, $p = 0.035$) predicted persistence. Notable variables that did not predict aneurysm occlusion were prior treatments, vessel of origin, fusiform morphology, and number of devices used.

CONCLUSIONS This is the largest single-institution study showing high rates of anterior circulation aneurysm occlusion after Pipeline embolization. Predictors of persistence after flow diversion included increasing aneurysm size and incorporated branch vessel, whereas adjunctive coiling predicted occlusion.

https://thejns.org/doi/abs/10.3171/2017.11.JNS171738


2.27cm


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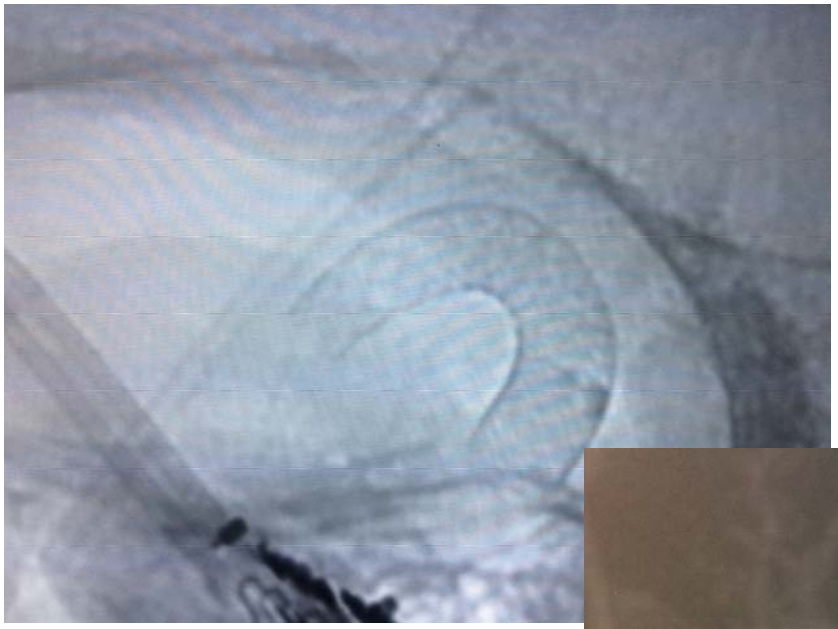
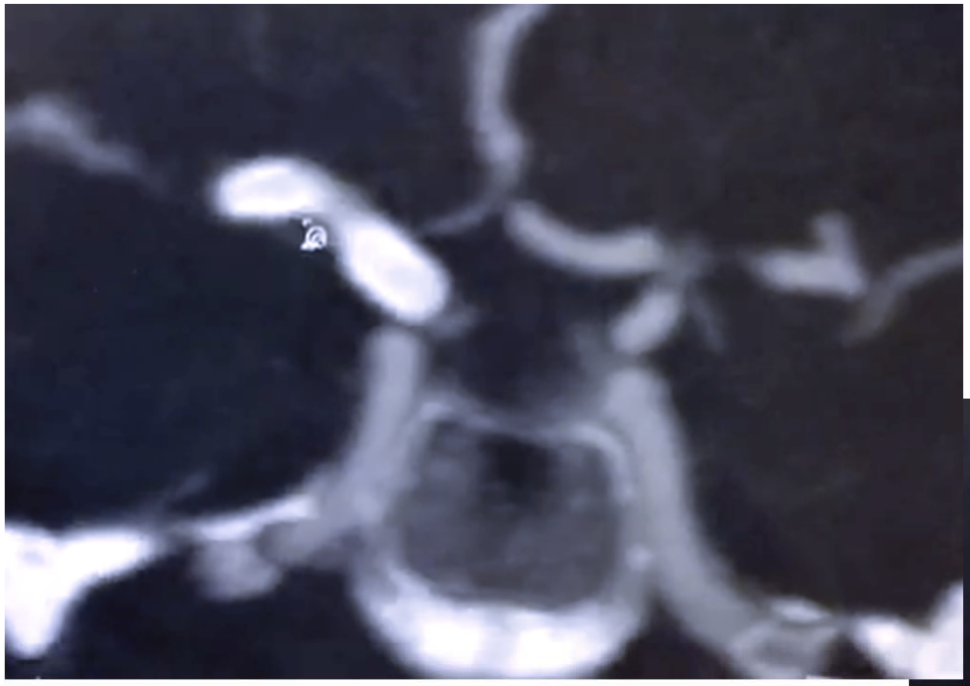
2.86mm
3.43mm


2.71mm
4.11mm





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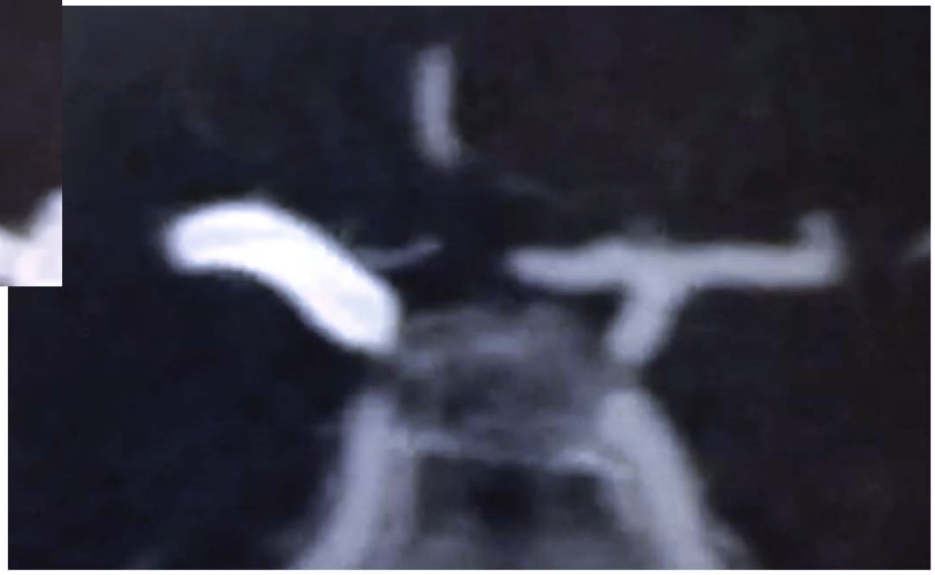

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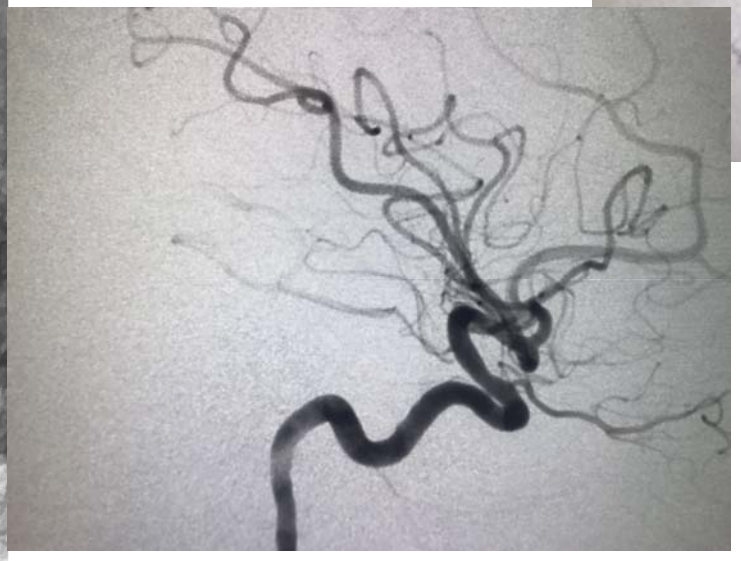

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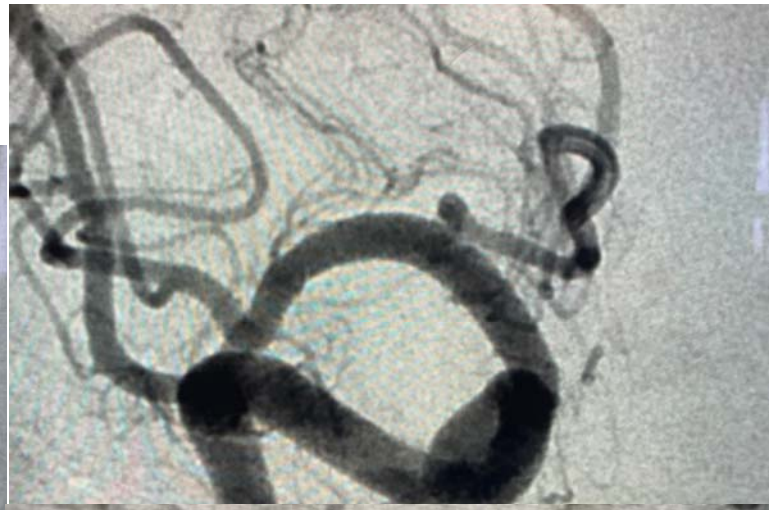

