ENDOVASCULAR NEUROSURGERY

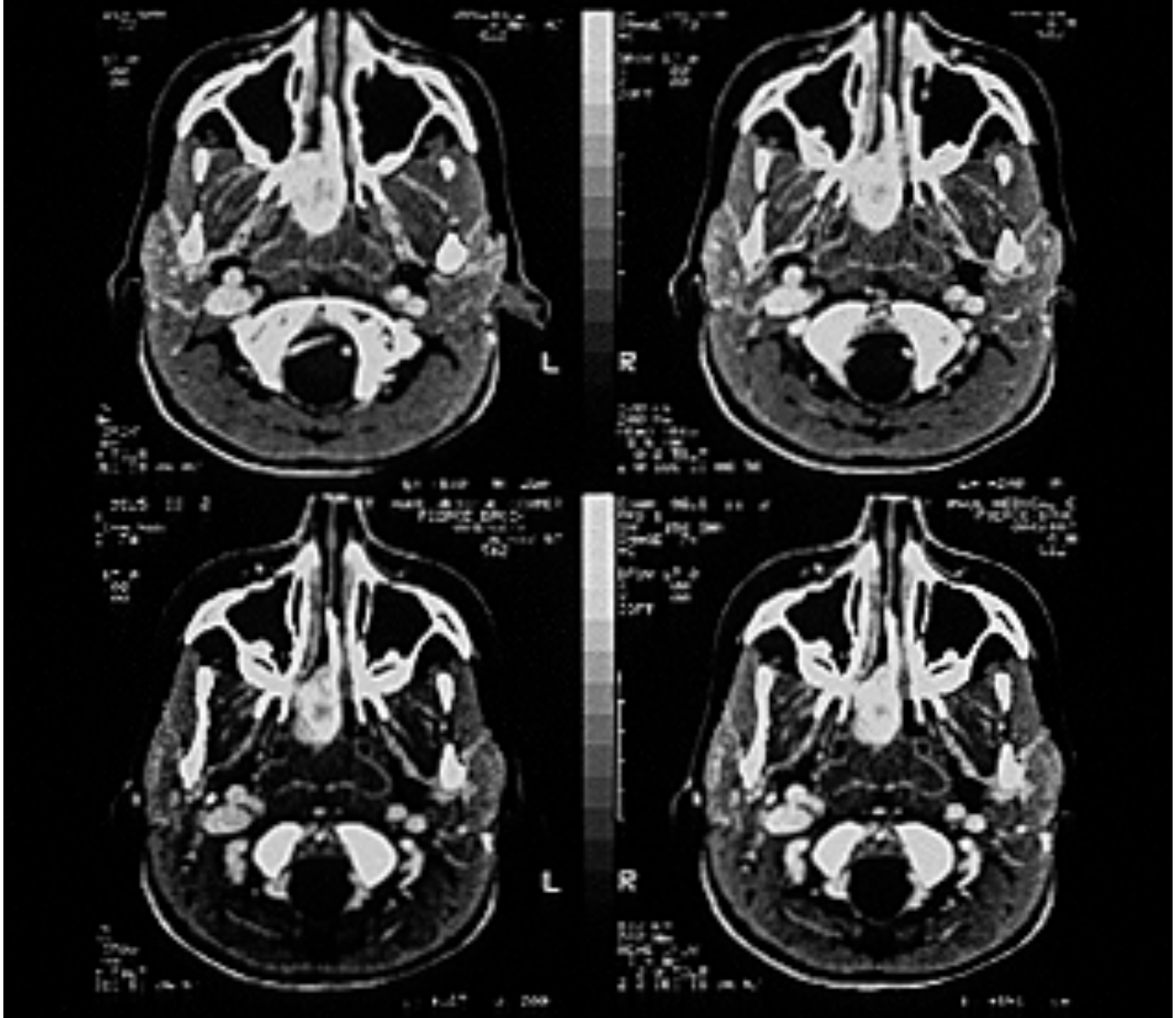
MICHAEL HOROWITZ, MD, FAANS, CAST

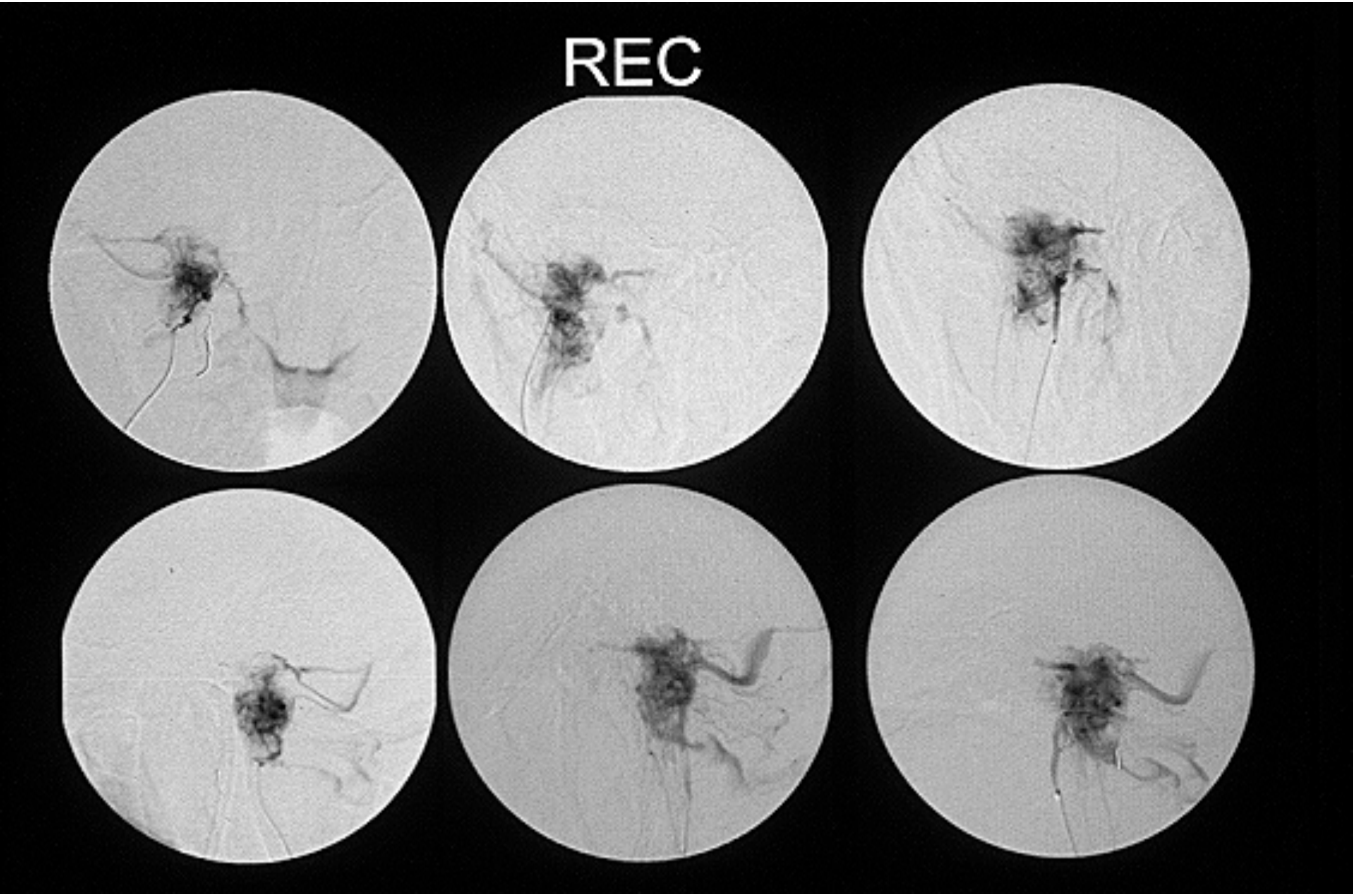
Procedures Performed

- Interventional Procedures
  - Balloon test occlusions
  - Vessel sacrifice and embolization
  - Tumor and AVM embolization-cranial and spine
  - Aneurysm embolization with and without stents
  - Extracranial angioplasty and stenting
  - Intracranial angioplasty and stenting
  - Sclerotherapy
  - Wada testing
  - Petrosal sinus sampling
  - Thrombolysis (arterial and venous)
  - CBF augmentation (Neuroflo)

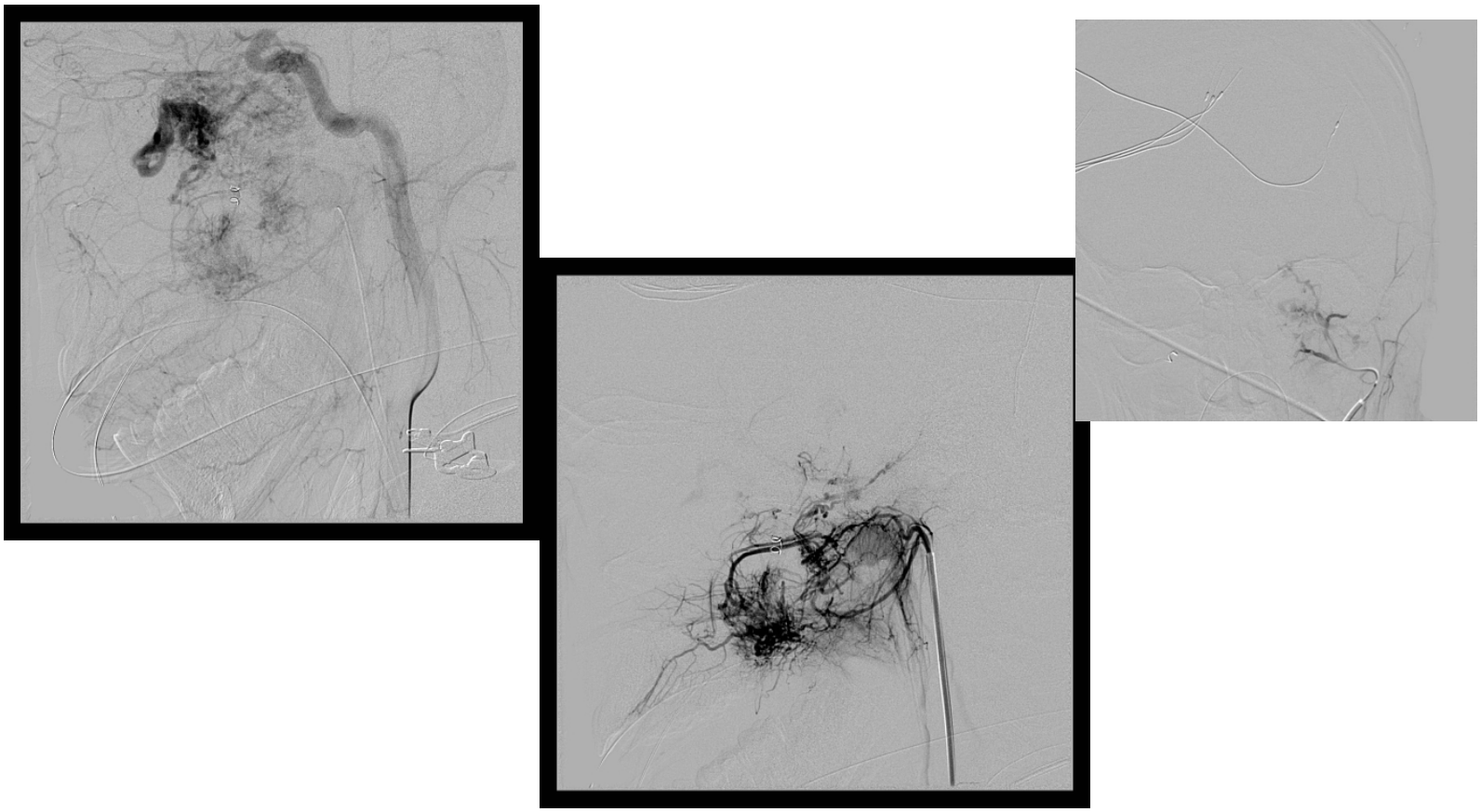
TUMOR EMBOLIZATION (VIDEO)