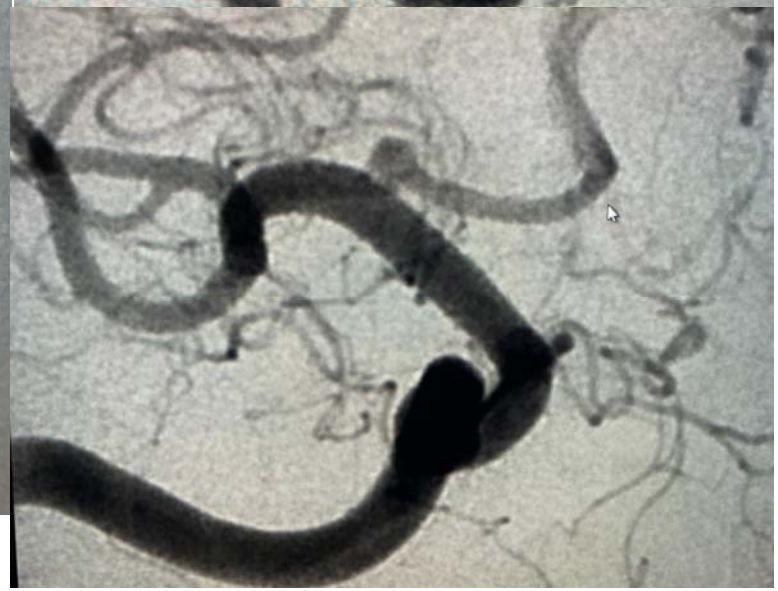

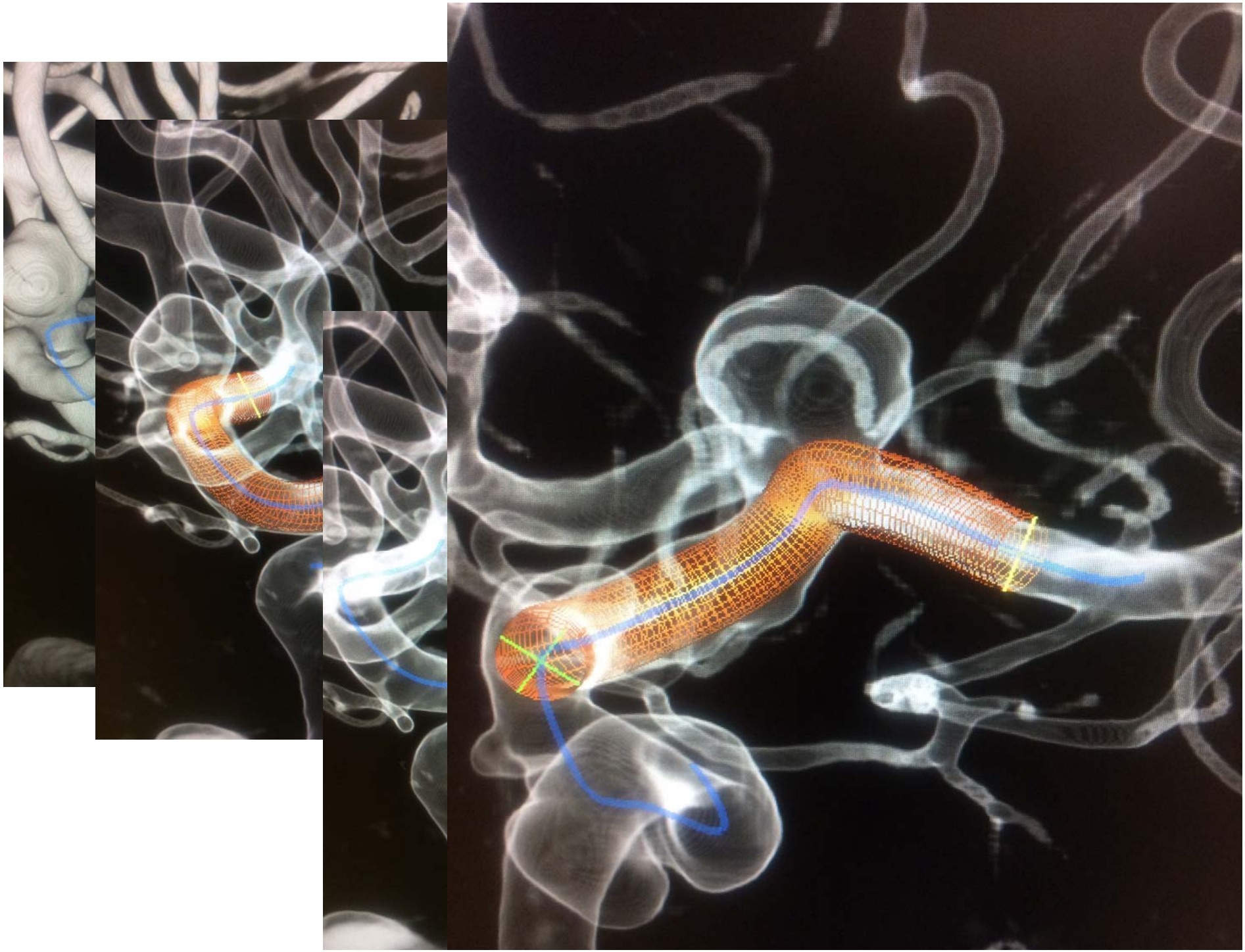

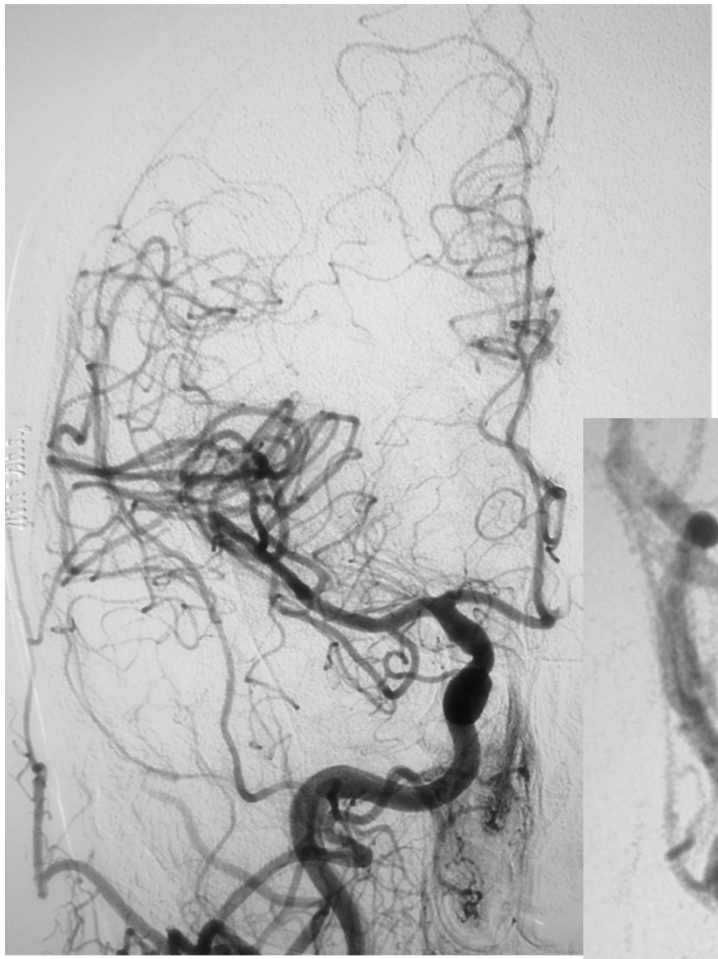

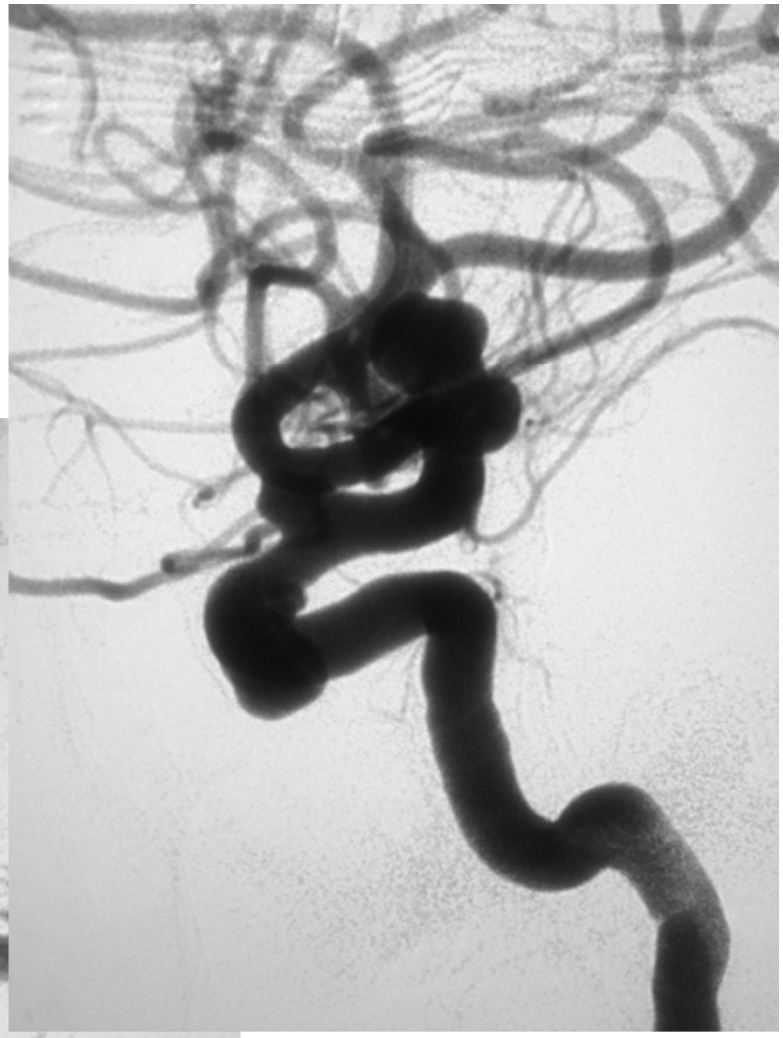

INDICACIONES

- ANEURISMAS GRANDES O GIGANTES
- SINTOMAS COMPRESIVOS
- ANEURISMAS FUSIFORMES
- ANEURISMAS FOSA POSTERIOR
- RECURRENCIAS POST-COILING?
- ANEURISMAS INCIDENTALES? CUALQUIER TAMAÑO?
  - EN VASOS PROXIMALES
  - EN VASOS DISTALES
    - FUSIFORMES
    - LATERALES
    - DE BIFURCACION
- DISECCIONES? ANEURISMAS ROTOS?

Acutely Ruptured Intracranial Aneurysms Treated with Flow-Diverter Stents: A Systematic Review and Meta-Analysis

F. Cagnazzo, D.T. di Carlo, M. Cappucci, P.-H. Lefevre, V. Costalat, and P. Perrini

AJNR Am J Neuroradiol 39:1669–75 Sep 2018 www.ajnr.org

ABSTRACT

BACKGROUND: The implantation of flow-diverter stents for the treatment of ruptured intracranial aneurysms required further investigation.

PURPOSE: Our aim was to analyze the outcomes after flow diversion of ruptured intracranial aneurysms.

DATA SOURCES: A systematic search of 3 databases was performed for studies published from 2006 to 2018.

STUDY SELECTION: According to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, we included studies (from 2010 to 2018) reporting acutely ruptured intracranial aneurysms treated with flow diversion.

DATA ANALYSIS: Random-effects meta-analysis was used to pool the following: aneurysm occlusion rate, complications, rebleeding, and factors influencing the studied outcomes.