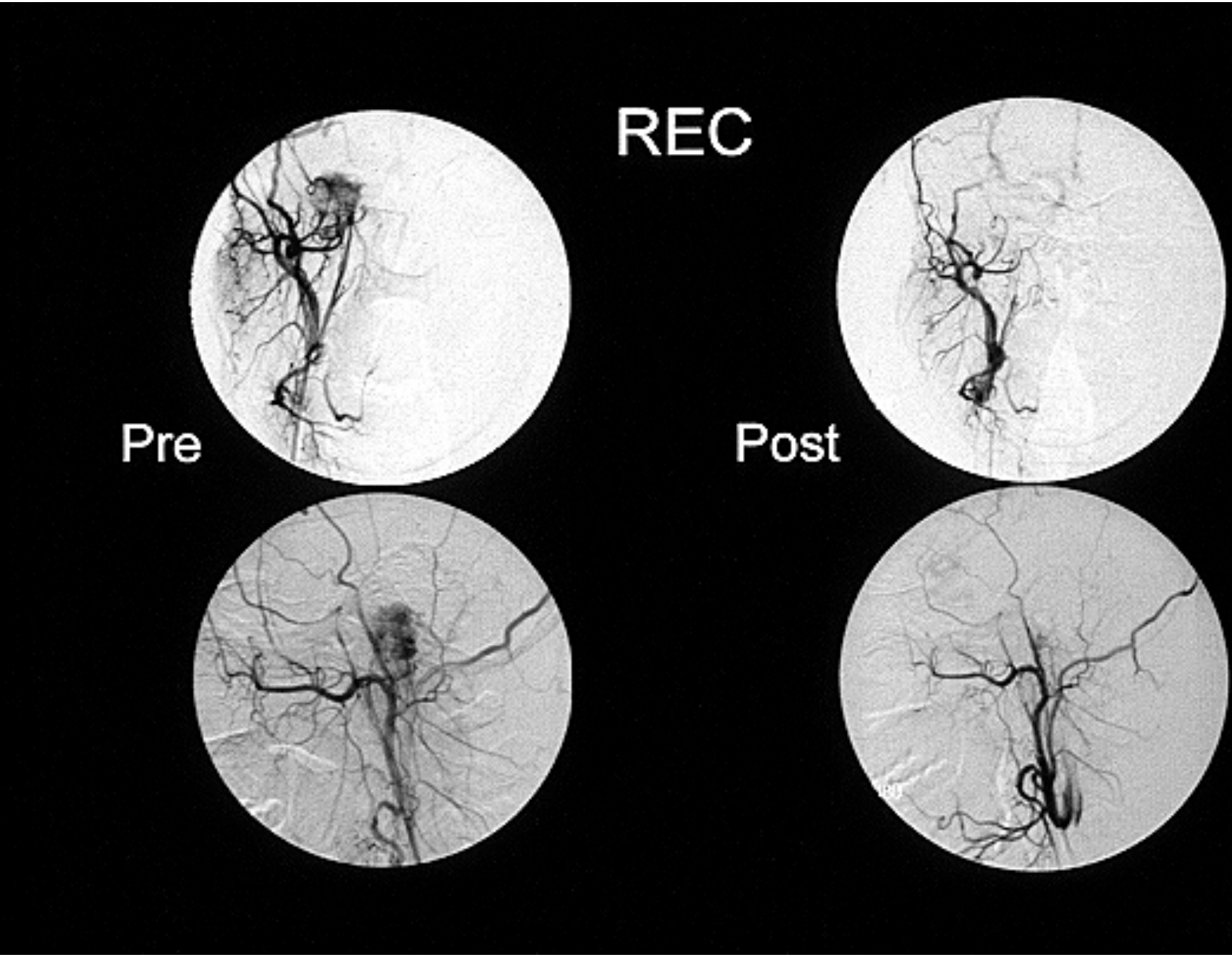
Tumor Embolization



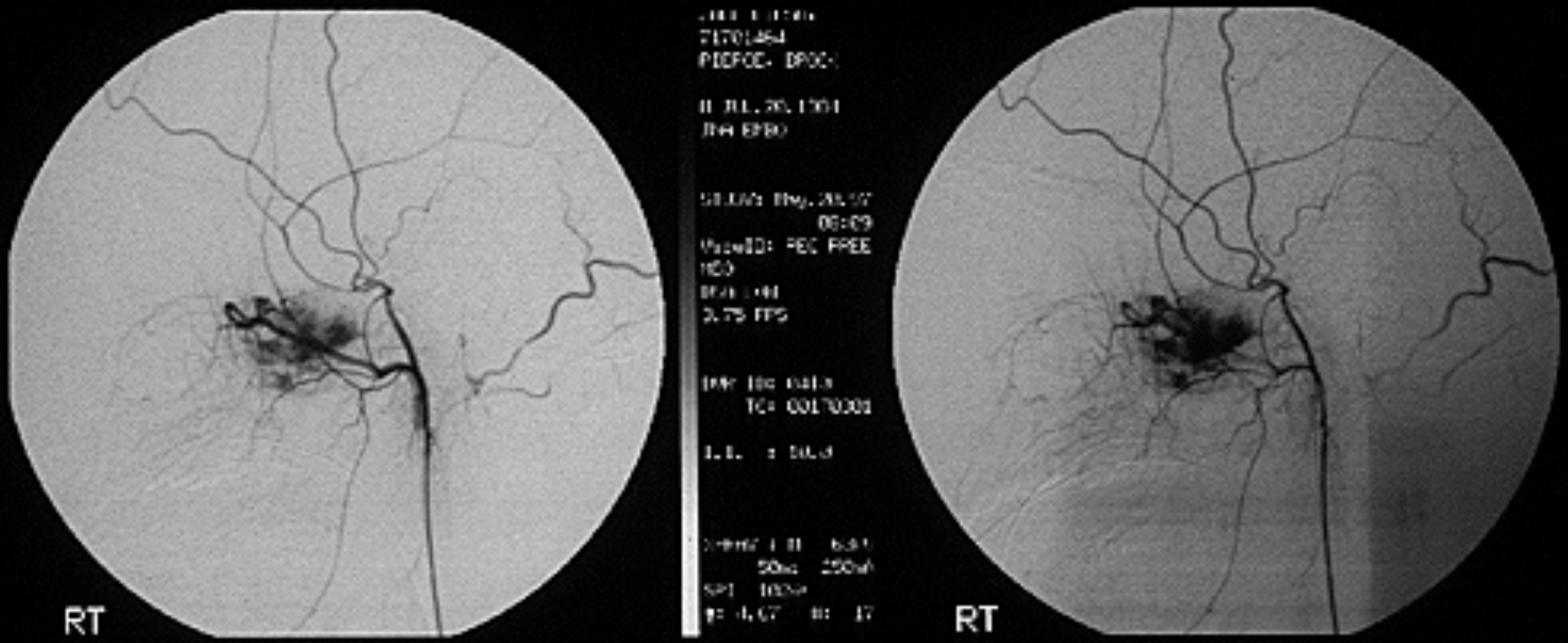

REC

JNA Tumor

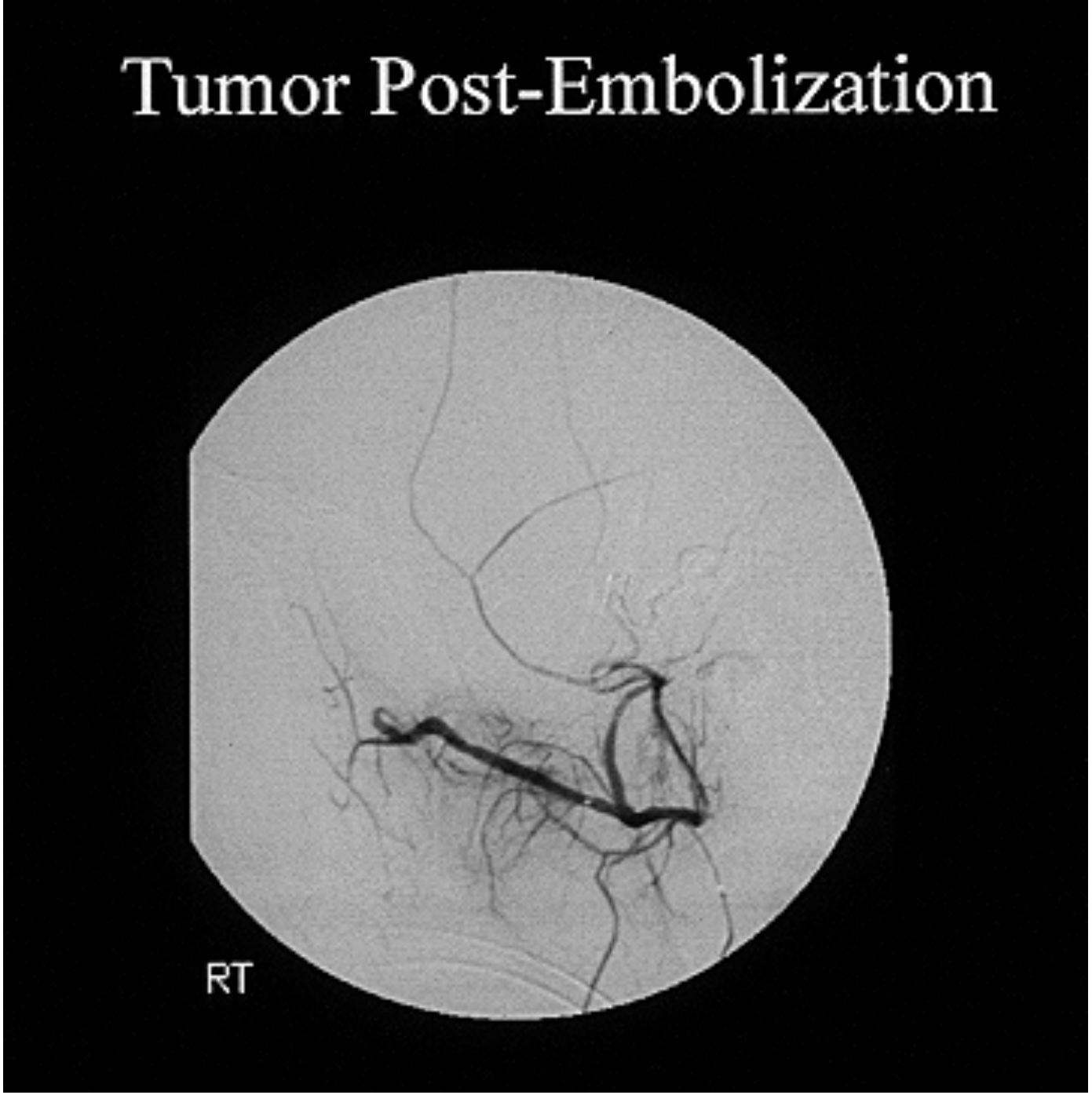



REC
Pre
Post

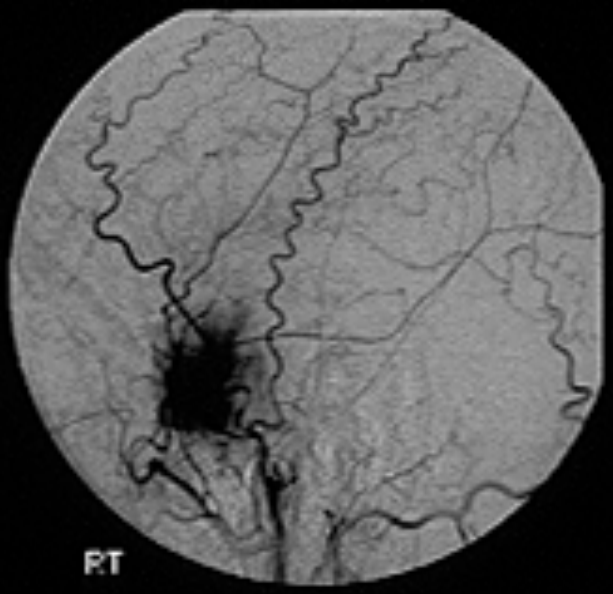
Tumor Blush Pre-Embolization

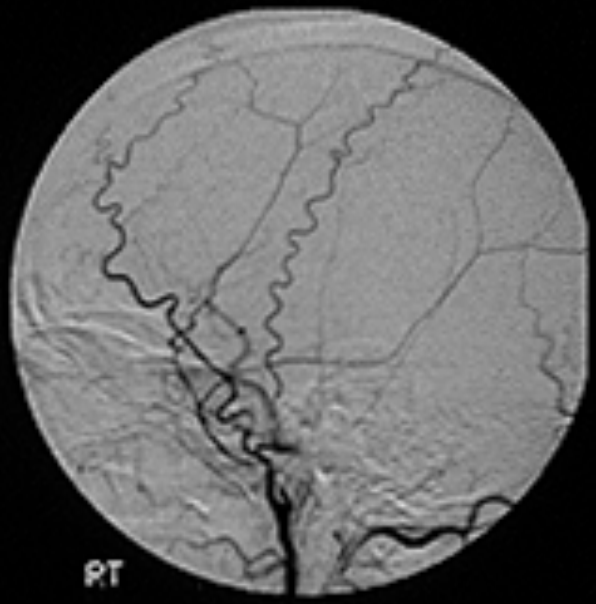


Tumor Post-Embolization



Meningioma Embolization





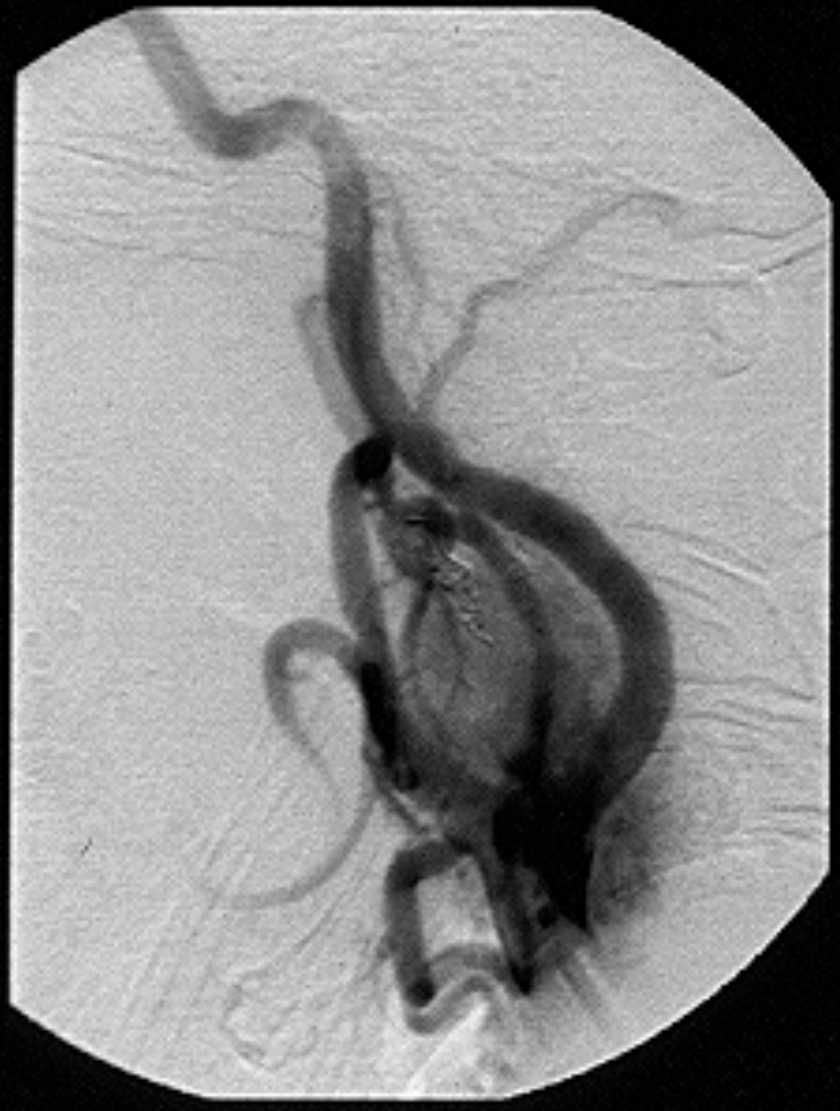
Tumor Embolization-Glomus

Pre Embo

Post Embo