DATA SYNTHESIS: We included 20 studies evaluating 223 patients with acutely ruptured intracranial aneurysms treated with flow-diverter stents. Immediate angiographic occlusion was obtained in 32% (29/86; 95% CI, 15.4%–48%; $I^2 = 79.6\%$) of aneurysms, whereas long-term complete/near-complete aneurysm occlusion was 88.9% (162/189; 95% CI, 84%–93.5%; $I^2 = 20.9\%$) (mean radiologic follow-up of 9.6 months). The treatment-related complication rate was 17.8% (42/223; 95% CI, 11%–24%; $I^2 = 52.6\%$). Complications were higher in the posterior circulation (16/72 = 27%; 95% CI, 14%–40%; $I^2 = 66\%$ versus 18/149 = 11.7%; 95% CI, 7%–16%; $I^2 = 0\%$) ($P = .004$) and after treatment with multiple stents (14/52 = 26%; 95% CI, 14%–45%; $I^2 = 59\%$) compared with a single stent (20/141 = 10%; 95% CI, 5%–15%; $I^2 = 0\%$) ($P = .004$). Aneurysm rebleeding after treatment was 4% (5/223; 95% CI, 1.8%–7%; $I^2 = 0\%$) and was higher in the first 72 hours.

LIMITATIONS: Small and retrospective series.

CONCLUSIONS: Flow-diversion treatment of ruptured intracranial aneurysms yields a high rate of long-term angiographic occlusion with a relatively low rate of aneurysm rebleeding. However, treatment is associated with a complication rate of 18%. When coiling or microsurgical clipping are not feasible strategies, anterior circulation ruptured aneurysms can be effectively treated with a flow-diversion technique, minimizing the number of stents deployed. Given the 27% rate of complications, flow diversion for ruptured posterior circulation aneurysms should be considered only in selected cases not amenable to other treatments.

ABBREVIATIONS: ASA = acetylsalicylic acid; CP = clopidogrel; IQR = interquartile range; PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses

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Clinical study

Basilar artery perforator aneurysms: Report of 9 cases and review of the literature

P. Bhogal [a,*], M. AlMatter [b], V. Hellstern [b], M. Aguilar Pérez [b], J. Lehmberg [c], O. Ganslandt [d], H. Bäzner [e], H. Henkes [b,f]

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ABSTRACT

Basilar perforator artery aneurysms (BAPA's) are an under-recognised cause of sub-arachnoid haemorrhage (SAH). We present our single centre experience of BAPA's and review of the literature.

We performed a retrospective review of our prospectively maintained database to identify all BAPA's that presented acute SAH between February 2009 and February 2018.

We identified 9 patients (male = 7), each with a single aneurysm, and average age 55 ± 9.7 years. All aneurysms were small, 2.1 ± 0.5 mm (range 1–3 mm). Three aneurysms were not detected on initial angiography. Six aneurysms were treated with flow diversion, 3 were managed conservatively. No repeat haemorrhage occurred in the flow diverted patients. One patient treated conservatively suffered a repeat haemorrhage and died (mRS 6). Follow up imaging (n = 7), at average 5.6 months (range 3–12 months), showed complete occlusion in all the flow-diverted aneurysms and no change in one conservatively managed patient. There was no evidence of perforator infarction on the follow-up post treatment imaging. Clinical follow-up data was available in 8 patients, 6 of whom (75%) had a good outcome (mRS ≤ 2).

A high index of suspicion is required to diagnose BAPA. Flow diversion can be used to treat BAPA's with acceptable risk of perforator infarction and low risk of repeat haemorrhage.

Endovascular Treatment of Ruptured Blister-Like Aneurysms: A Systematic Review and Meta-Analysis with Focus on Deconstructive versus Reconstructive and Flow-Diverter Treatments

AJNR Am J Neuroradiol 36:2331–39 Dec 2015

A. Rouchaud, W. Brinjikji, H.J. Cloft, and D.F. Kallme

ABSTRACT

BACKGROUND AND PURPOSE: Various endovascular techniques have been applied to treat blister-like aneurysms. We performed systematic review to evaluate endovascular treatment for ruptured blister-like aneurysms.

MATERIALS AND METHODS: We performed a comprehensive literature search and subgroup analyses to compare deconstructive versu reconstructive techniques and flow diversion versus other reconstructive options.

RESULTS: Thirty-one studies with 265 procedures for ruptured blister-like aneurysms were included. Endovascular treatment wa associated with a 72.8% (95% CI, 64.2%–81.5%) mid- to long-term occlusion rate and a 19.3% (95% CI, 13.6%–25.1%) retreatment rate Mid- to long-term neurologic outcome was good in 76.2% (95% CI, 68.9%–8.4%) of patients. Two hundred forty procedures (90.6% were reconstructive techniques (coiling, stent-assisted coiling, overlapped stent placement, flow diversion) and 25 treatments (9.4% were deconstructive. Deconstructive techniques had higher rates of initial complete occlusion than reconstructive technique (77.3% versus 33.0%, $P = .0003$) but a higher risk for perioperative stroke (29.1% versus 5.0%, $P = .04$). There was no difference in goo mid- to long-term neurologic outcome between groups, with 76.2% for the reconstructive group versus 79.9% for the deconstruc tive group ($P = .30$). Of 240 reconstructive procedures, 62 (25.8%) involved flow-diverter stents, with higher rates of mid- t long-term complete occlusion than other reconstructive techniques (90.8% versus 67.9%, $P = .03$) and a lower rate of retreatmen (6.6% versus 30.7%, $P < .0001$).

CONCLUSIONS: Endovascular treatment of ruptured blister-like aneurysms is associated with high rates of complete occlusion and goo mid- to long-term neurologic outcomes in most patients. Deconstructive techniques are associated with higher occlusion rates but higher risk of perioperative ischemic stroke. In the reconstructive group, flow diversion carries a higher level of complete occlusion an similar clinical outcomes.

Early Versus Delayed Flow Diversion for Ruptured Intracranial Aneurysms: A Meta-Analysis

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Key words
- Flow diversion
- Ruptured aneurysm
- Subarachnoid hemorrhage

Abbreviations and Acronyms
CI: Confidence interval
IPD: Individual Participant Data
mRS: Modified Rankin Scale
OR: Odds ratio
SAH: Subarachnoid hemorrhage

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1878-8750/$ - see front matter

OBJECTIVE: The use and timing of flow diversion for aneurysmal subarachnoid hemorrhage is controversial. The objective of this study is to perform a meta-analysis and systematic review to compare overall complication rate between early versus delayed flow diversion for ruptured aneurysms.

METHODS: A literature search for all eligible articles was performed using PubMed, Cochrane, and Web of Science databases. The primary outcome was the overall complication rate (any complication in the perioperative period), and secondary outcomes were 1) hemorrhage and 2) stroke/death (all hemorrhagic/ischemic strokes and/or death).

RESULTS: Thirteen articles including 142 patients met inclusion criteria. Eighty-nine (62.7%) patients underwent early deployment of flow diverters (i.e., 2 days or less). The odds ratio for overall complication rate with early versus delayed flow diversion was 0.95 (95% confidence interval [CI] 0.36–2.49, $P = 0.42$). The odds ratio for the secondary outcome of hemorrhagic complication for early versus delayed flow diversion was 1.44 (95% CI 0.45–4.52, $P = 0.87$) and of stroke/death was 1.67 (95% CI 0.5–4.9, $P = 0.69$). The odds ratio of early versus delayed flow diversion for blister/dissecting/fusiform aneurysms was 0.82 (95% CI 0.29–2.30) and for saccular/giant aneurysms was 2.23 (95% CI 0.17–29.4). At last follow-up, 71.6% of patients had good performance status (modified Rankin Scale score 0–2), and the rate of angiographic aneurysm occlusion was 90.2%.

CONCLUSIONS: This meta-analysis did not show a difference in overall complication rate between early versus delayed flow diversion for ruptured aneurysms. Early flow diversion for ruptured blister/fusiform/dissecting aneurysms carries a lower risk of aneurysm rerupture and overall complications as compared with that for ruptured saccular/giant aneurysms.

INTRODUCTION

Subarachnoid hemorrhage (SAH) from a ruptured intracranial aneurysm occurs with an incidence of 6–8 per 100,000 in the Western population.[1-3] The Interna-

ORIGINAL RESEARCH

Flow diversion treatment for acutely ruptured aneurysms

Michelle F M ten Brinck,[1] Maike Jäger,[2] Joost de Vries,[1] J André Grotenhuis,[1] René Aquarius,[1] Svein H Mørkve,[3] Riitta Rautio,[4] Jussi Numminen,[5] Rahul Raj,[5] Ajay K Wakhloo,[6,7] Ajit S Puri,[7] Christian A Taschner,[2] Hieronymus D Boogaarts[1]

► Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/neurintsurg-2019-015077).

For numbered affiliations see end of article.

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Ms. Michelle F M ten Brinck, Neurosurgery, Radboudumc, Nijmegen 6500 HB, The Netherlands; michelle.tenbrinck@radboudumc.nl

CAT and HDB contributed equally.

Oral presentation at ESMINT, 6-8 September 2018, Nice, France. Oral presentation at the DGNR (Deutsche Gesellschaft für Neuroradiologie eV), 3-6 October 2018, Frankfurt, Germany.

Received 25 May 2019
Revised 4 August 2019
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ABSTRACT

Background and purpose Flow diverters are sometimes used in the setting of acutely ruptured aneurysms. However, thromboembolic and hemorrhagic complications are feared and evidence regarding safety is limited. Therefore, in this multicenter study we evaluated complications, clinical, and angiographic outcomes of patients treated with a flow diverter for acutely ruptured aneurysms.

Methods We conducted a retrospective observational study of 44 consecutive patients who underwent flow diverter treatment within 15 days after rupture of an intracranial aneurysm at six centers. The primary end point was good clinical outcome, defined as modified Rankin Scale score (mRS) 0–2. Secondary endpoints were procedure-related complications and complete aneurysm occlusion at follow-up.

Results At follow-up (median 3.4 months) 20 patients (45%) had a good clinical outcome. In 20 patients (45%), 25 procedure-related complications occurred. These resulted in permanent neurologic deficits in 12 patients (27%). In 5 patients (11%) aneurysm re-rupture occurred. Eight patients died resulting in an all-cause mortality rate of 18%. Procedure-related complications were associated with a poor clinical outcome (mRS 3–6; OR 5.1(95% CI 1.0 to 24.9), p=0.04). Large aneurysms were prone to re-rupture with rebleed rates of 60% (3/5) vs 5% (2/39) (p=0.01) for aneurysms with a size ≥20 mm and <20 mm, respectively. Follow-up angiography in 29 patients (median 9.7 months) showed complete aneurysm occlusion in 27 (93%).

Conclusion Flow diverter treatment of ruptured intracranial aneurysms was associated with high rates of procedure-related complications including aneurysm re-ruptures. Complications were associated with poor clinical outcome. In patients with available angiographic follow-up, a high occlusion rate was observed.

patients are often loaded with dual antiplatelet therapy (DAPT).