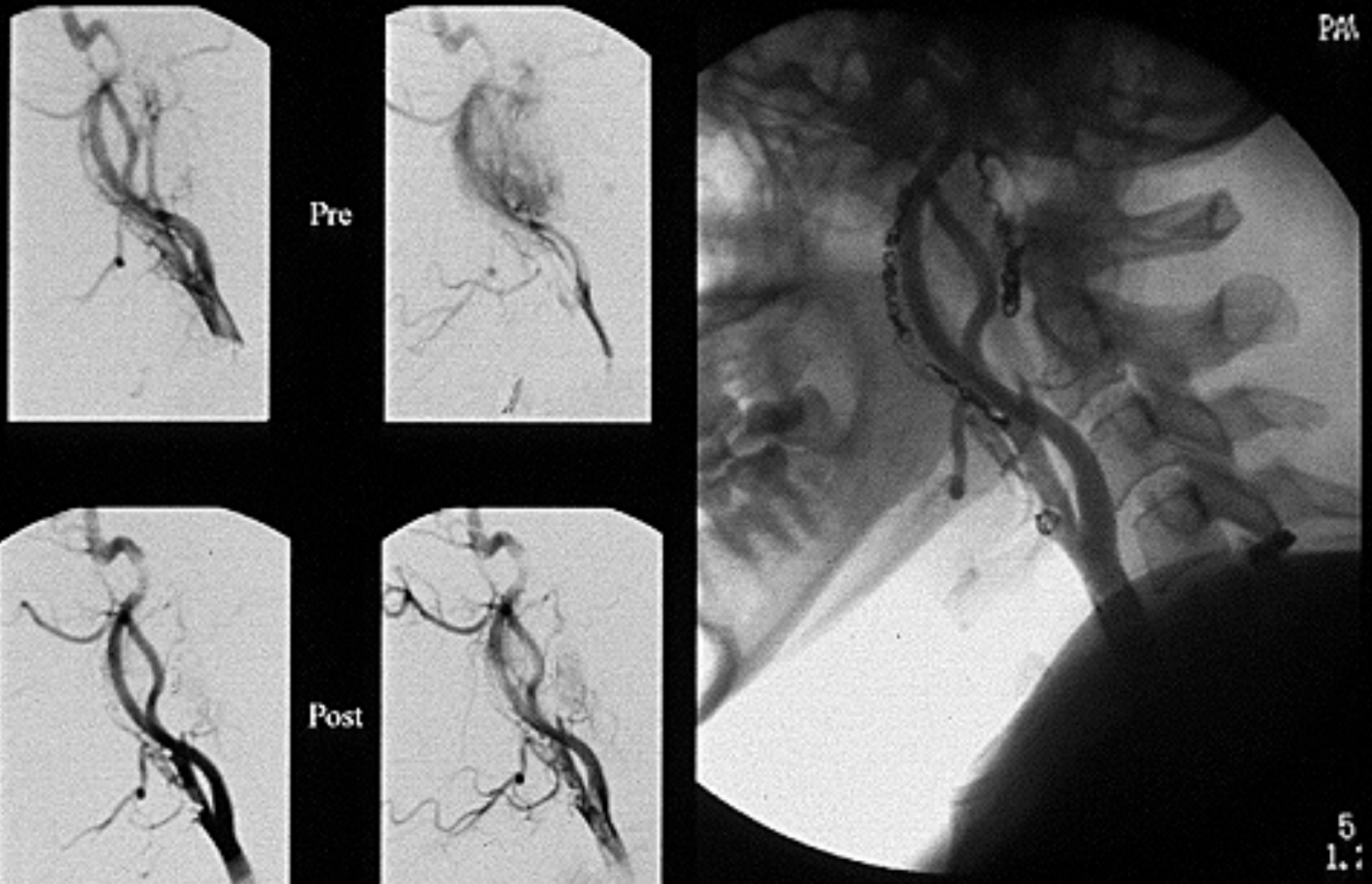
Tumor Embolization-Glomus

Pre Embo

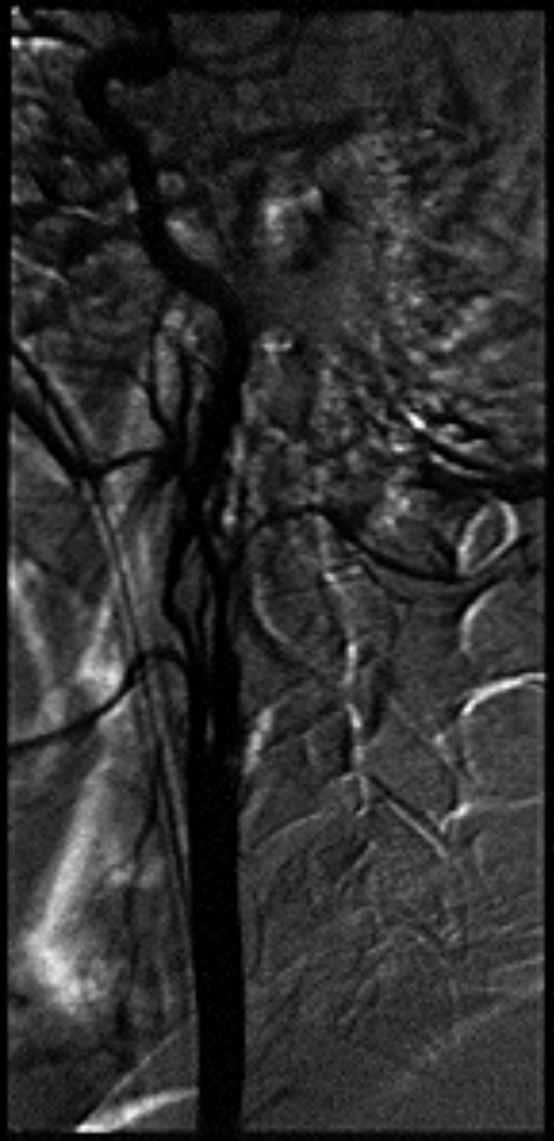


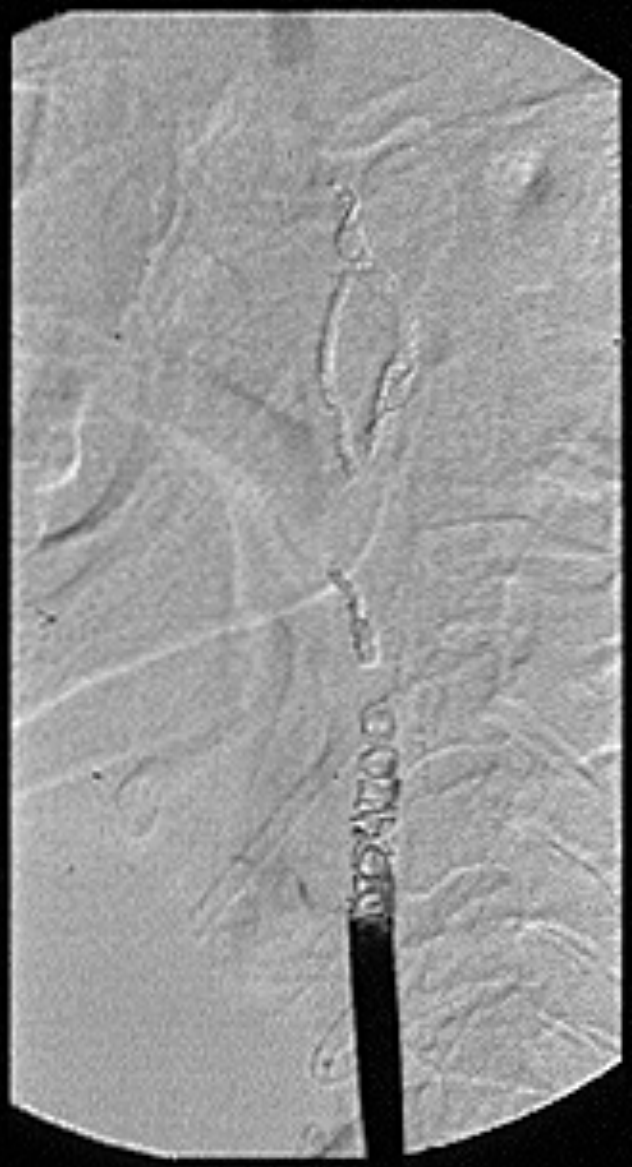
Post Embo

Glomus Vagale Embo



Tumor encased vessels- carotid sacrifice post TBO



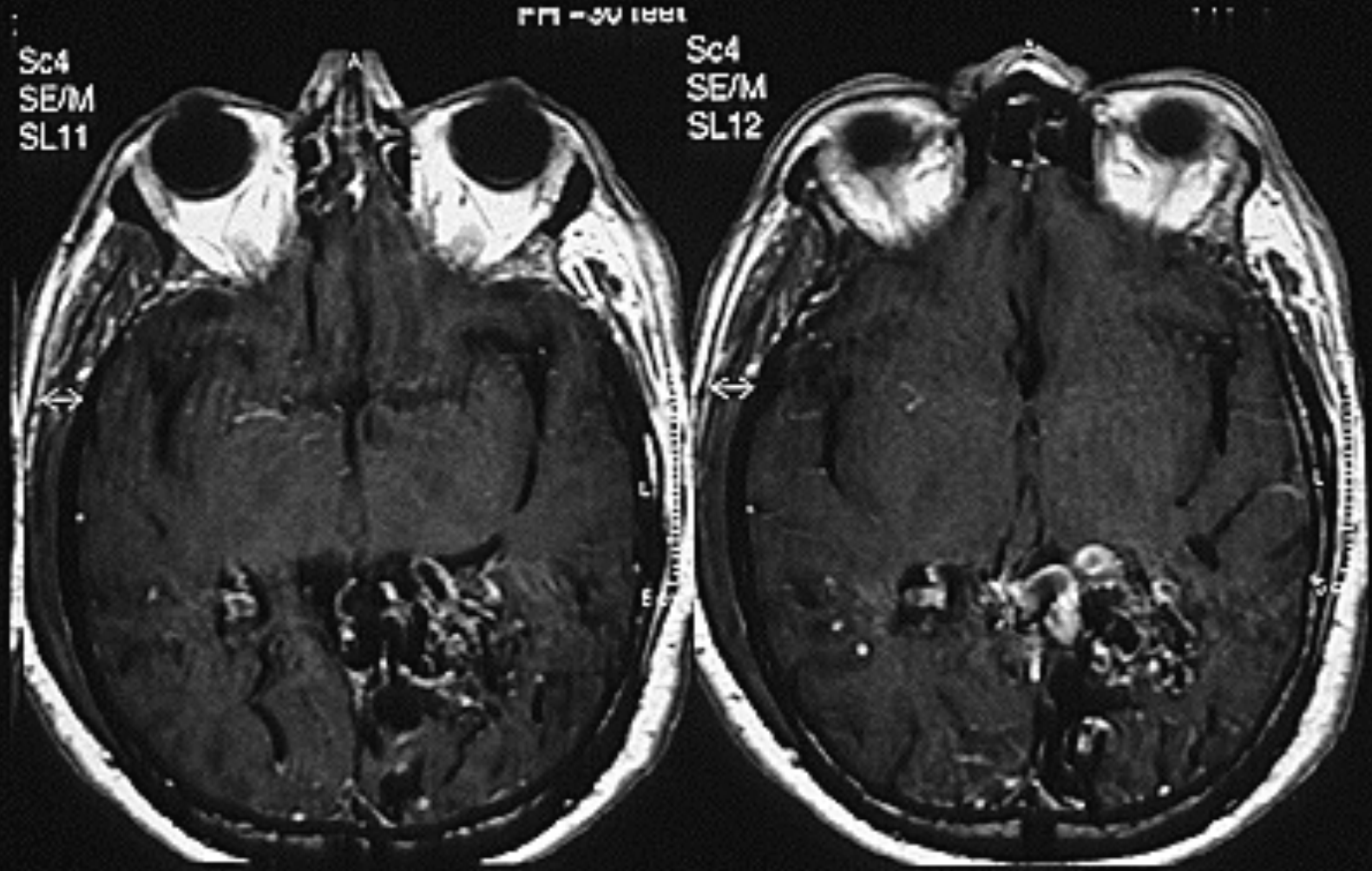


INFERIOR PETROSAL SINUS AMPLING FOR CUSHING'S DISEASE (VIDEO)

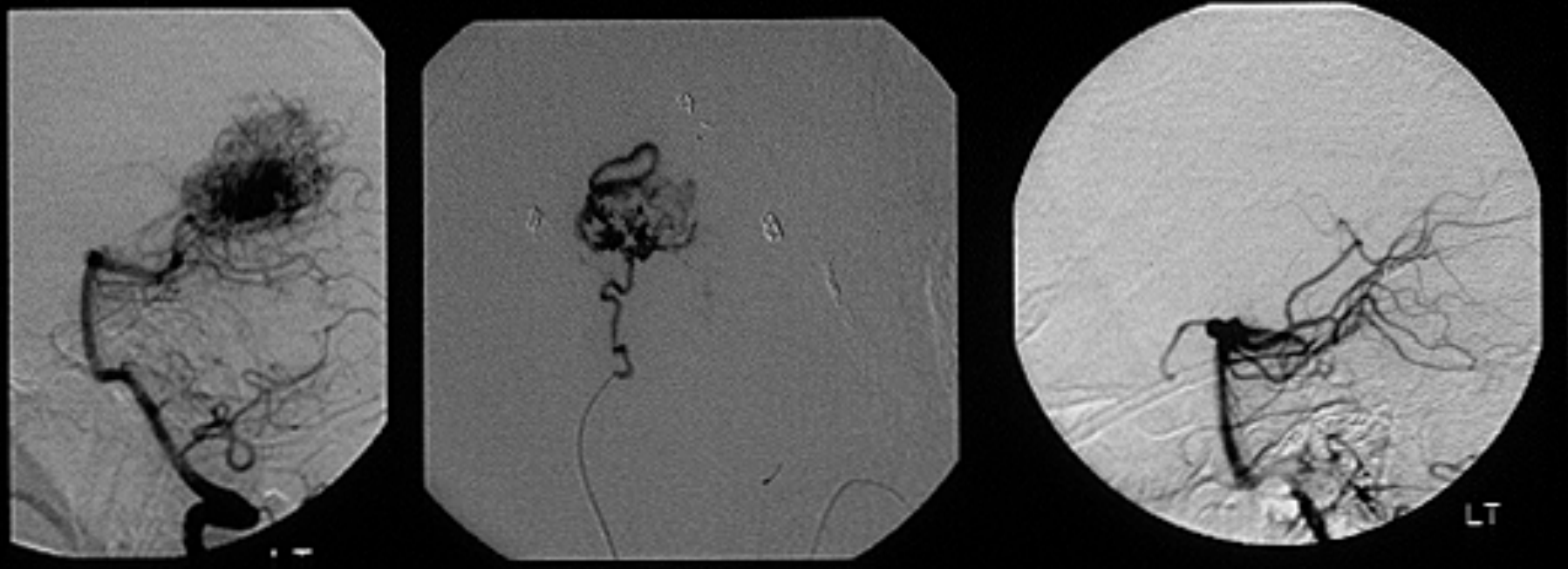
Embolization For Epistaxis

ARTERIOVENOUS MALFORMATION EMBOLIZATION (VIDEO)