Flow diverters (FDs) reconstruct the lumen of the parent artery and require no manipulation within the aneurysm sac, so the risk of intraoperative rupture is minimized. However, thromboembolic and hemorrhagic complications have been reported in the literature. The use of DAPT in the setting of acute SAH is of extra concern since these patients are often subjected to other crucial intracranial procedures. If the complication rate of FDs as treatment for acute SAH is comparable to that of stent-assisted coiling, then it would favor FD treatment for some aneurysm subtypes since FD technology is thought to have better durability with a lower recanalization rate. Several cases have been reported in the recent past, and a meta-analysis showed higher rates of long-term complete occlusion and a lower rate of retreatment for patients with ruptured blister-like aneurysms treated with FDs versus those treated with other reconstructive techniques.[6–10]

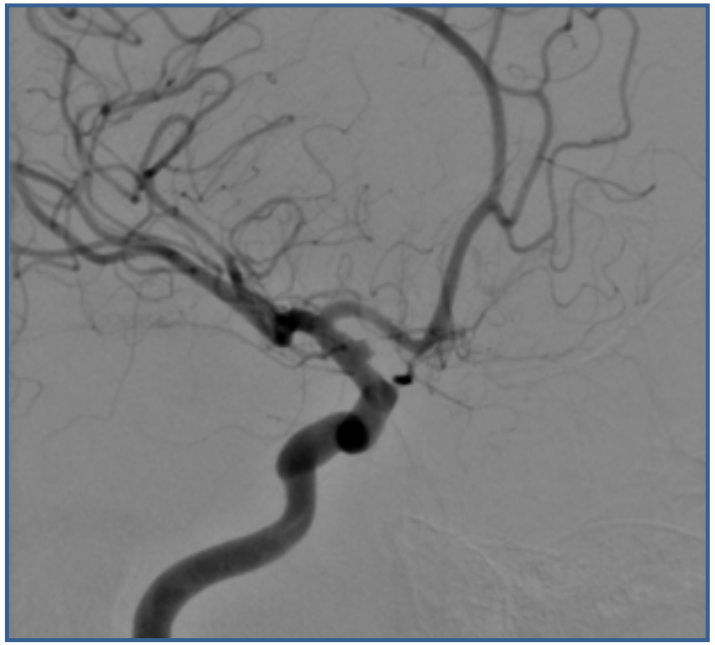
However, evidence is still limited and complication rates and clinical outcomes vary between published meta-analyses.[11 12] The efficacy and safety of the use of FDs in the acute SAH phase is therefore still open to question.

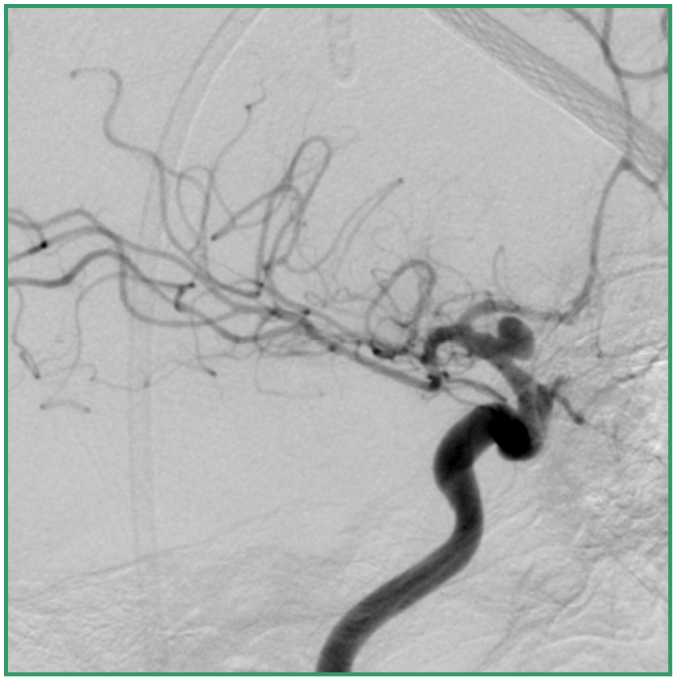
In this study we present a multicenter experience of FDs for acutely ruptured aneurysms. The objective was to evaluate the complications, clinical and angiographic outcomes of consecutive patients treated with a FD for acutely ruptured intracranial aneurysms.

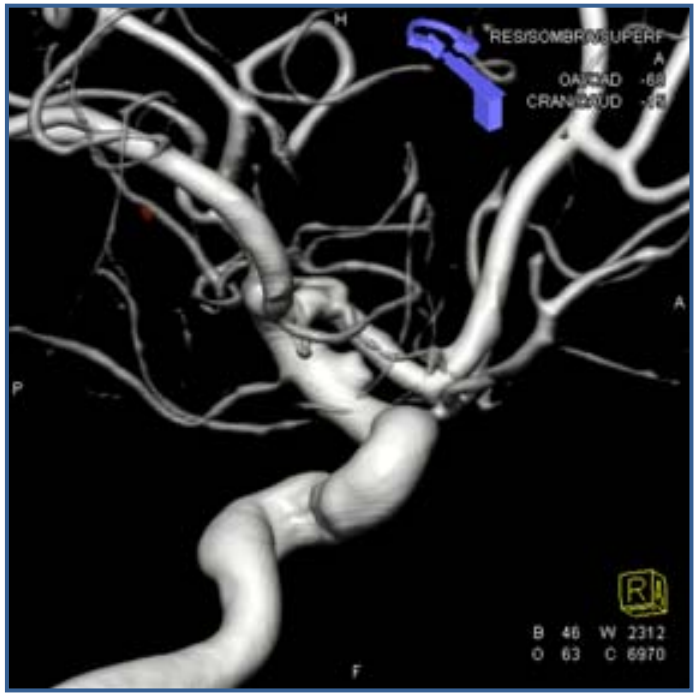
METHODS

Study design

This retrospective analysis of prospectively kept



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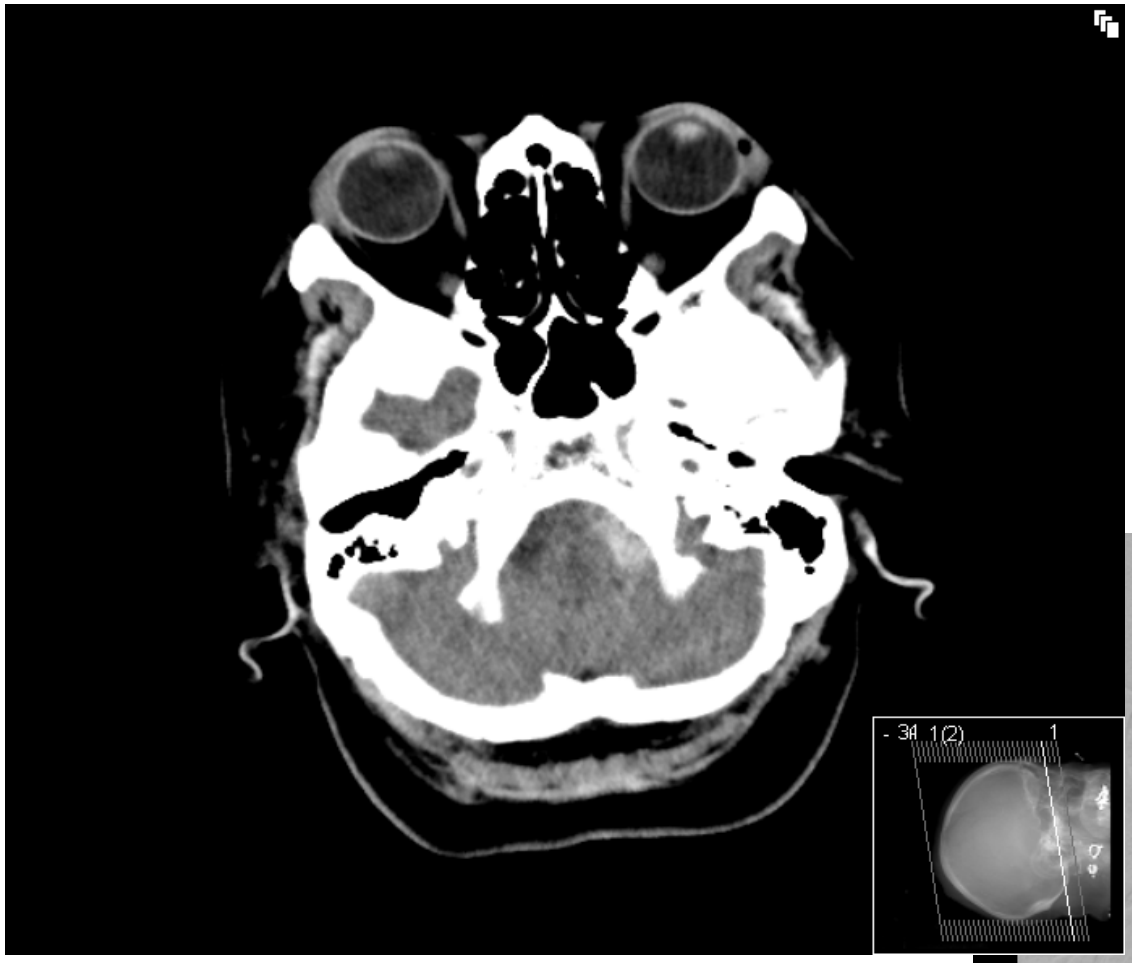
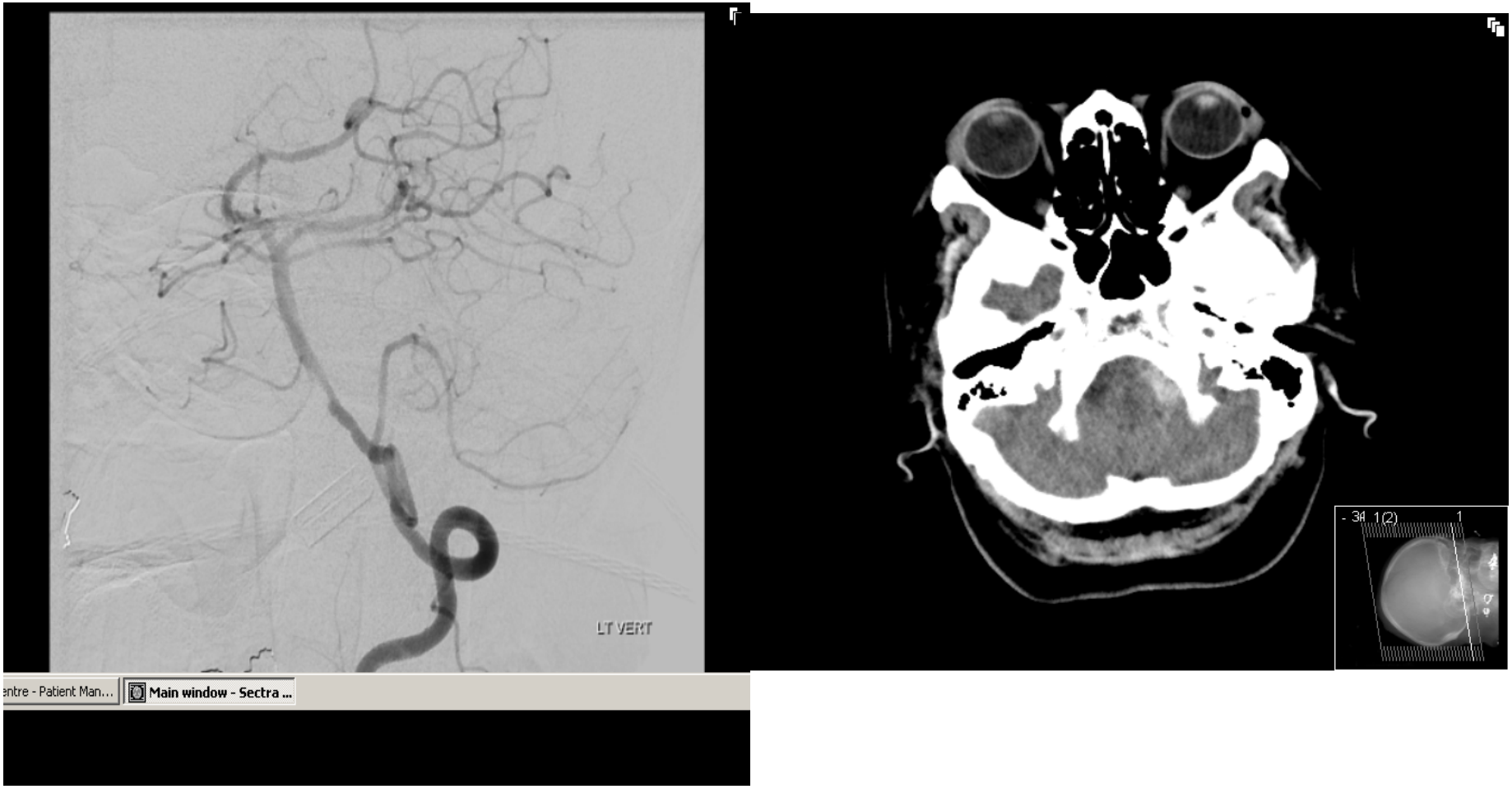


72 yo, female, acute SAH
Surpass™ 4x25mm

72 years of age, female, acute SAH: Surpass™ 4x25mm



72 yo, female, acute SAH
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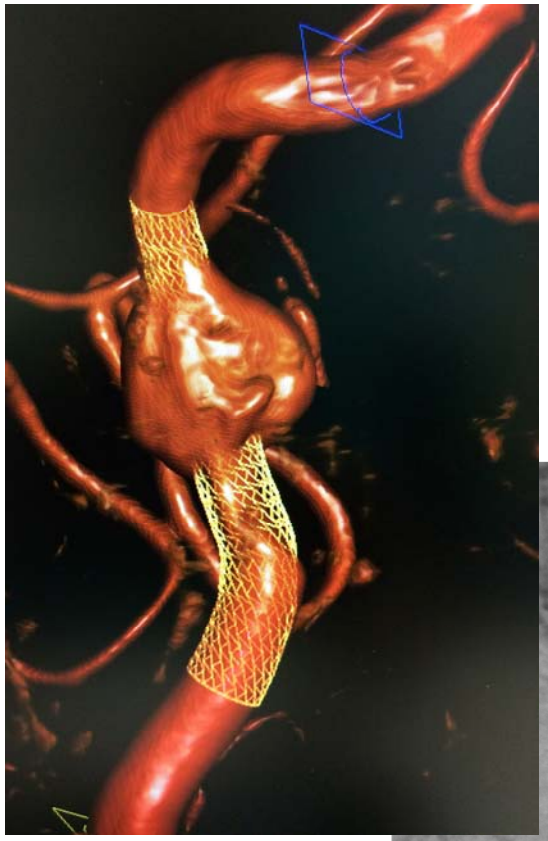
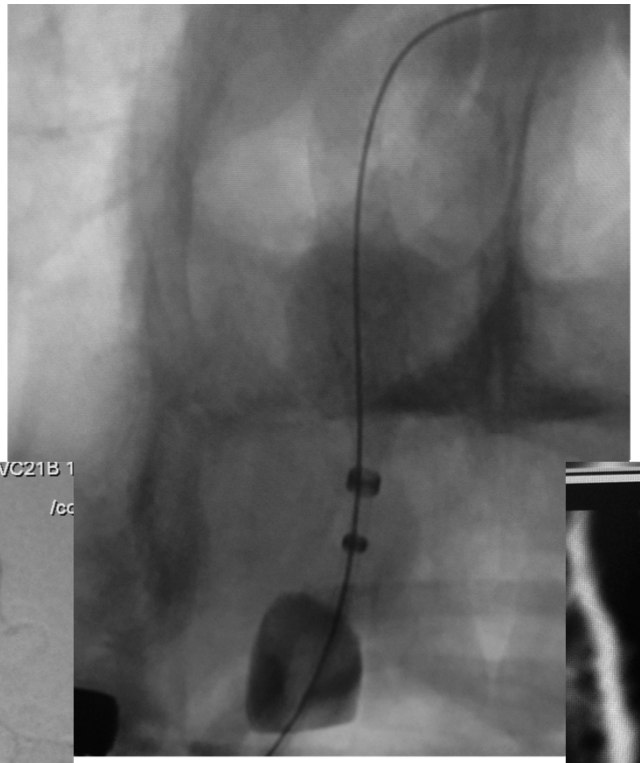
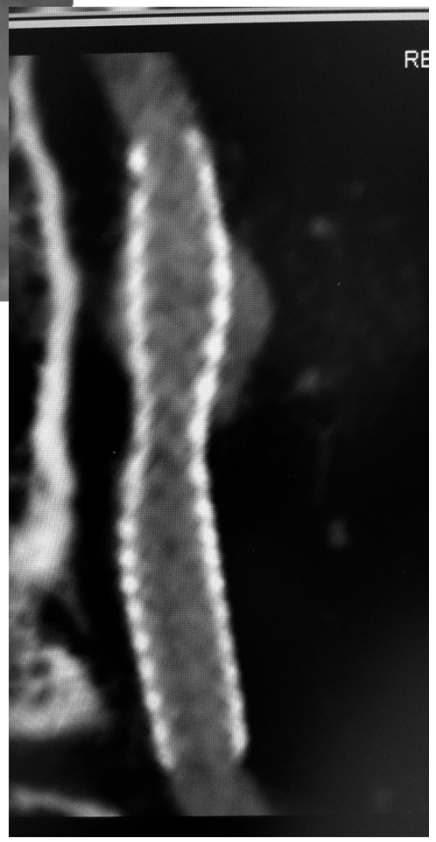
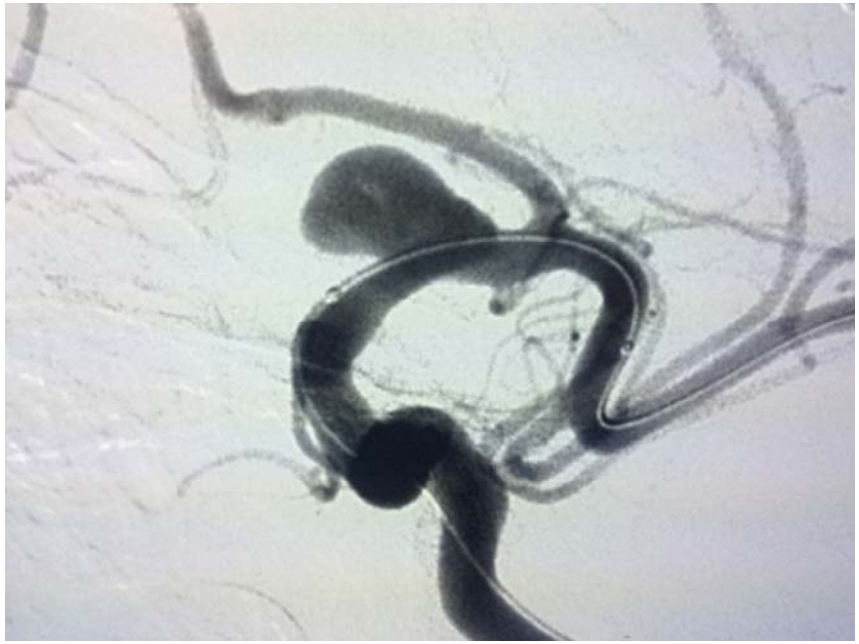
Operative

3 Months Follow Up







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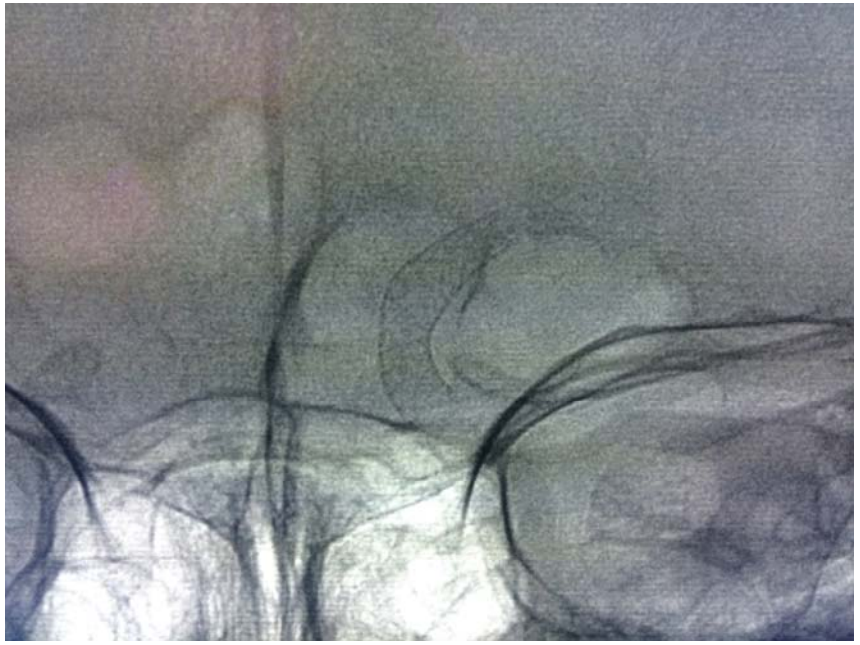