AVM Pre-Operative Embolization



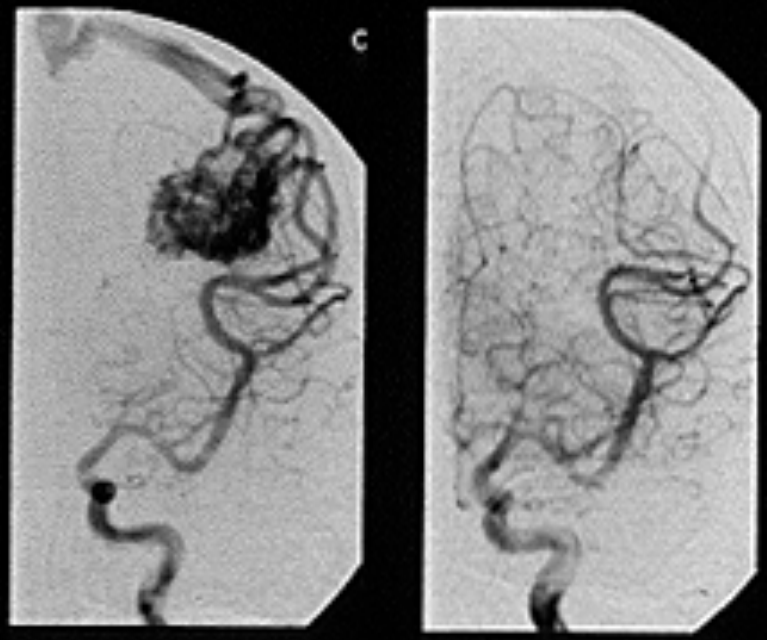
AVM Pre-Operative Embolization



AVM Embo-PVA/Coils

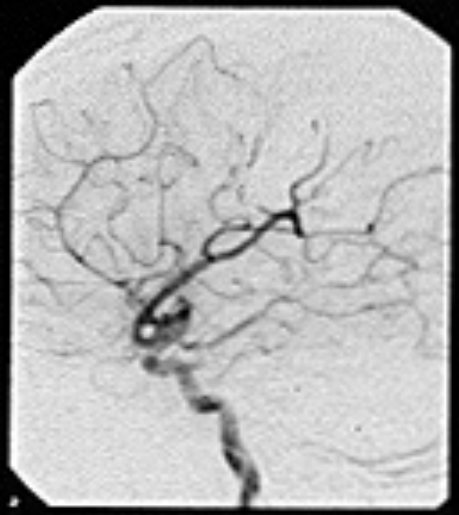
Pre

Post



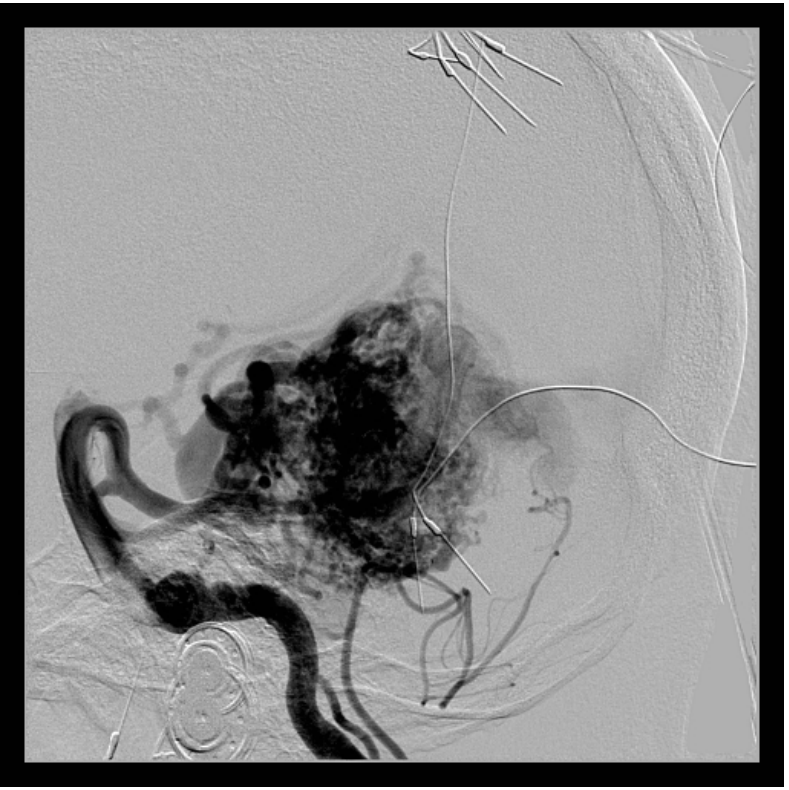
Pre

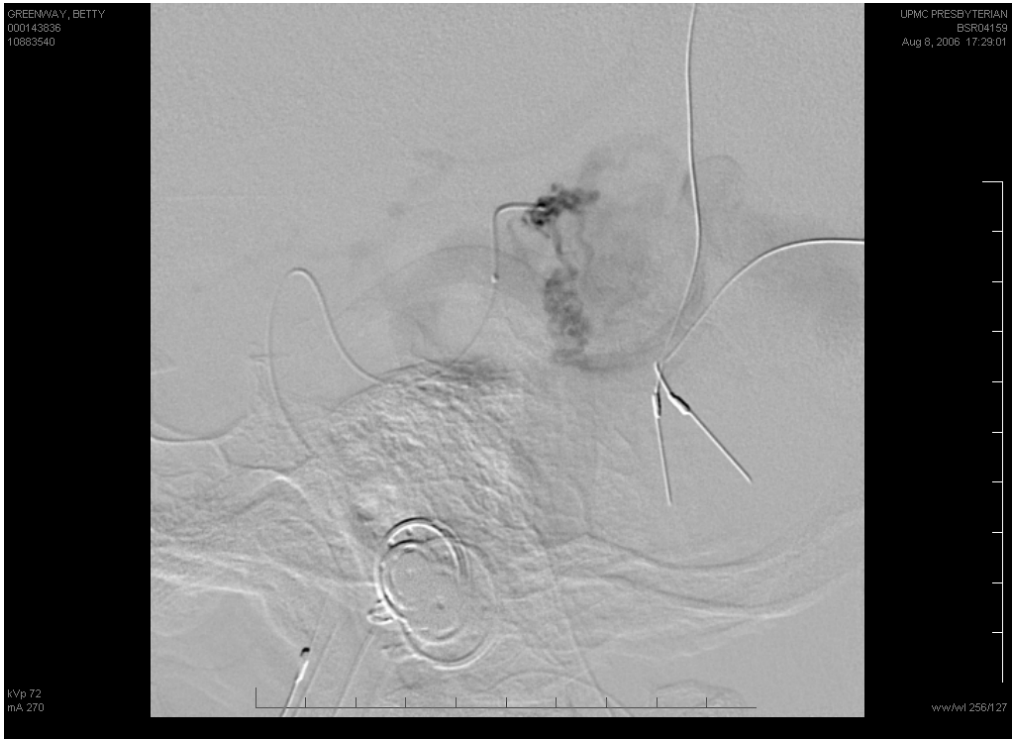
Post



AVM EMBOLIZATION

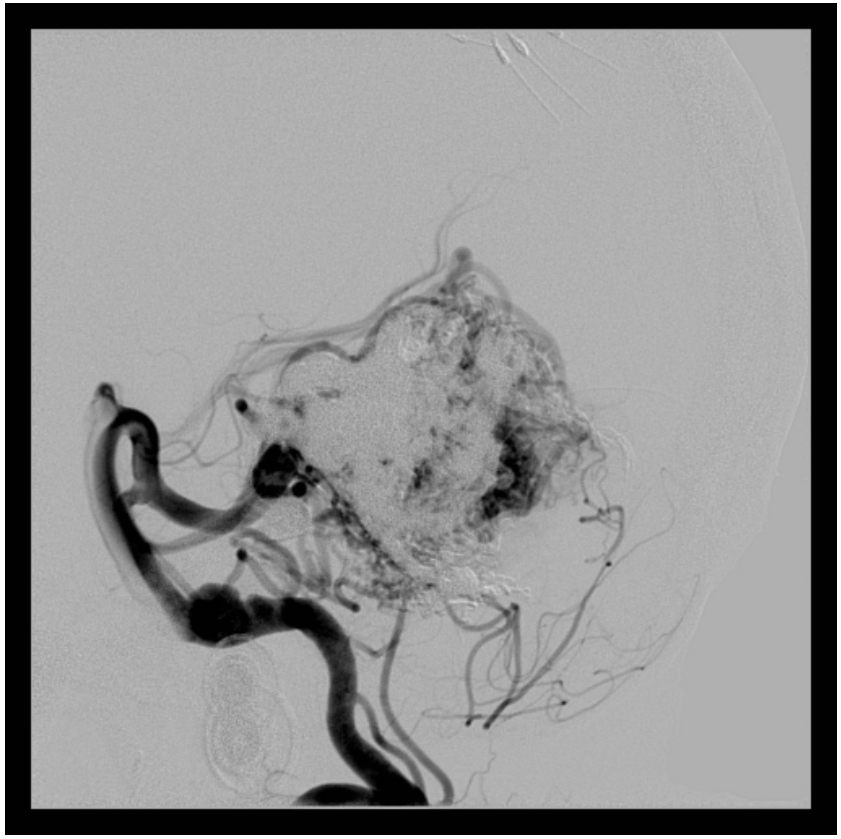
- Onyx 18 AVM Embolization

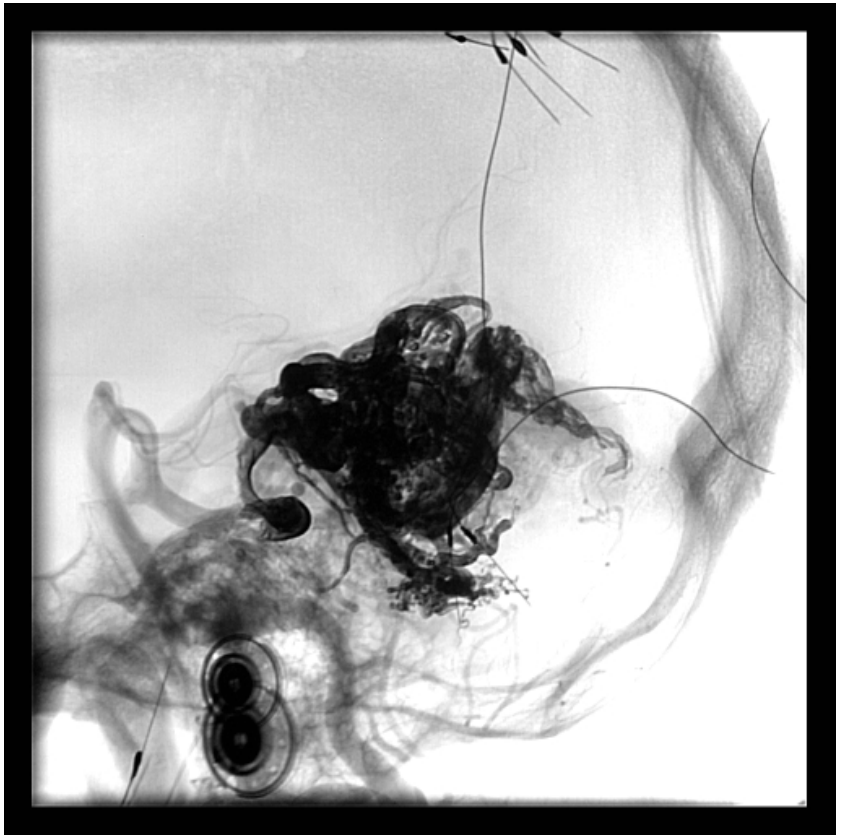




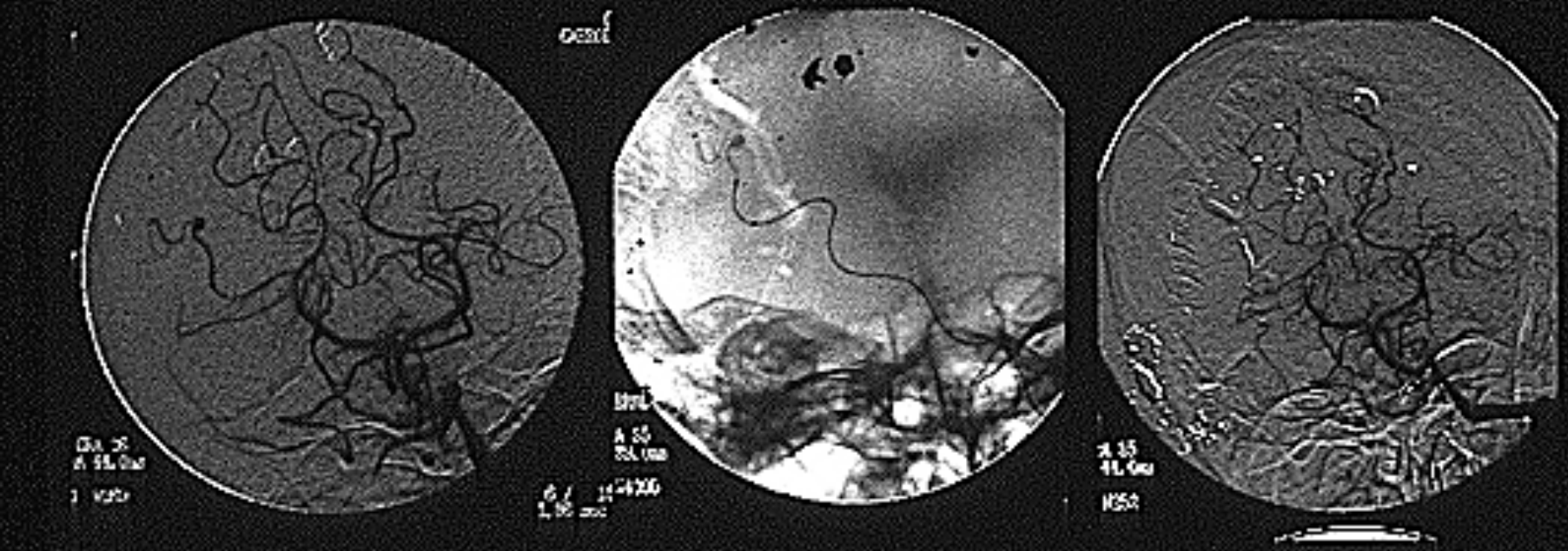
AVM EMBOLIZATION

- Onyx 18 AVM Embolization



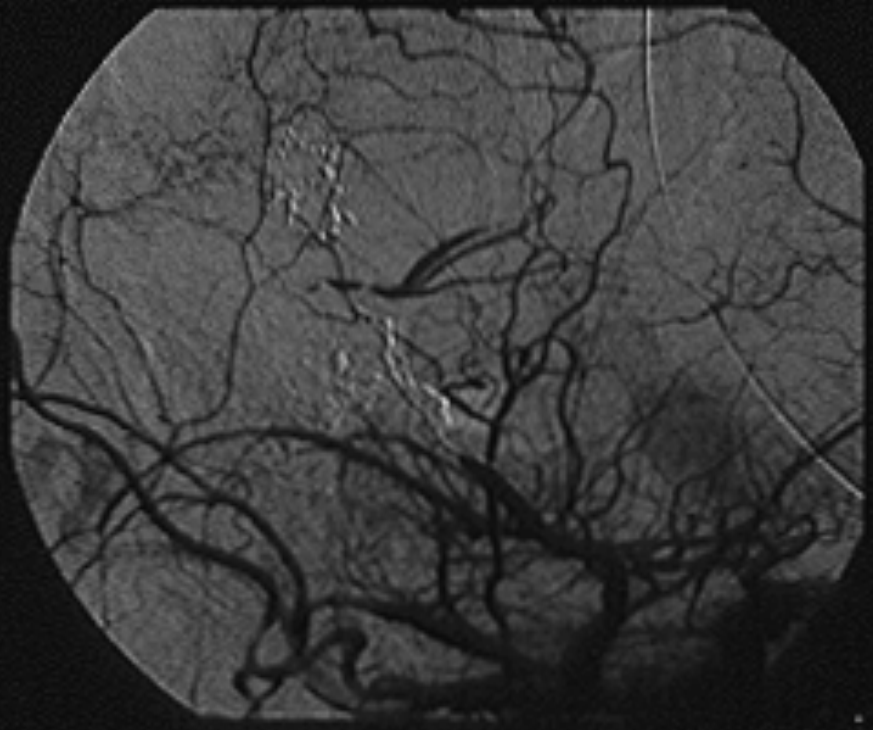


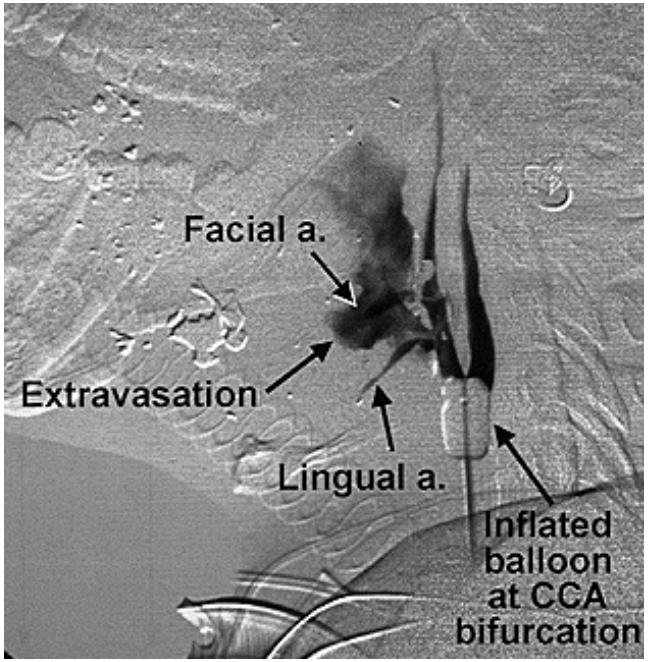
Distal PCA Sacrifice for Traumatic Aneurysm

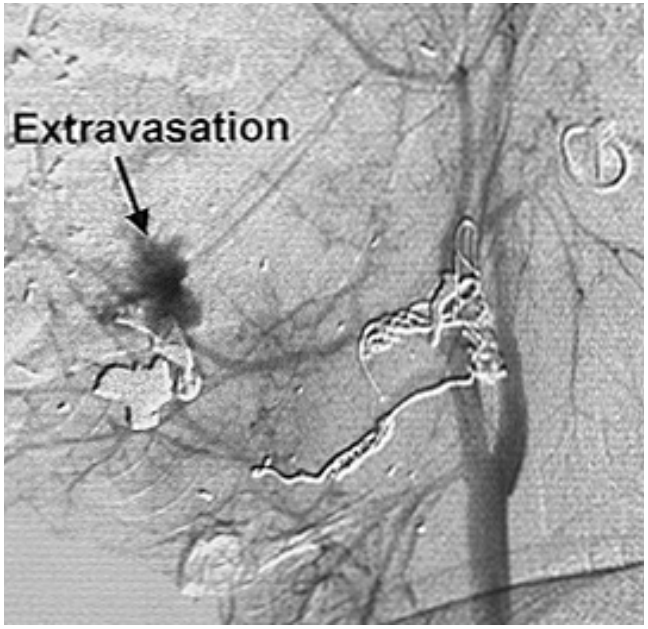


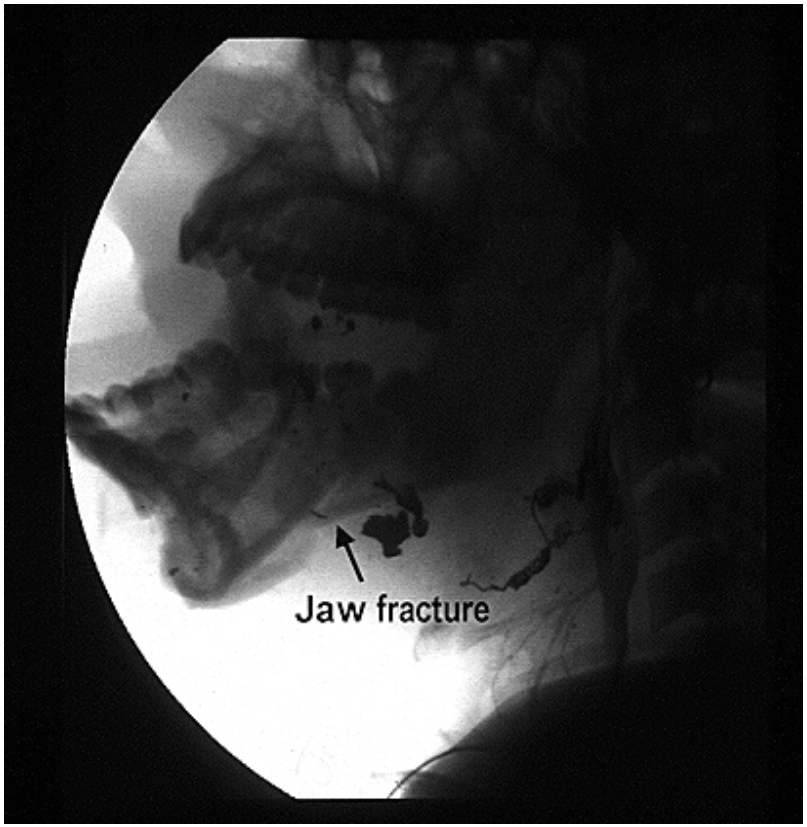
Embolization Facial A-V Fistula Post GSW

Embolization Facial A-V Fistula Post GSW

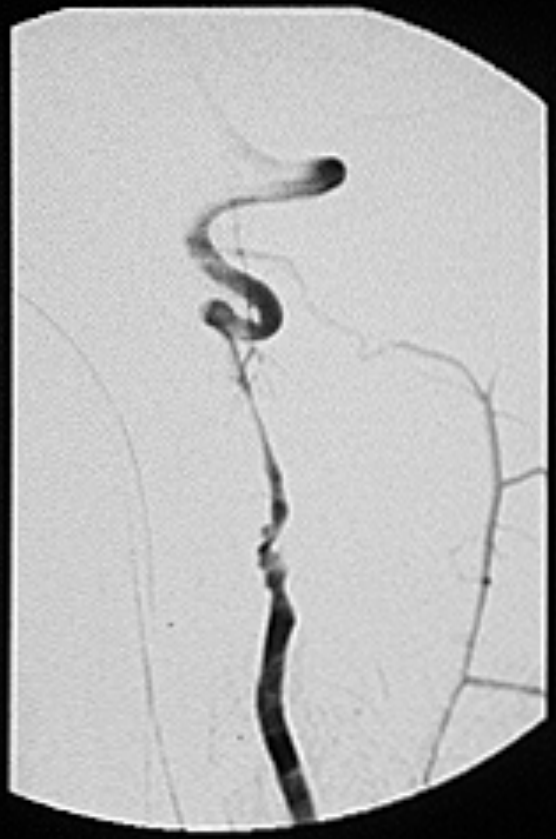


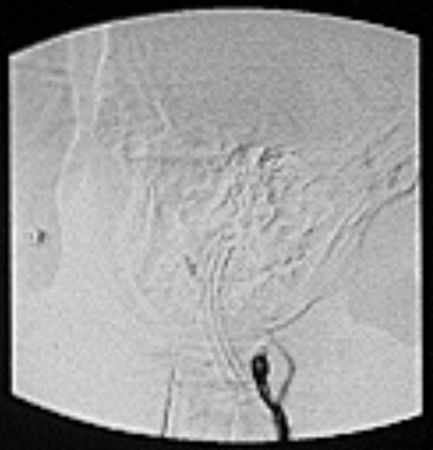

Facial a.
Extravasation
Lingual a.
Inflated balloon at CCA bifurcation

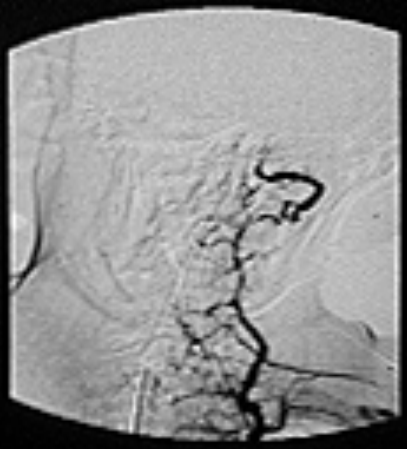

Extravasation


Jaw fracture

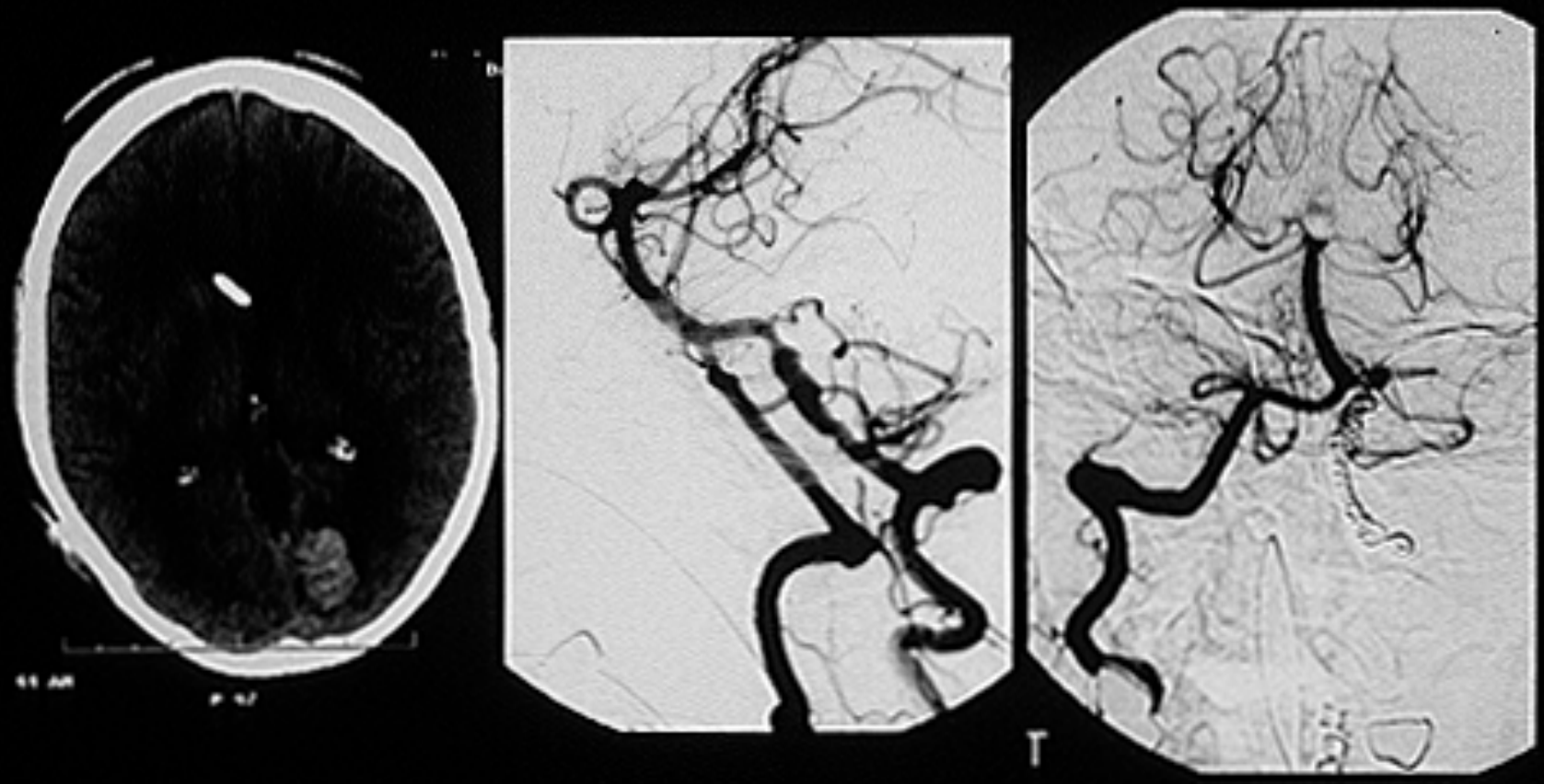
Vertebral Artery Sacrifice





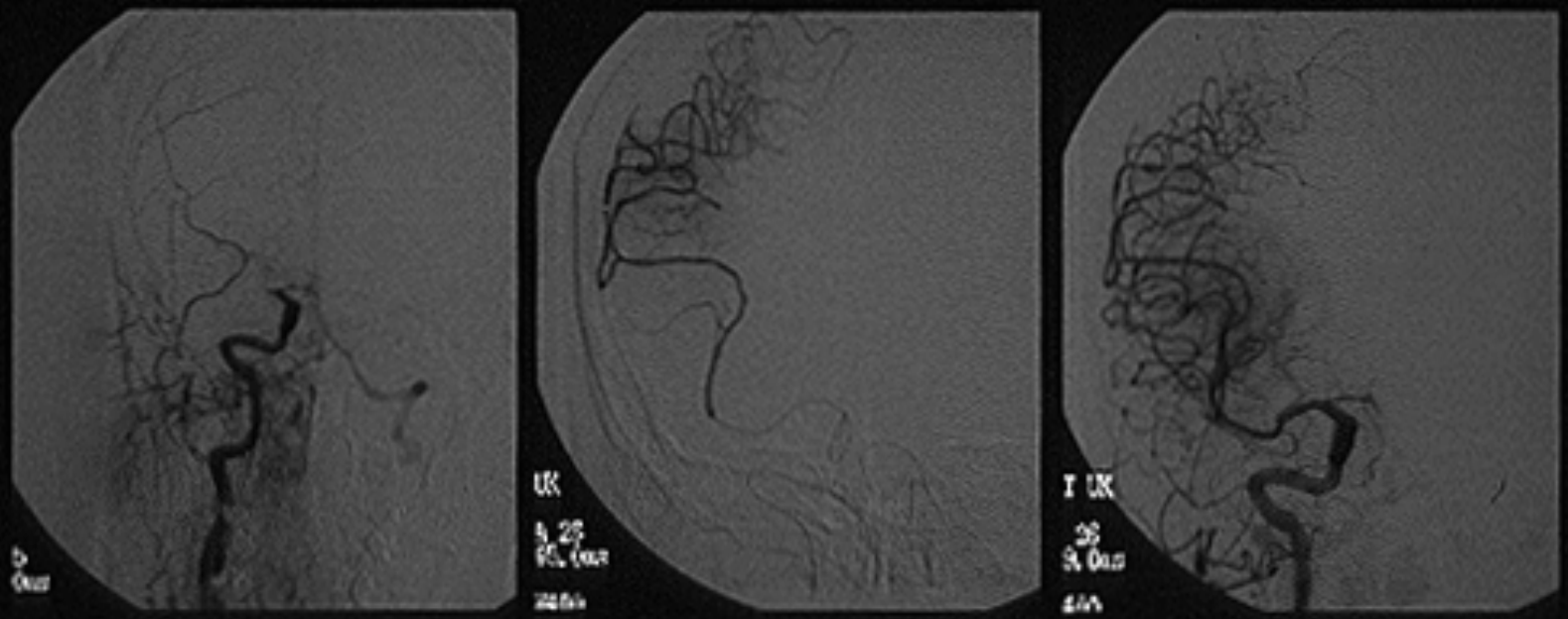


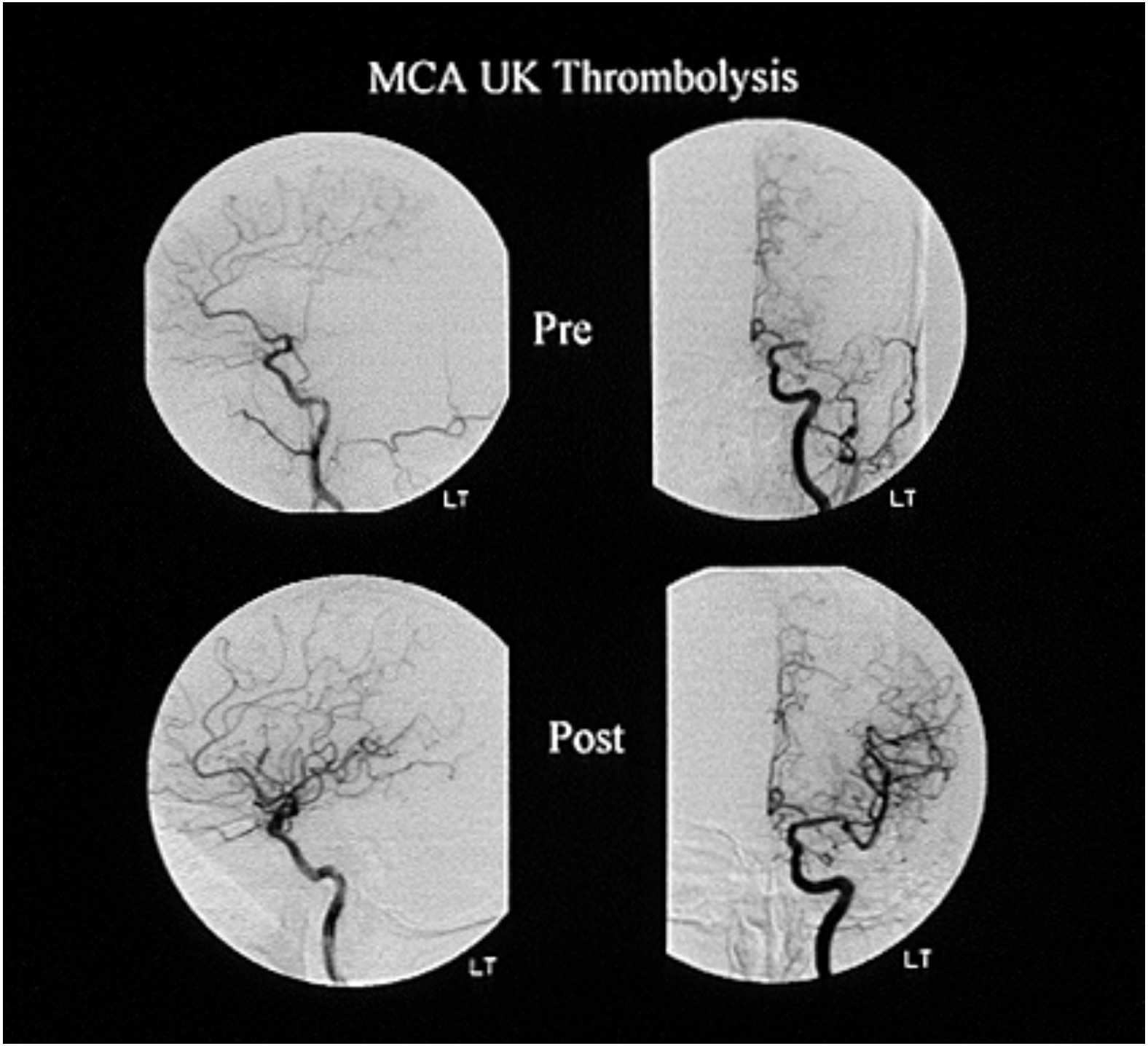
Vertebral Sacrifice For Dissection



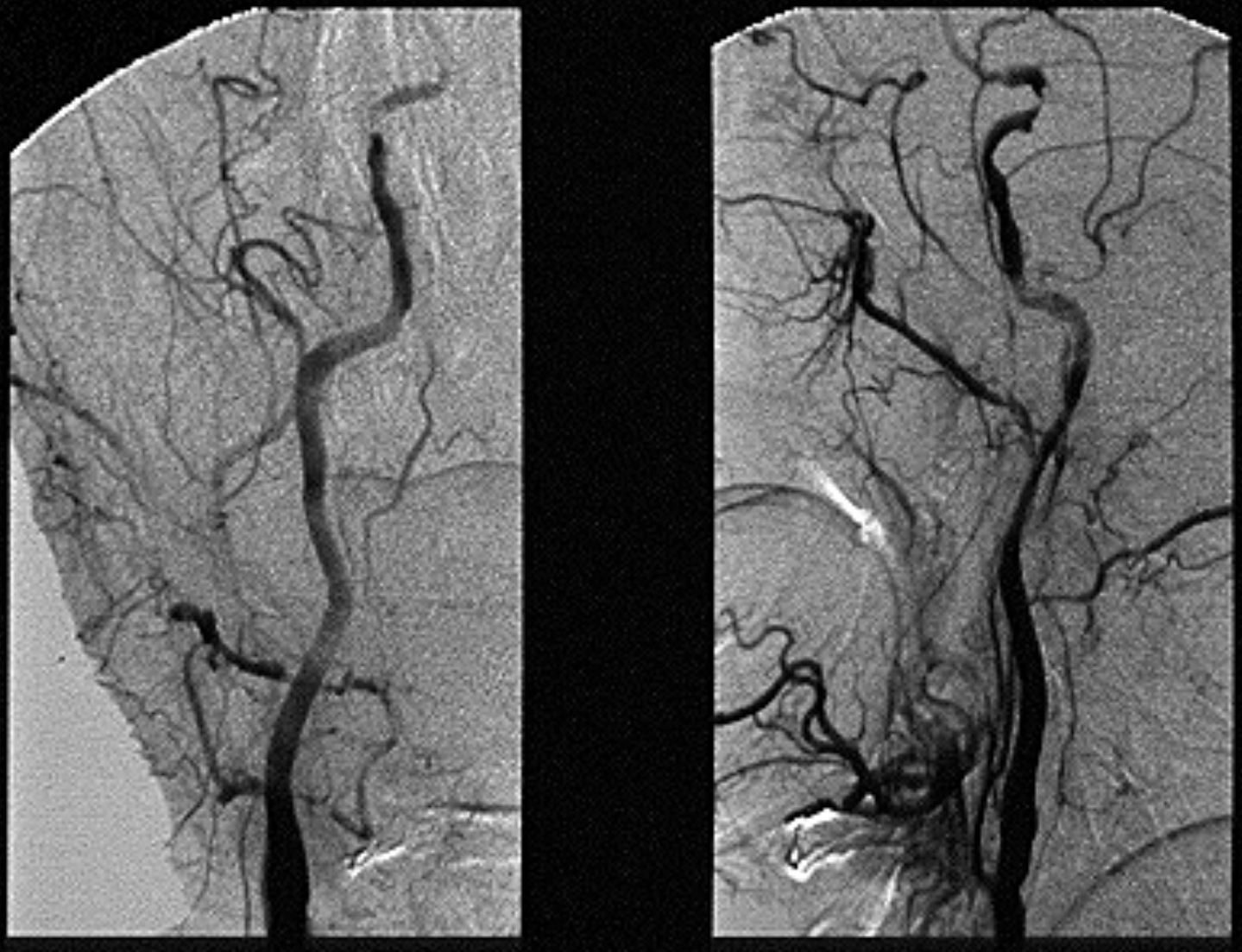
STROKE THROMBECTOMY (VIDEO)