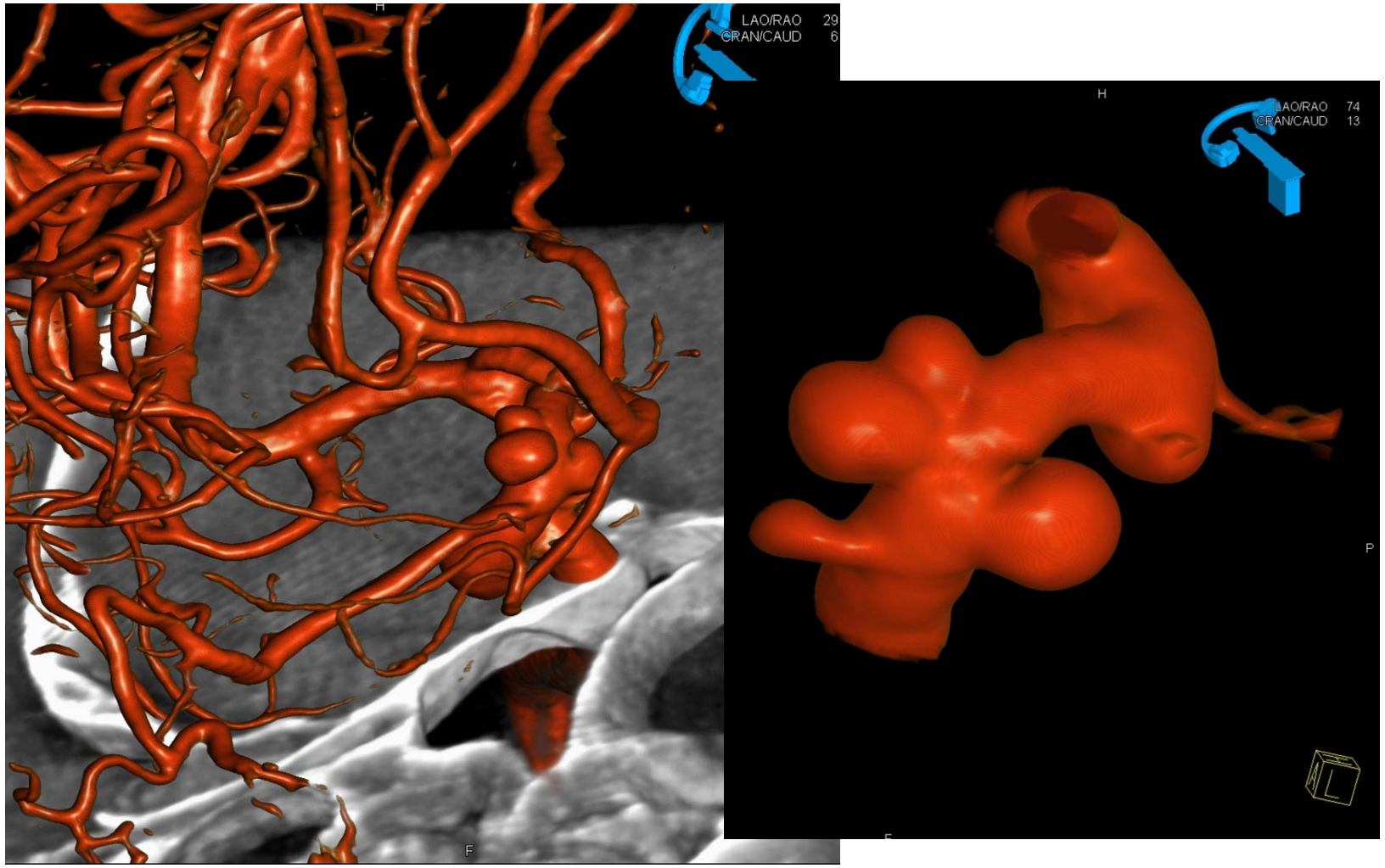
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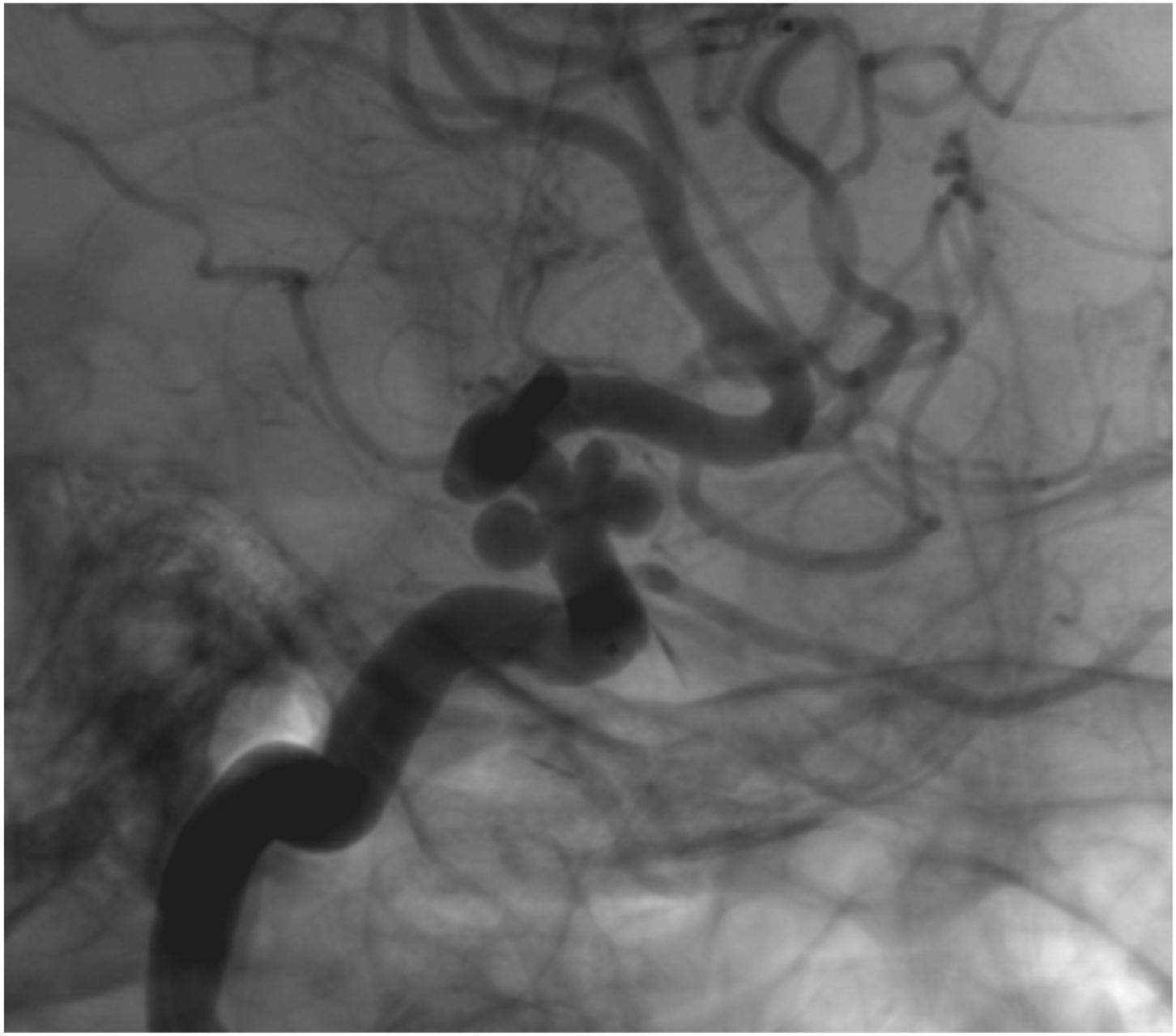