MCA Embolus UK-Thrombolysis




MCA UK Thrombolysis
Pre
Post
LT
LT
LT
LT

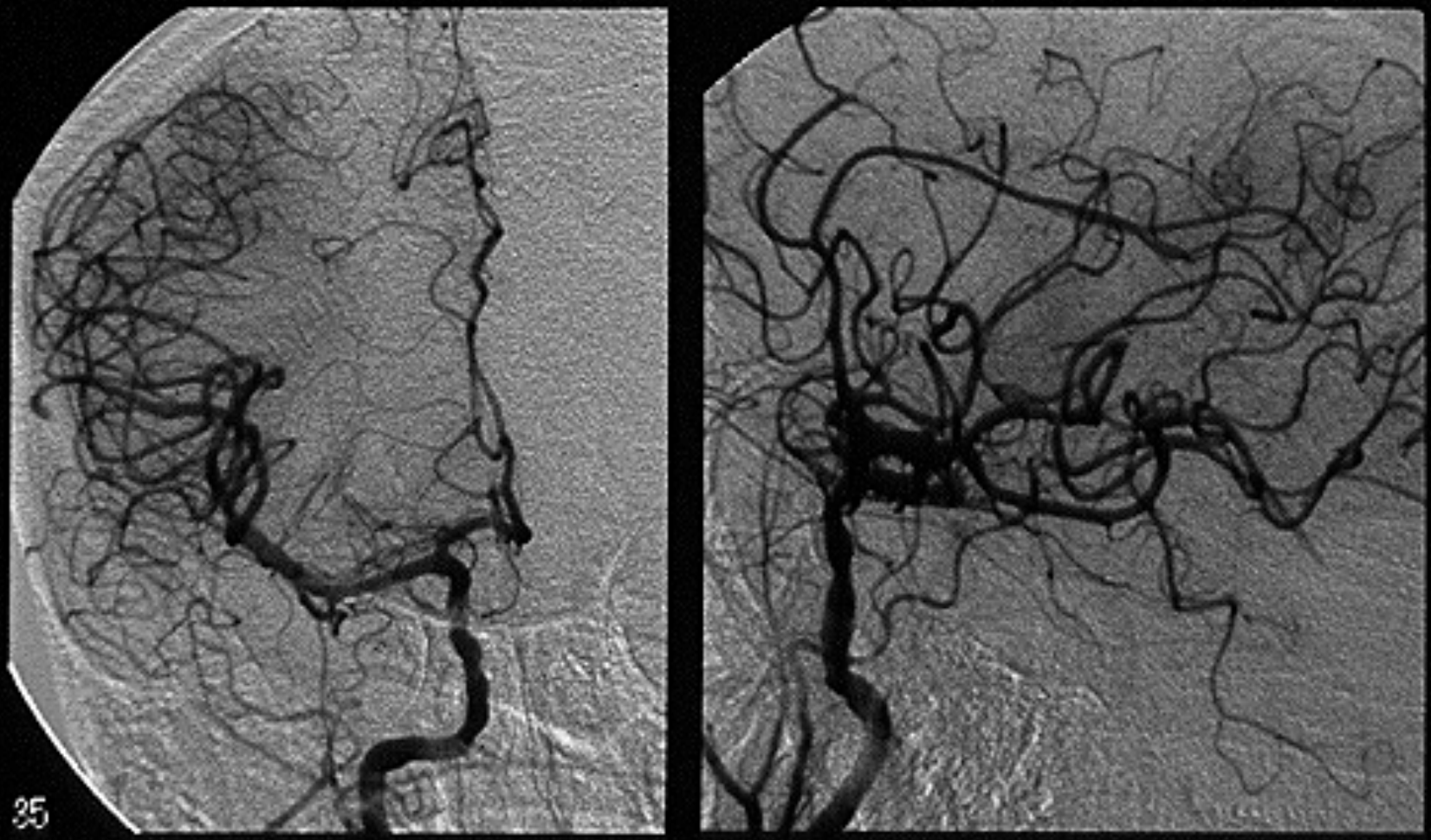
Cardiogenic ICA Embolus



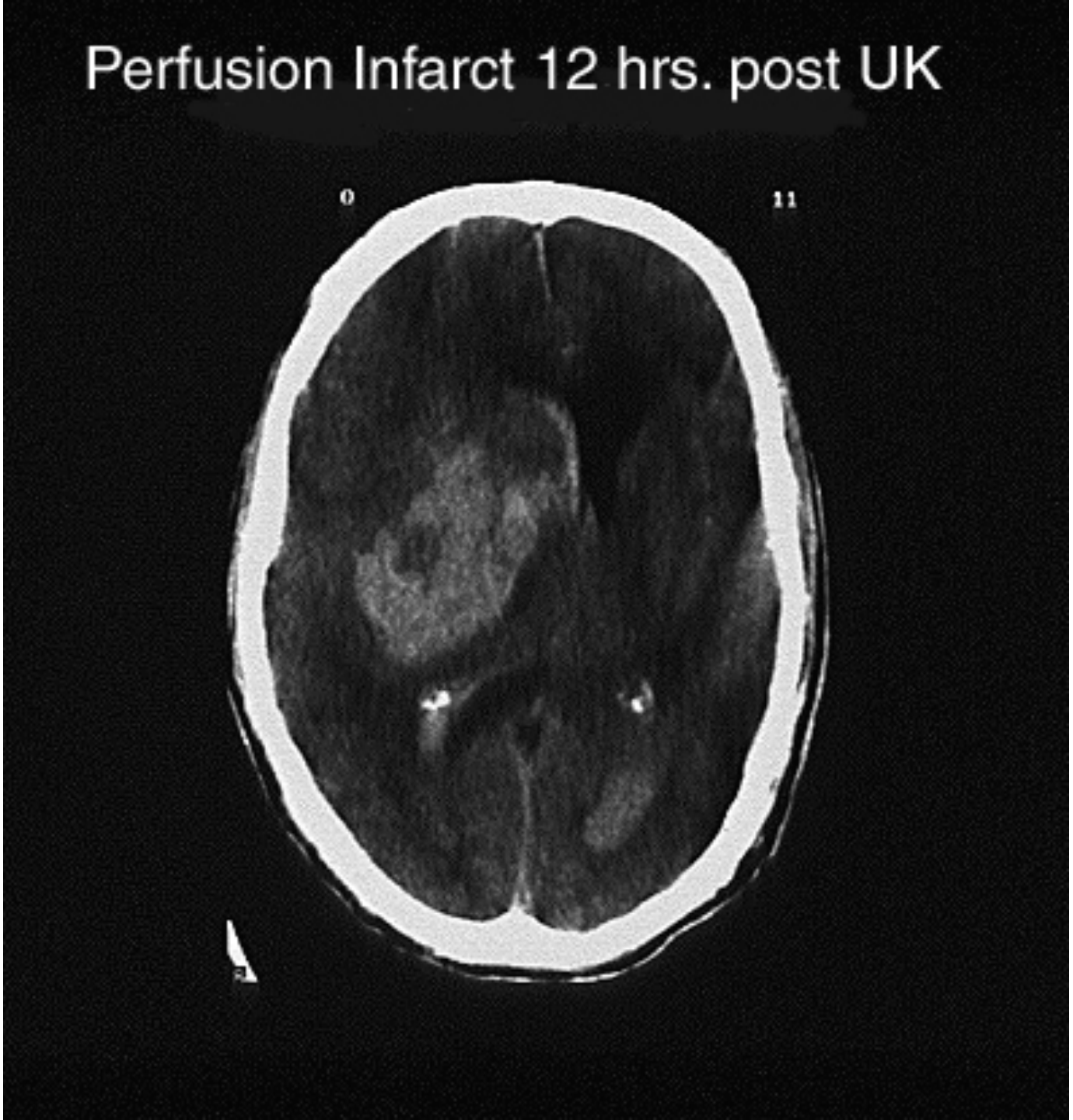
Cardiogenic ICA Embolus
Cross-filling

Cardiogenic ICA Embolus During Thrombolysis

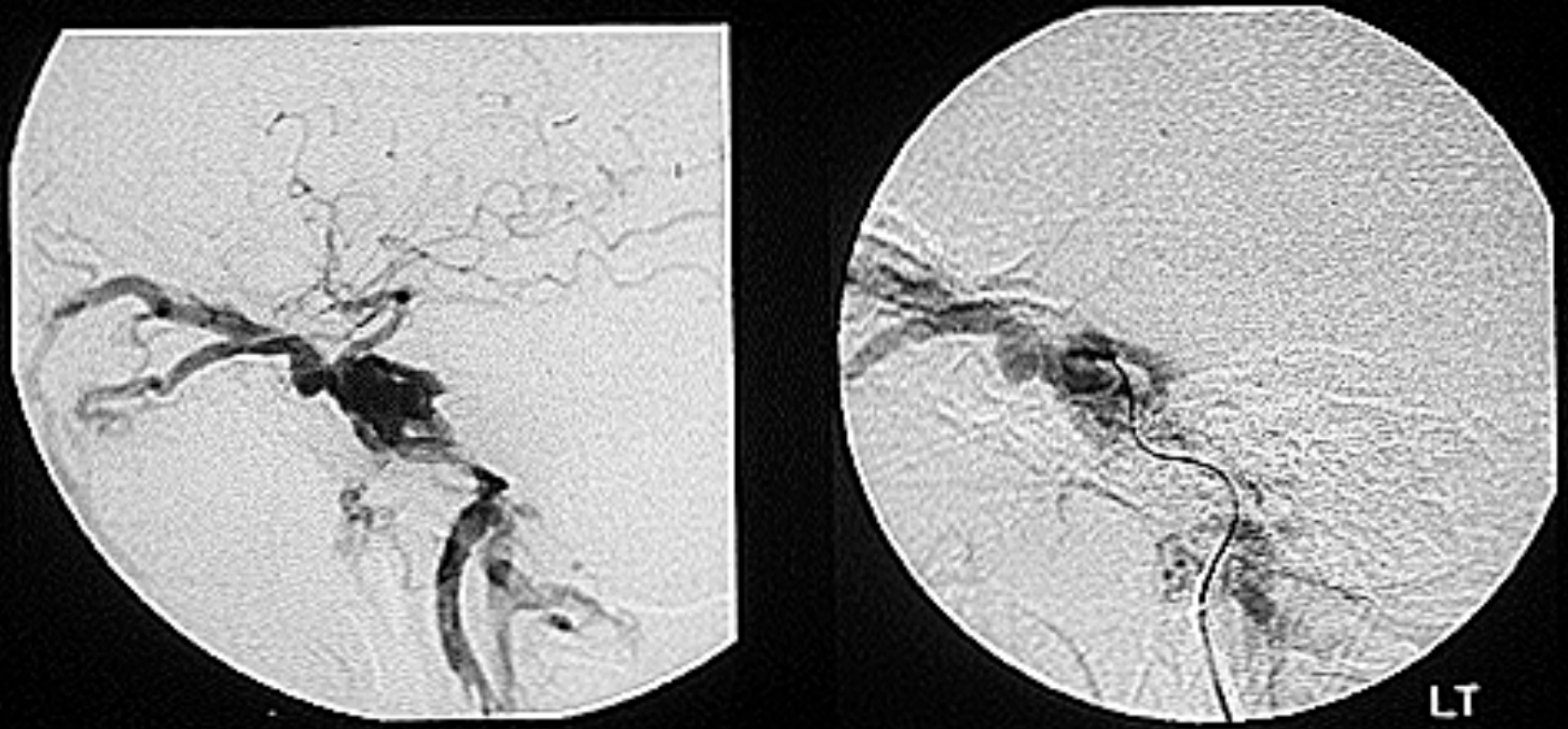
Cardiogenic ICA Embolus
Post UK Thrombolysis



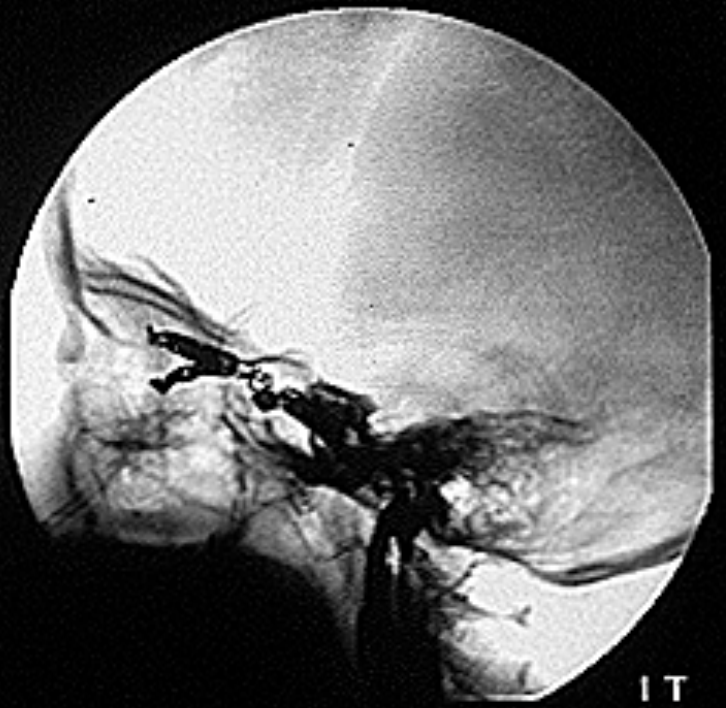
Perfusion Infarct 12 hrs. post UK



Carotid-Cavernous Fistula



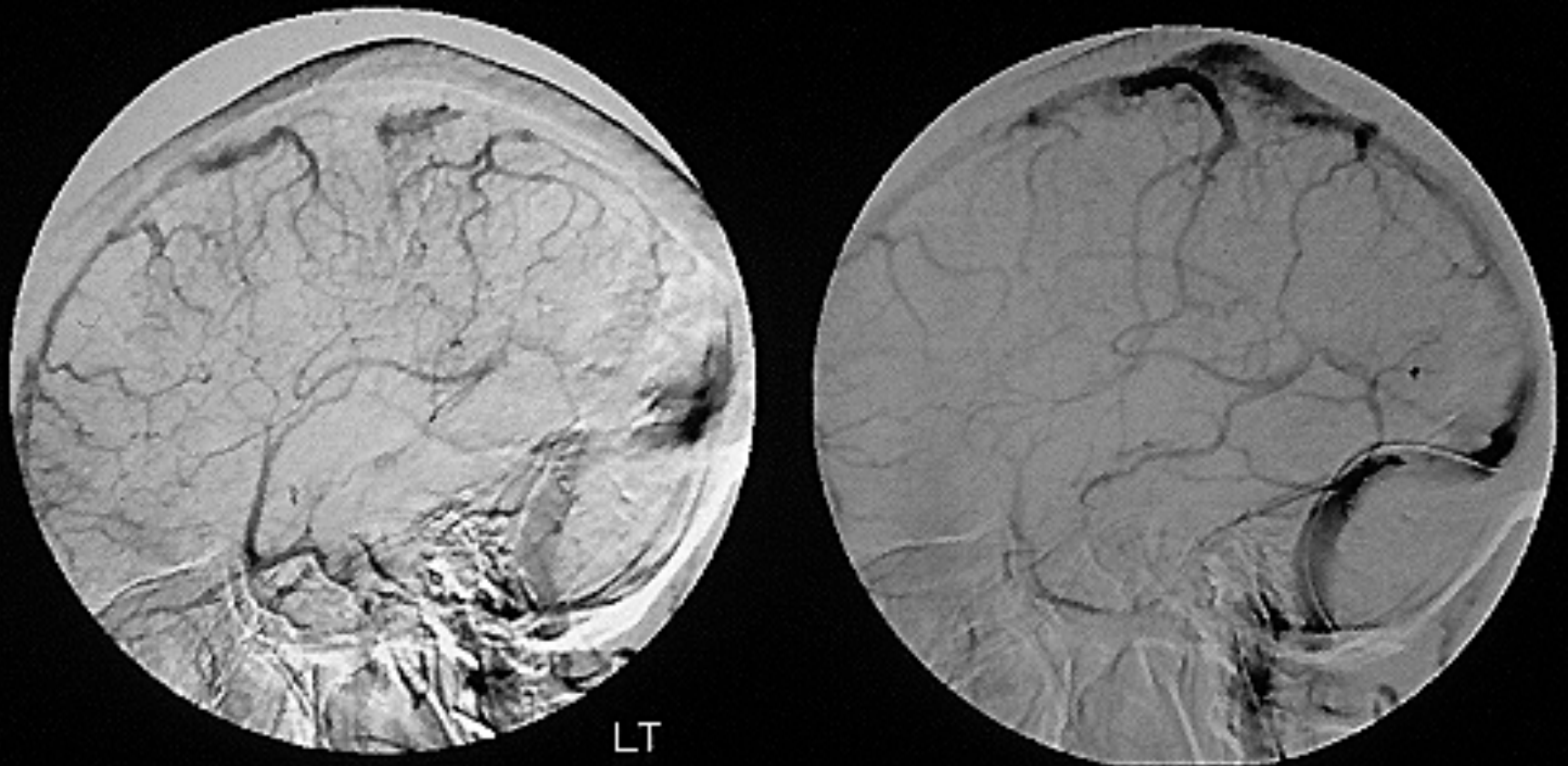
Carotid-Cavernous Fistula



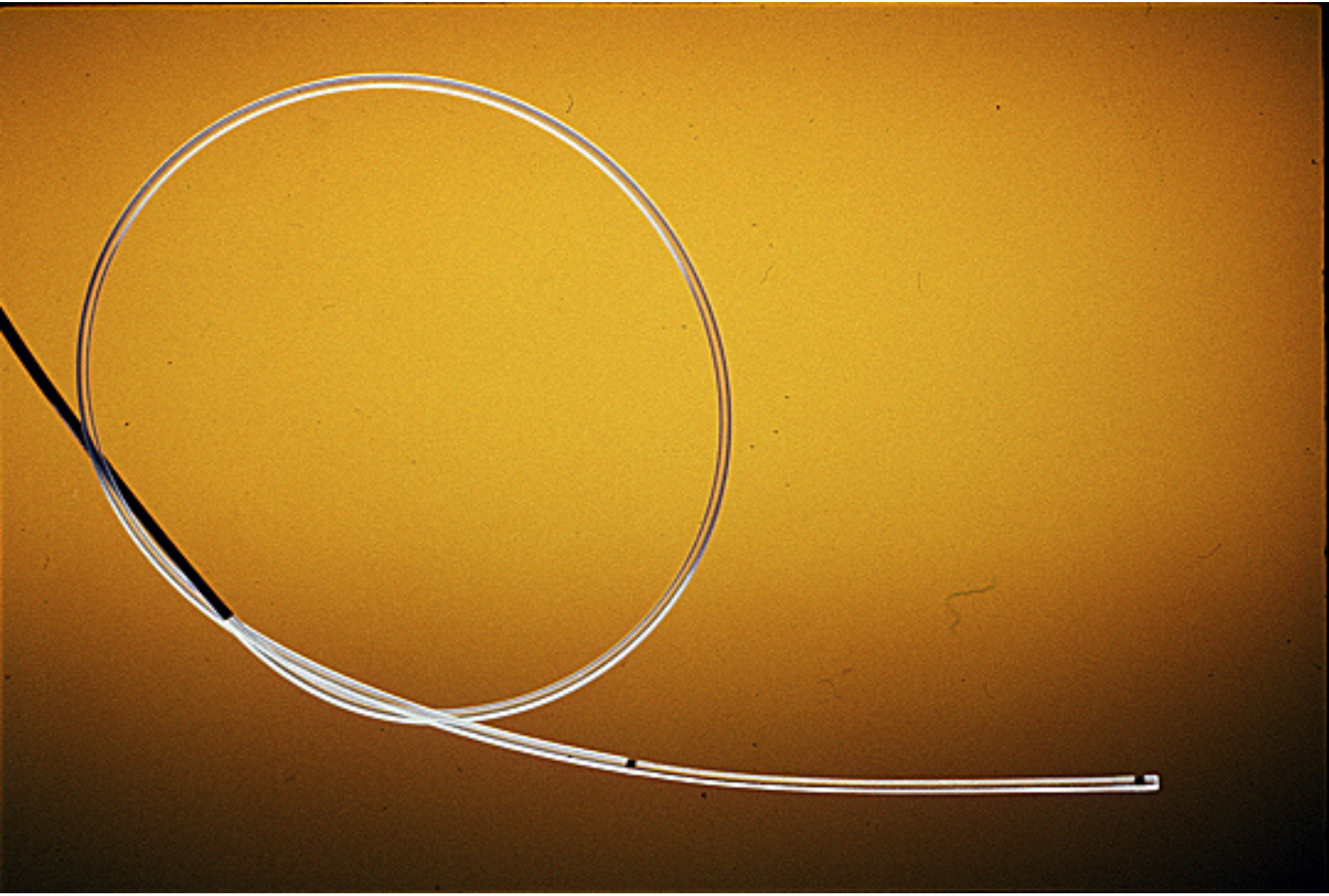
IT

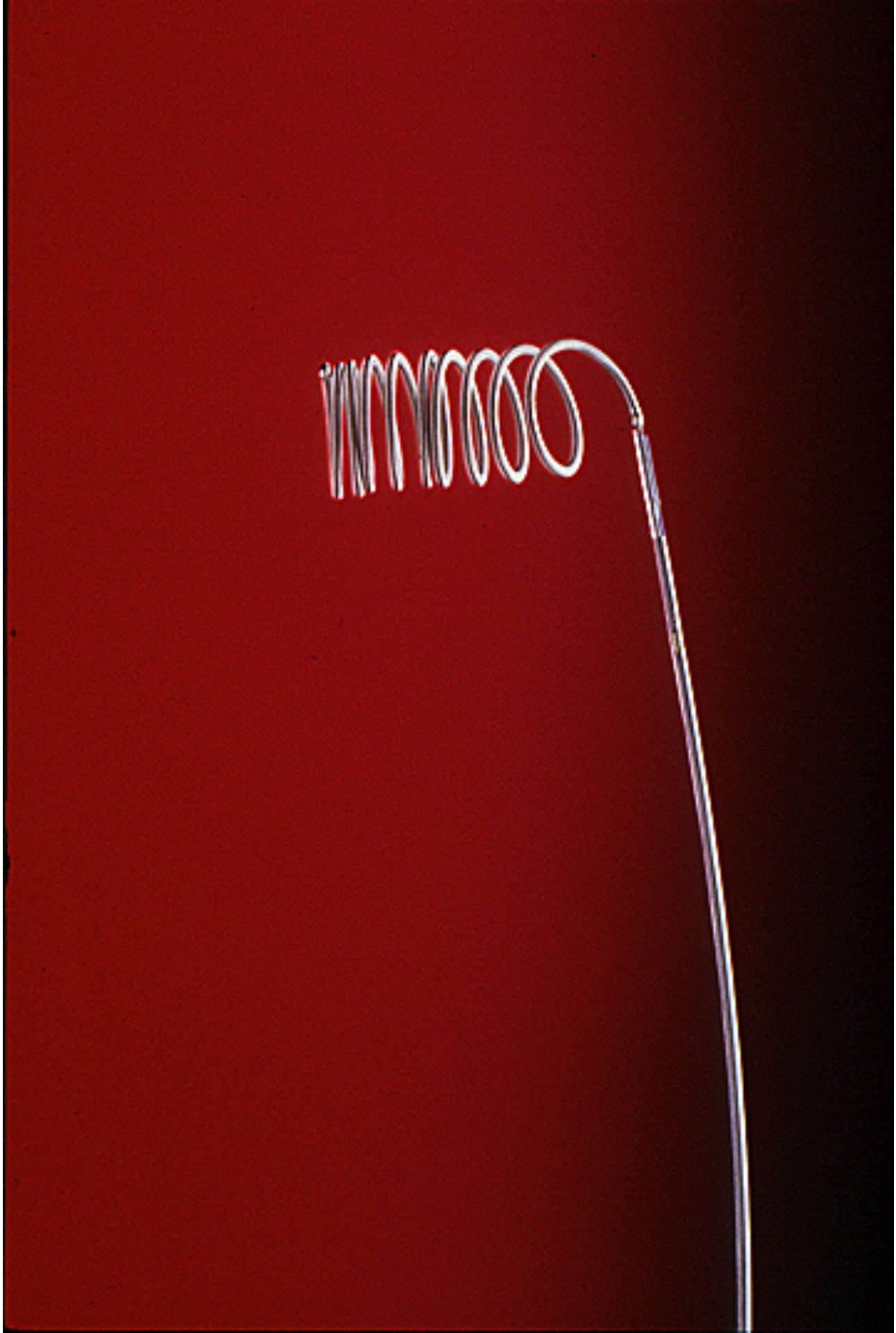
Carotid-Cavernous Fistula

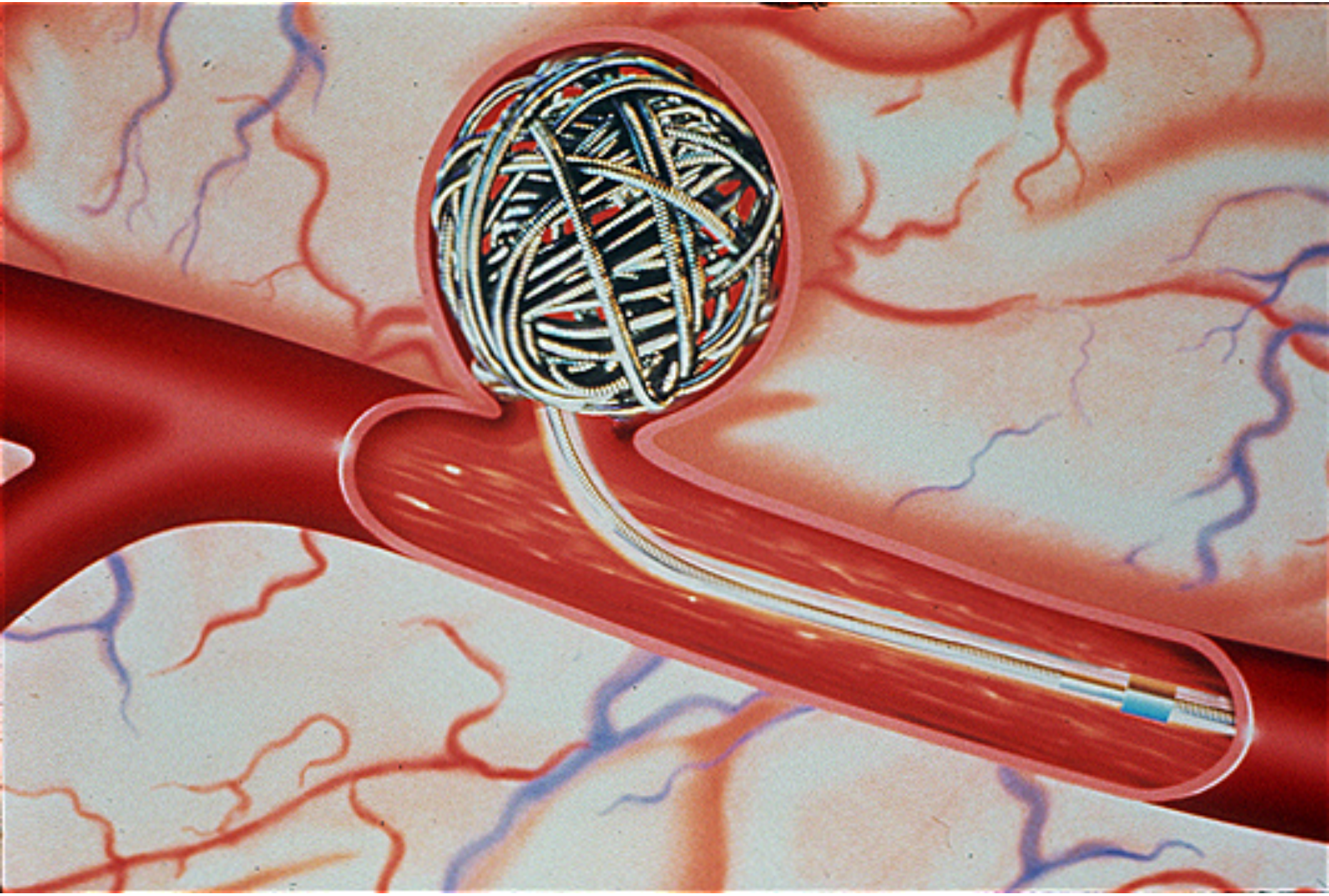
SSS Thrombolysis



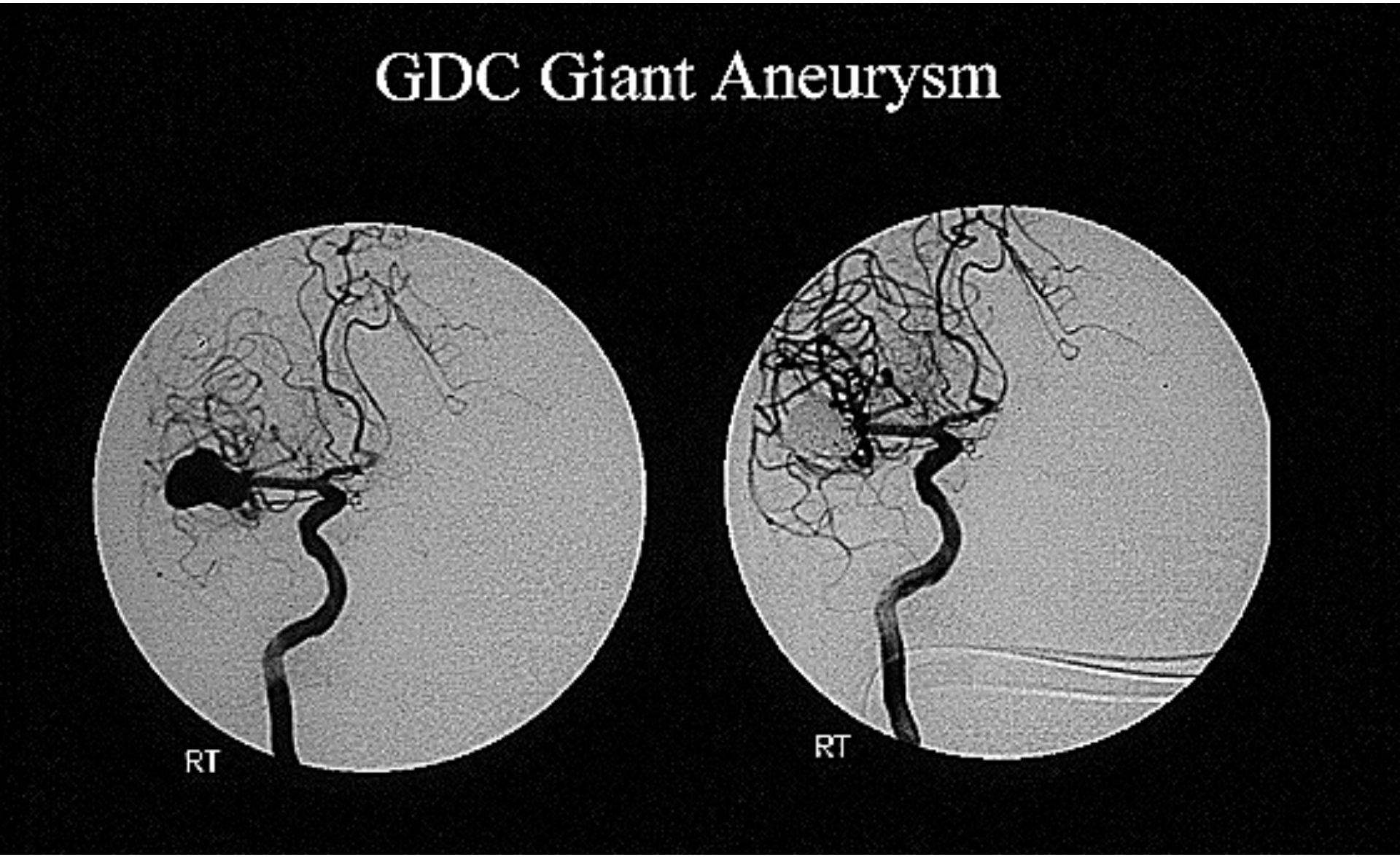
ANEURYSM COILING VIDEO







GDC Giant Aneurysm



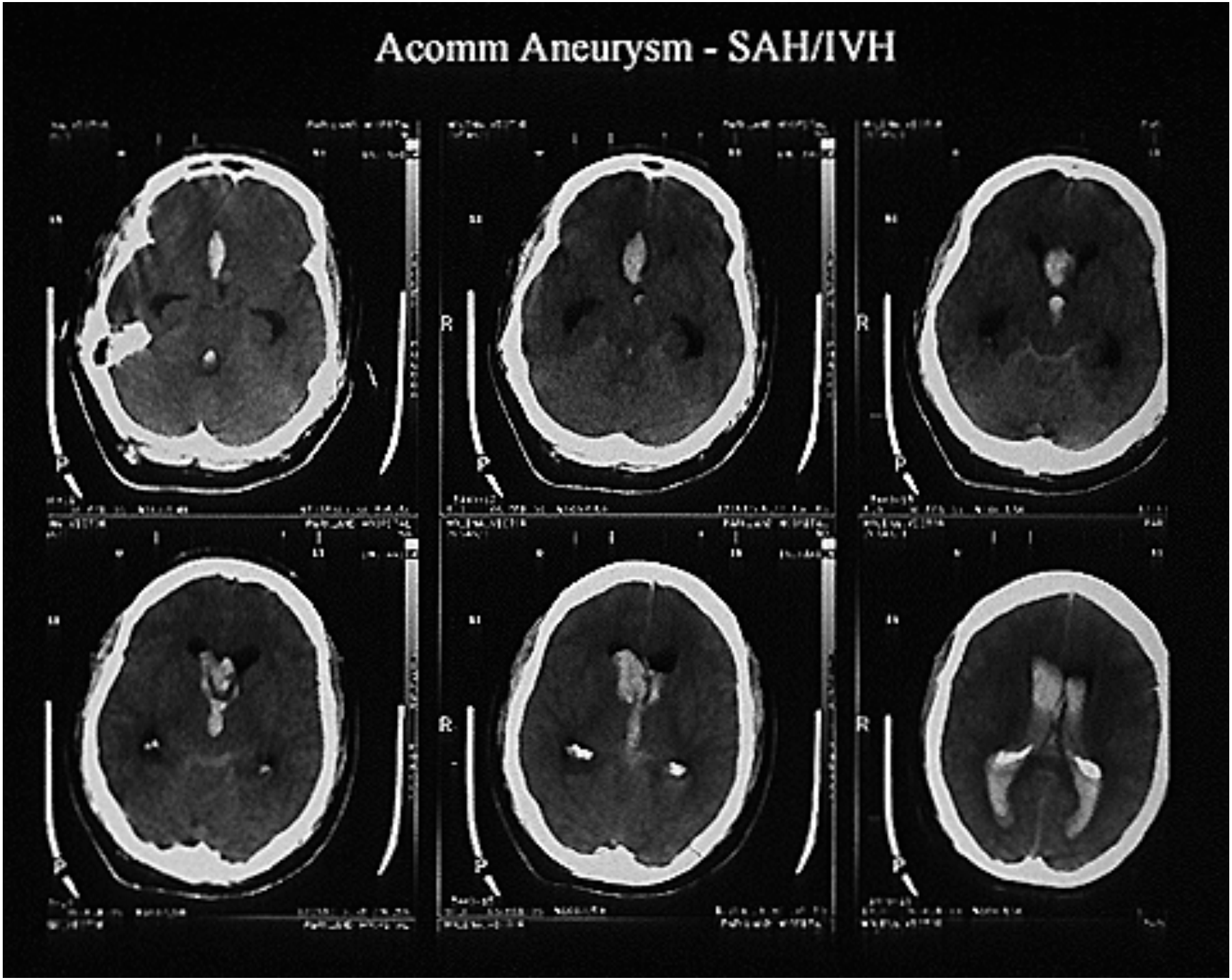
GDC Embolization with Balloon Remodeling Technique

GDC Embolization with Balloon Remodeling Technique

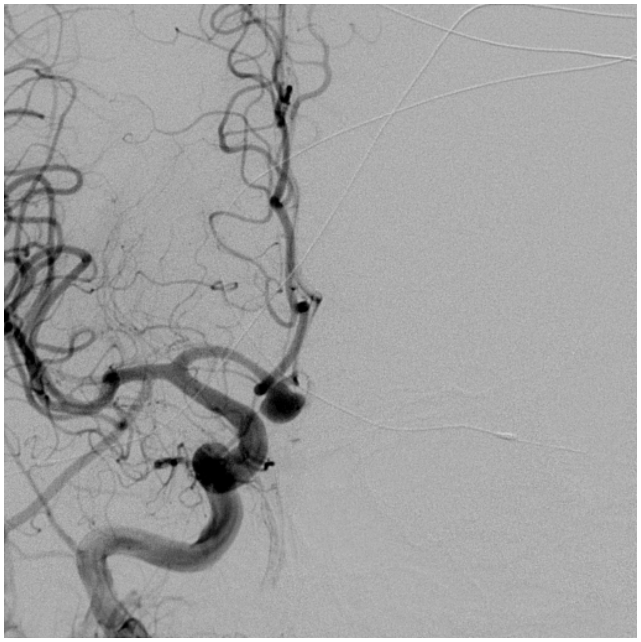
GDC Embolization with Balloon Remodeling Technique

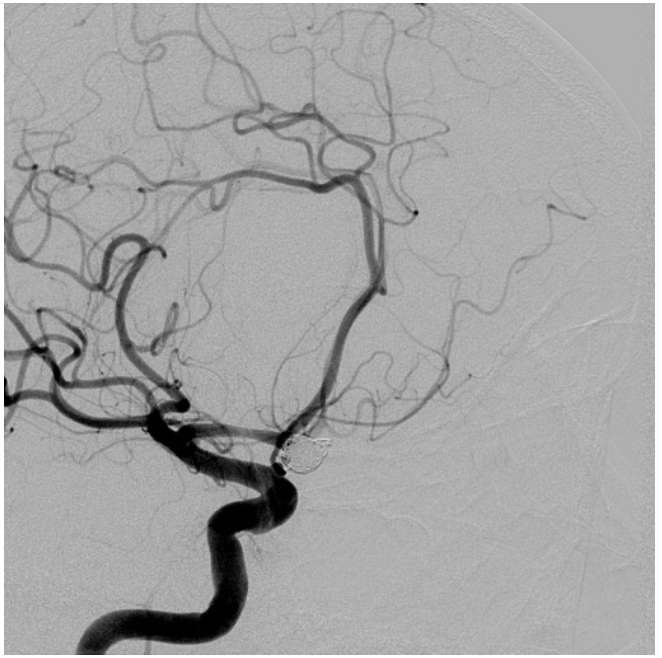
GDC Embolization with Balloon Remodeling Technique