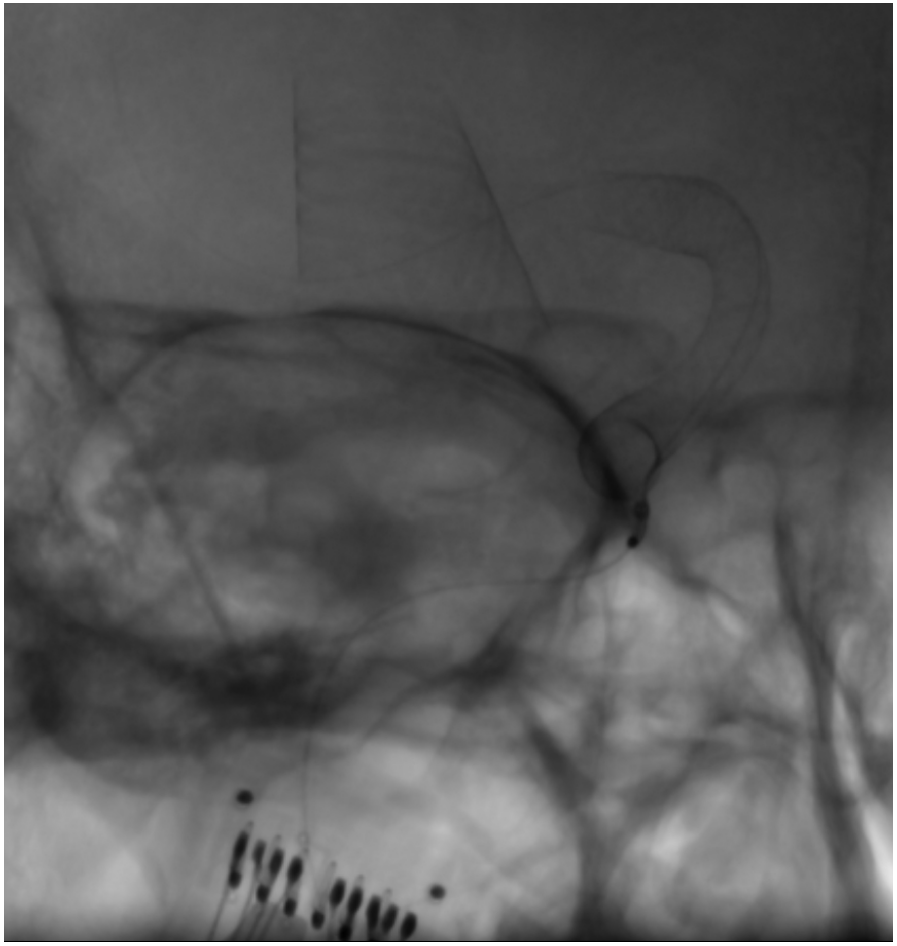

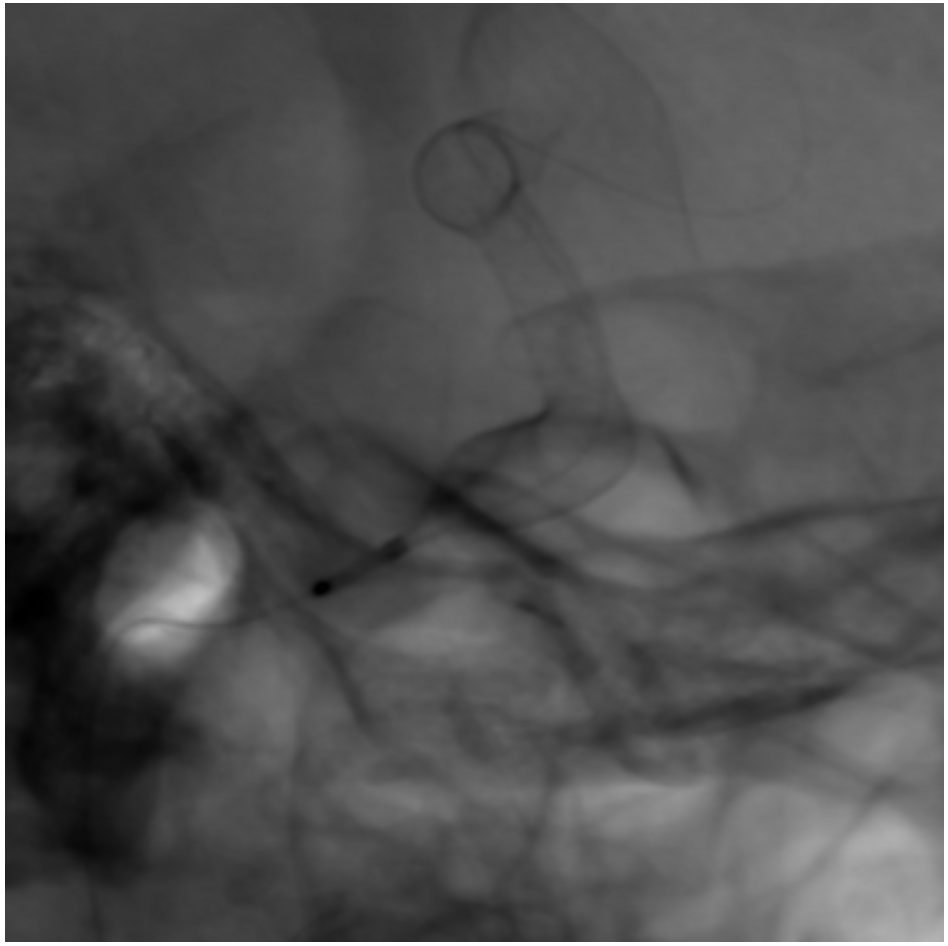

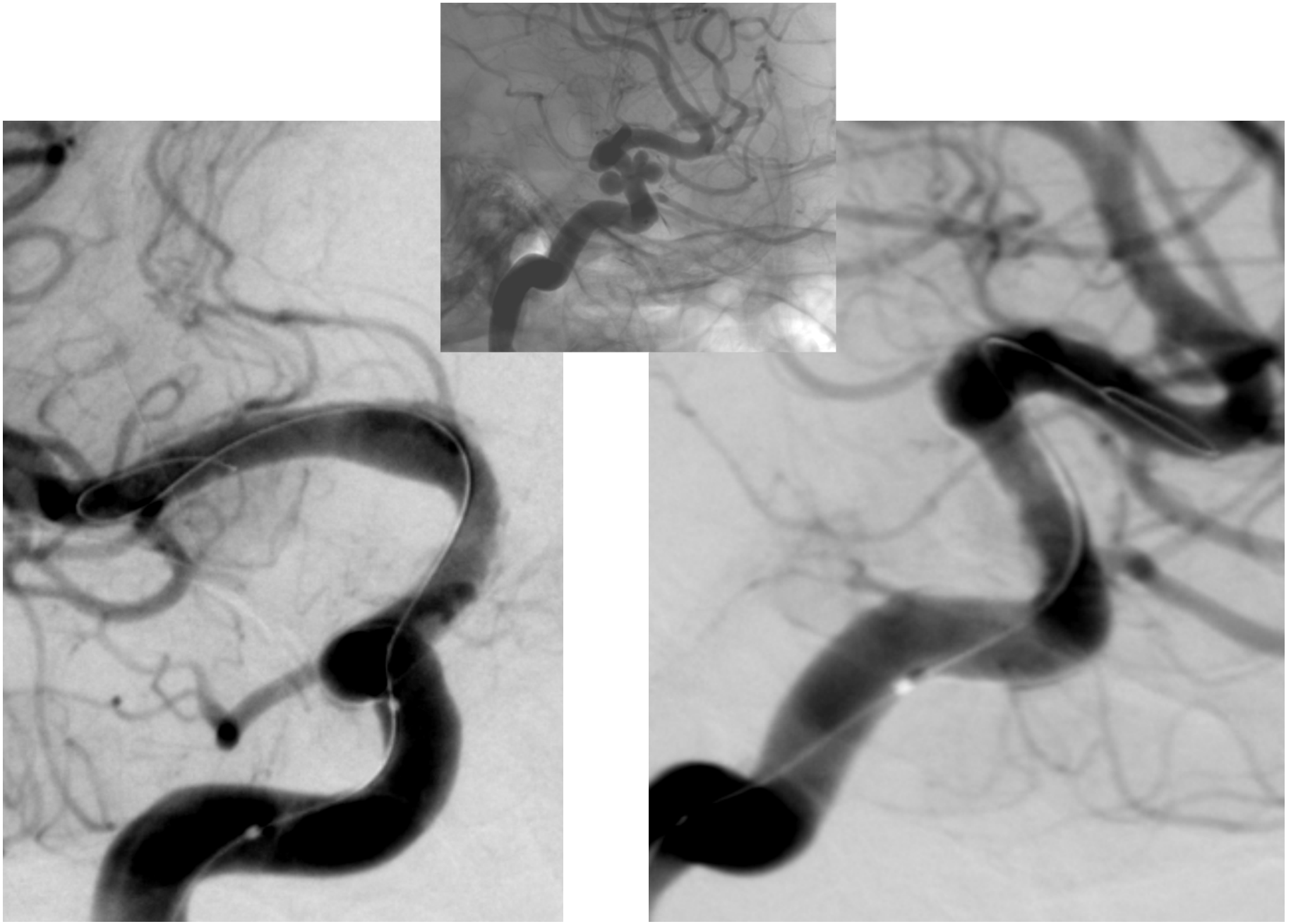

24 yo, Female, 5 Days Post Ictal Surpass™ 4x30mm

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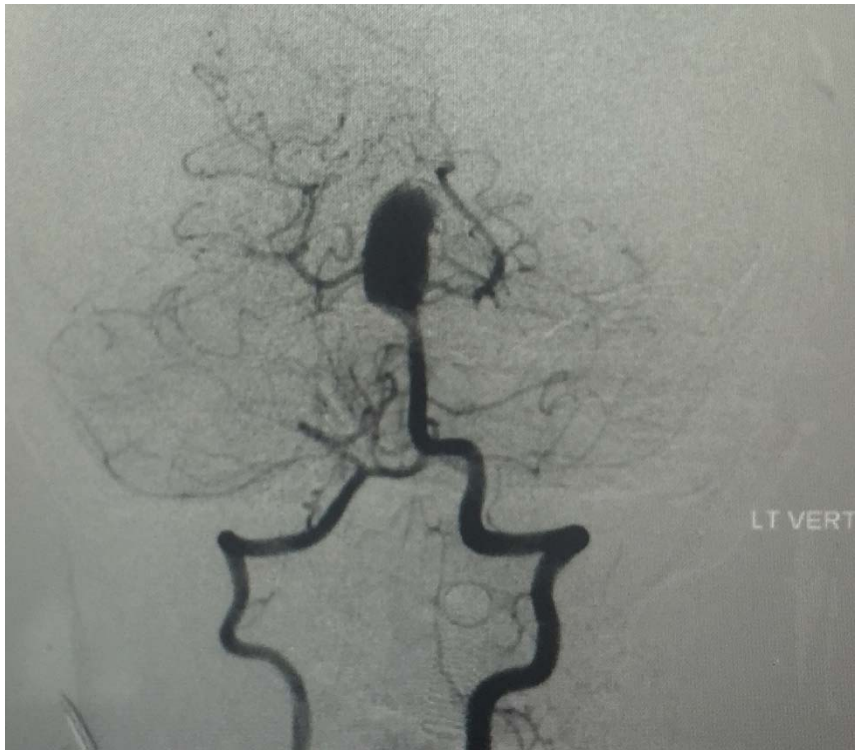
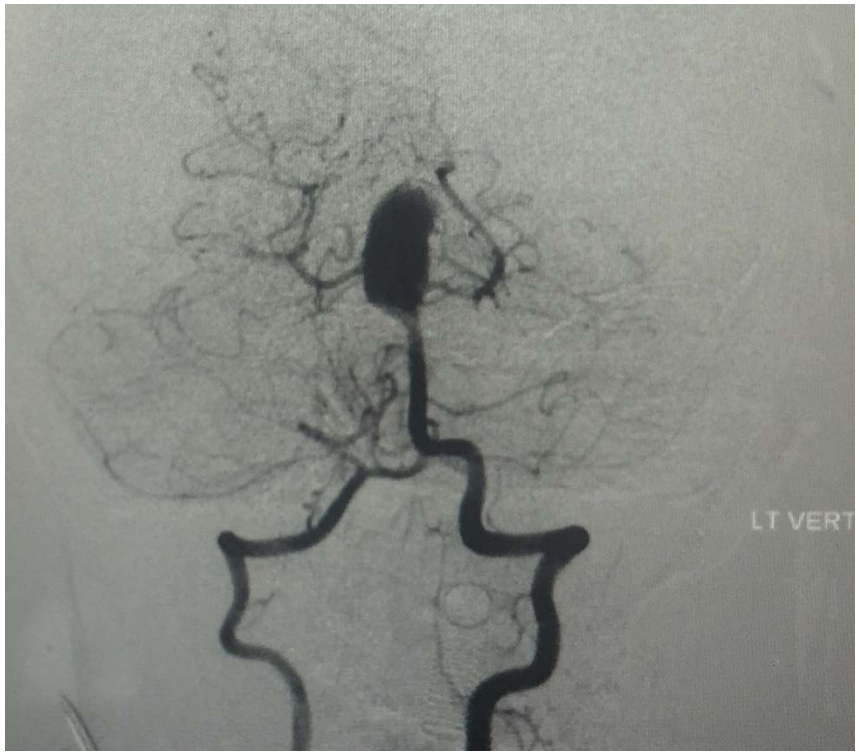


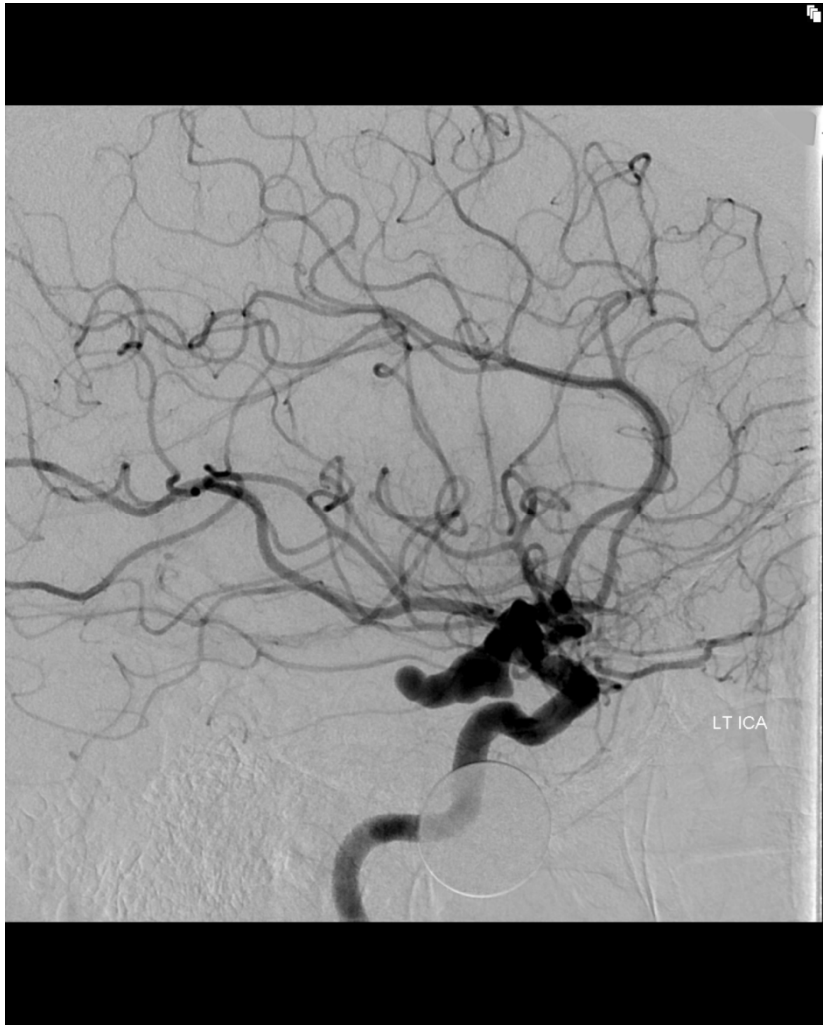
1 MONTH DSA Follow Up

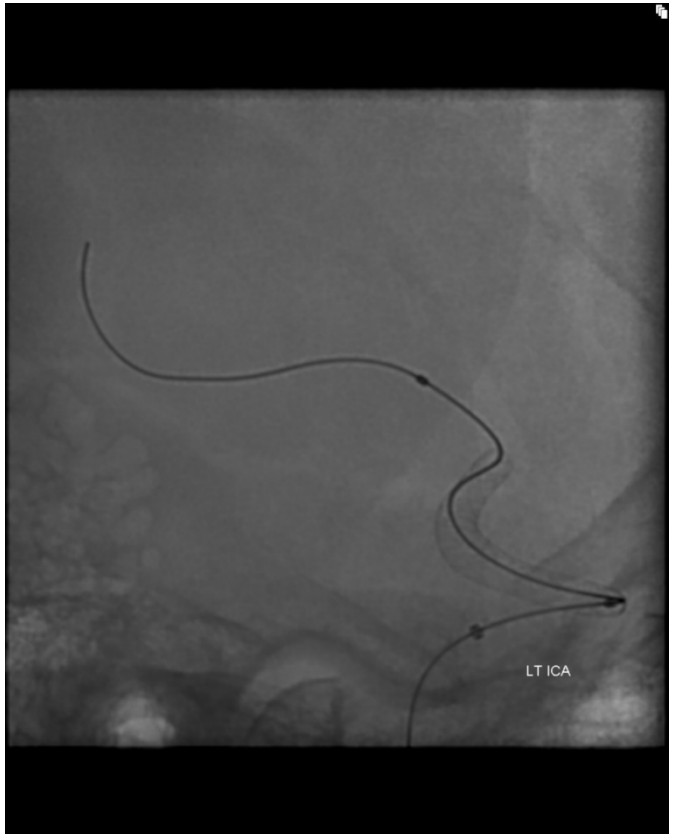
24 yo, Female, 5 Days Post Ictal Surpass™ 4x30mm



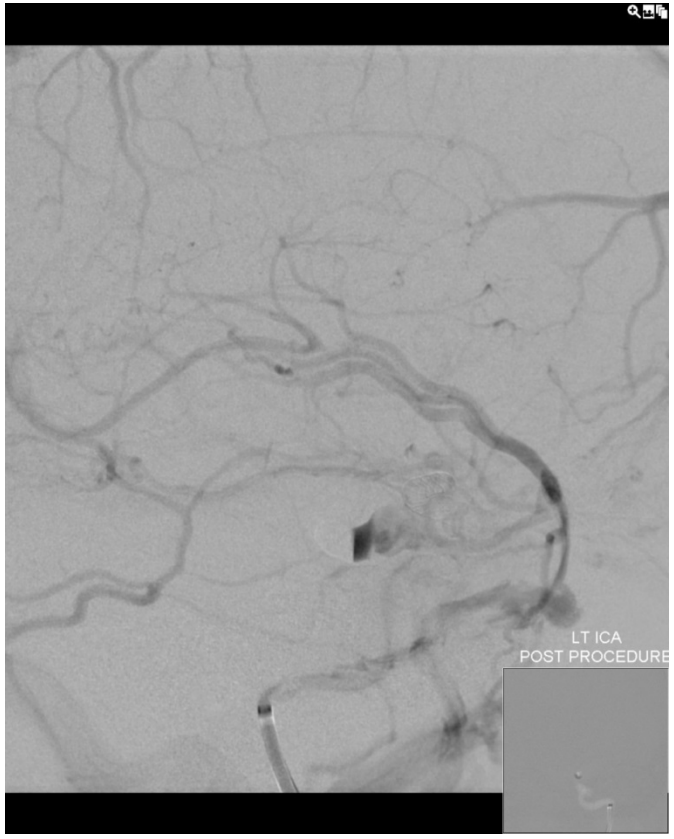
1 Year Follow Up

67 yo, female, acute SAH, Left Pcom: Surpass™ 4x25mm



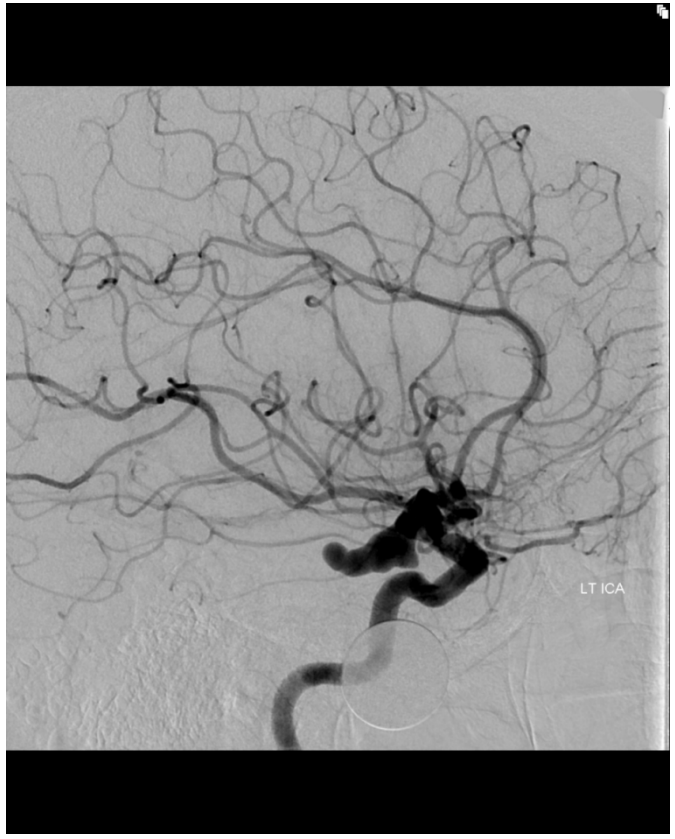


67 yo, female, acute SAH, Left Pcom: Surpass™ 4x25mm



67 yo, female, acute SAH, Left Pcom: Surpass™ 4x25mm

Pre-operative



7 months FU

INDICACIONES

- ANEURISMAS GRANDES O GIGANTES
- SINTOMAS COMPRESIVOS
- ANEURISMAS FUSIFORMES
- ANEURISMAS FOSA POSTERIOR
- RECURRENCIAS POST-COILING?
- ANEURISMAS INCIDENTALES? CUALQUIER TAMAÑO?
  - EN VASOS PROXIMALES
  - EN VASOS DISTALES
    - FUSIFORMES
    - LATERALES
    - DE BIFURCACION
- DISECCIONES? ANEURISMAS ROTOS?

CONCLUSIONES

- TRATAMIENTO SEGURO Y EFECTIVO EN ANEURISMAS NO ROTOS
- ALTAS TASAS DE OCLUSIÓN COMPLETA
- MORBIMORTALIDAD VARIABLE EN LA LITERATURA PERO ACEPTABLE EN EL CONTEXTO DEL TIPO DE ANEURISMAS DEL CUAL HABLAMOS
- ANEURISMAS DE CIRCULACIÓN POSTERIOR Y LOS PREVIAMENTE TRATADOS CON STENT PRESENTAN PEORES RESULTADOS
- PERMITE TRATAMIENTO DE ANEURISMAS PREVIAMENTE INTRATABLES
- EN EL FUTURO, UNA MEJOR COMPRENSIÓN DE SU FUNCIONAMIENTO, DE SUS COMPLICACIONES Y MEJORAS EN SU DISEÑO PERMITIRÁN AMPLIAR LAS INDICACIONES