Acomm Aneurysm - SAH/IVH



Acomm Aneurysm

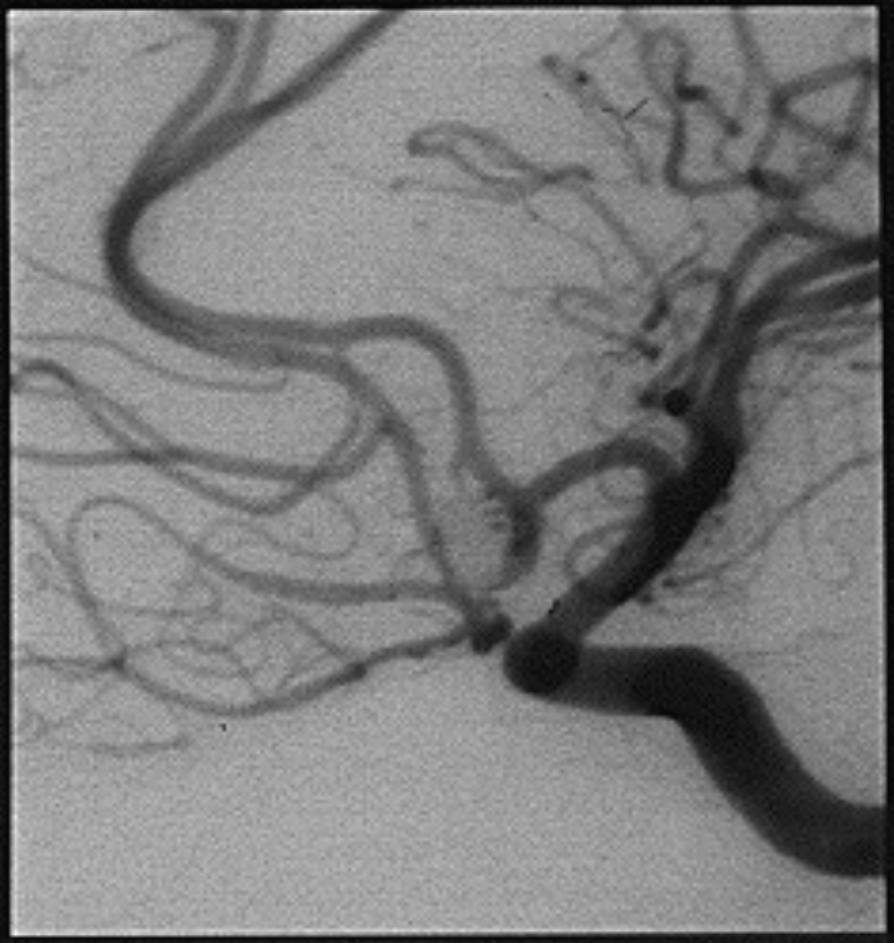




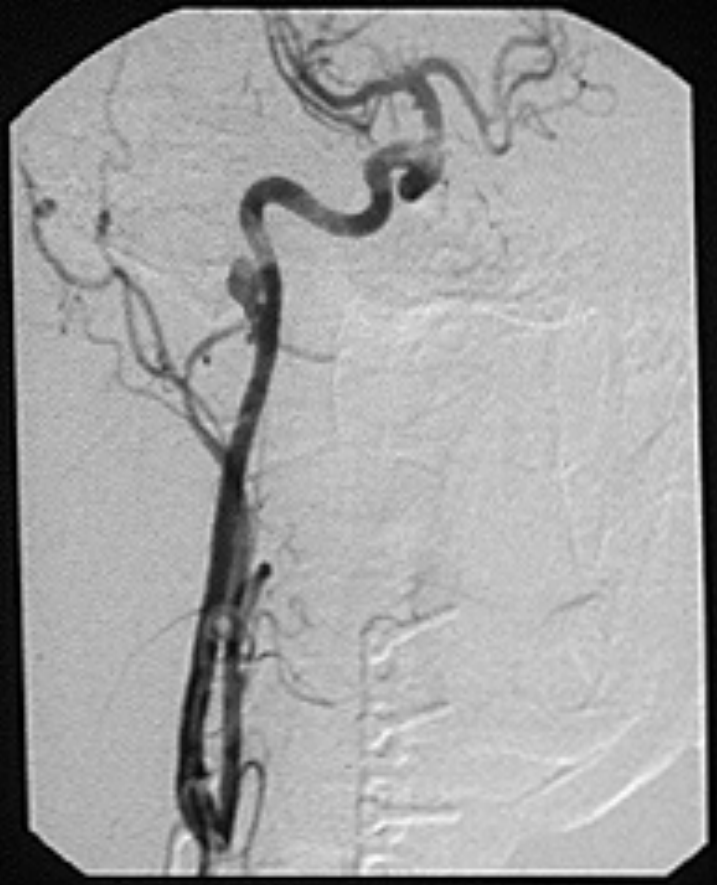
Acomm Aneurysm - GDC Coiling

L Obl. Pre GDC

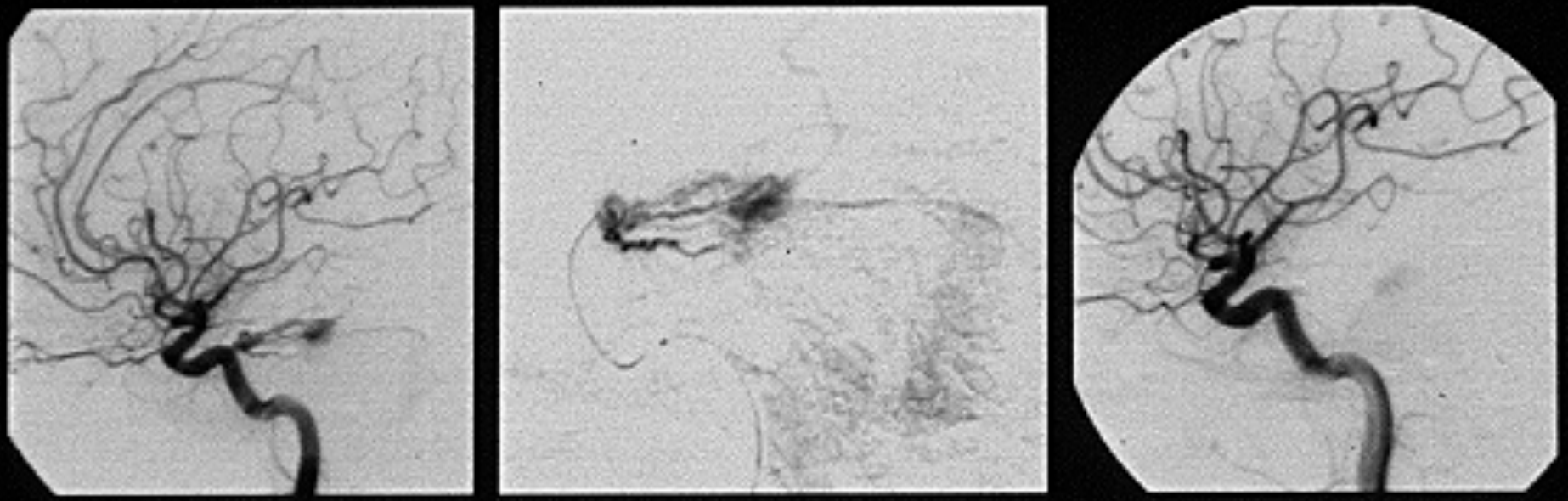
L Obl. Post GDC



Stenting Pseudoaneurysm

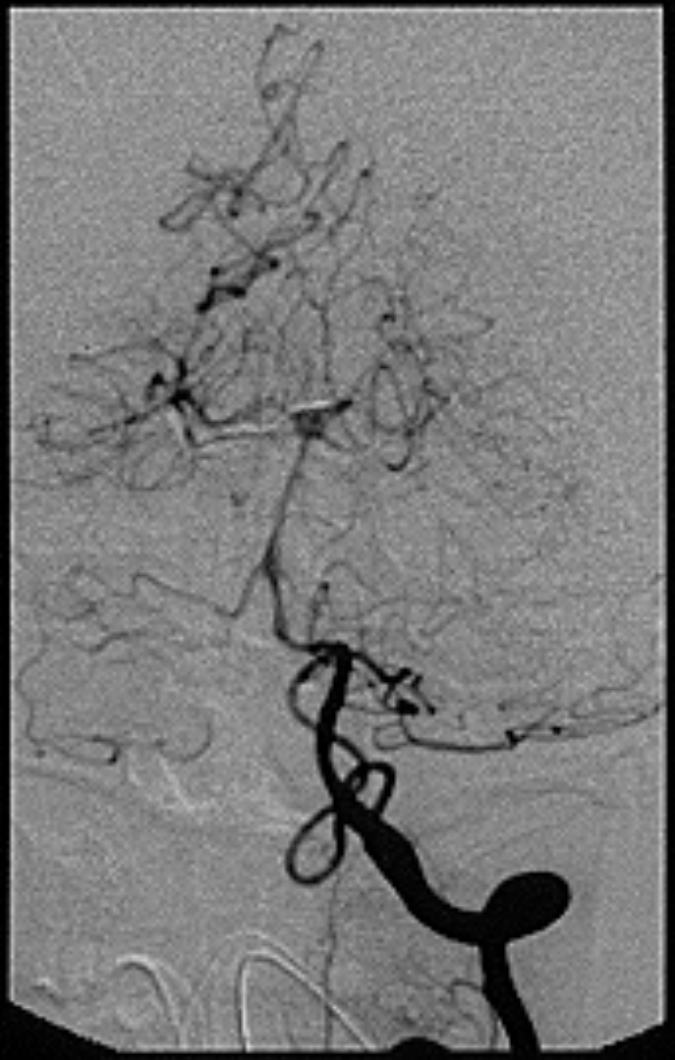


Dural AVF embo with GDC

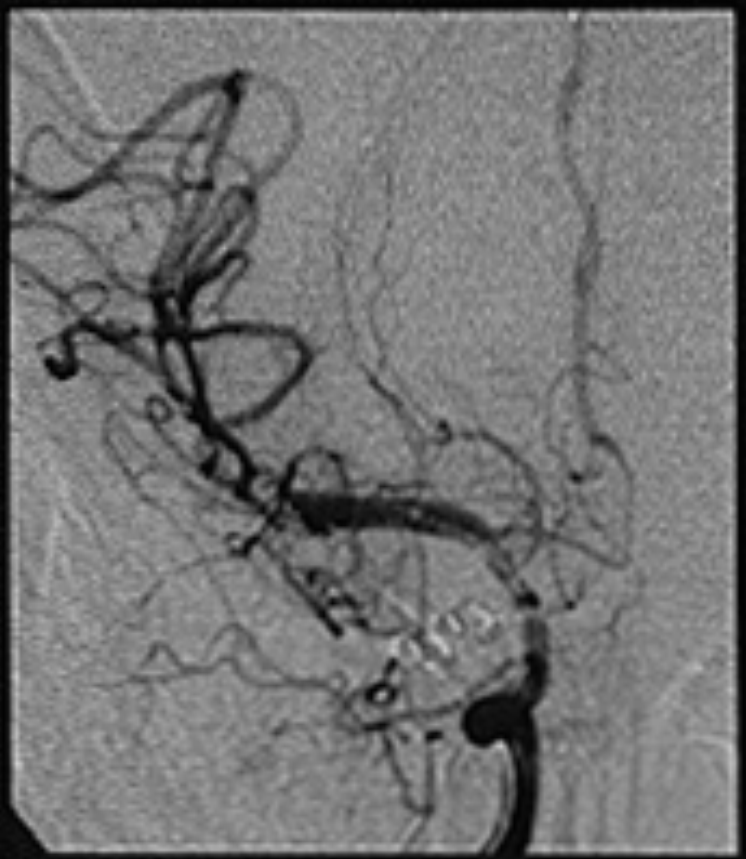


Trial Balloon Occlusion

Vasospasm Balloon Angioplasty



Vasospasm Angioplasty



Basilar Occlusion/Stenosis

AP

Lateral

Basilar Occlusion

Lateral L ICA

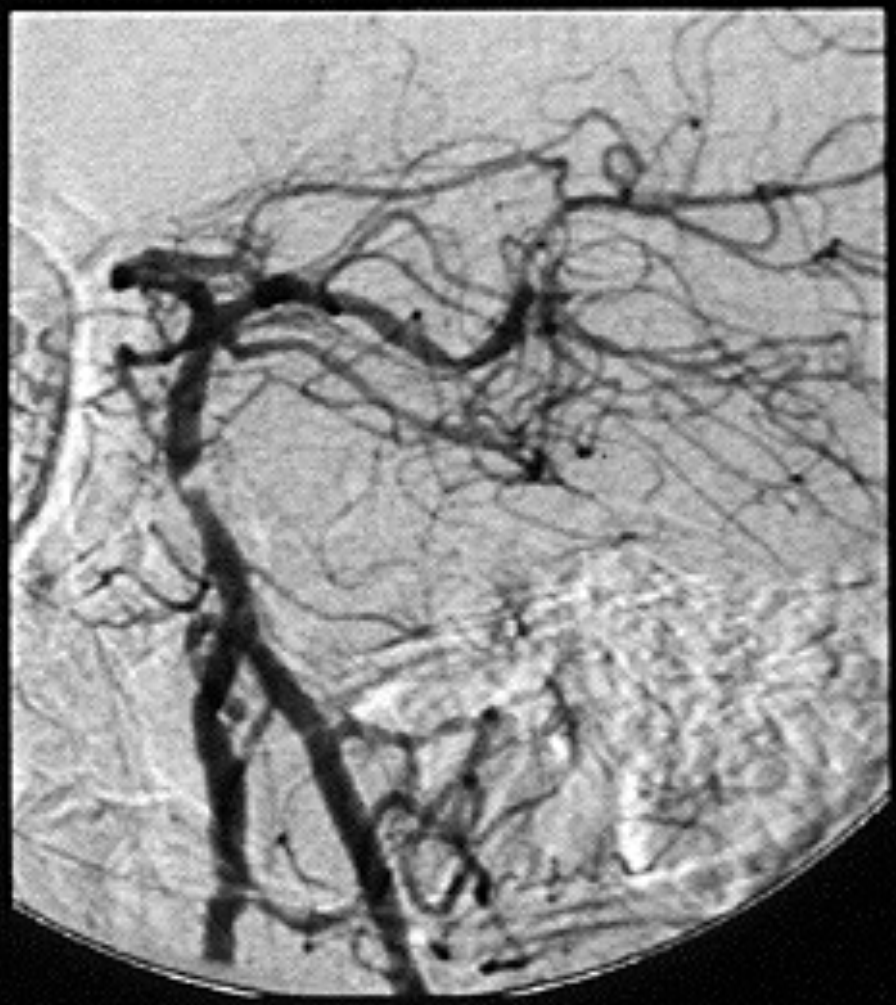
Basilar Thrombolysis

S/P 550K U urokinase

Basilar Angioplasty/Stent

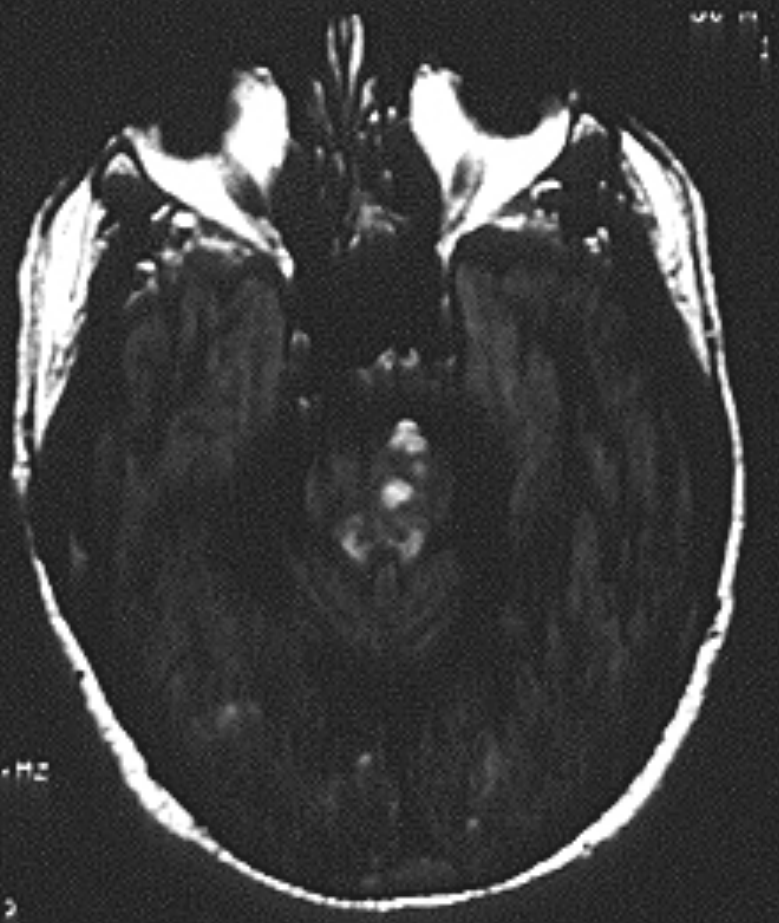
S/P 3 x 13mm ACS Multilink

Basilar Stenosis

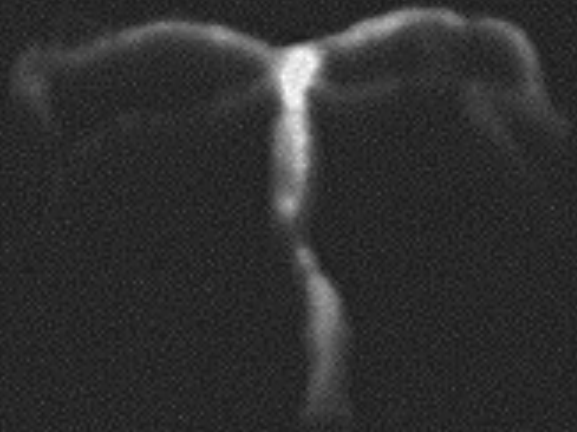


Basilar Stenosis

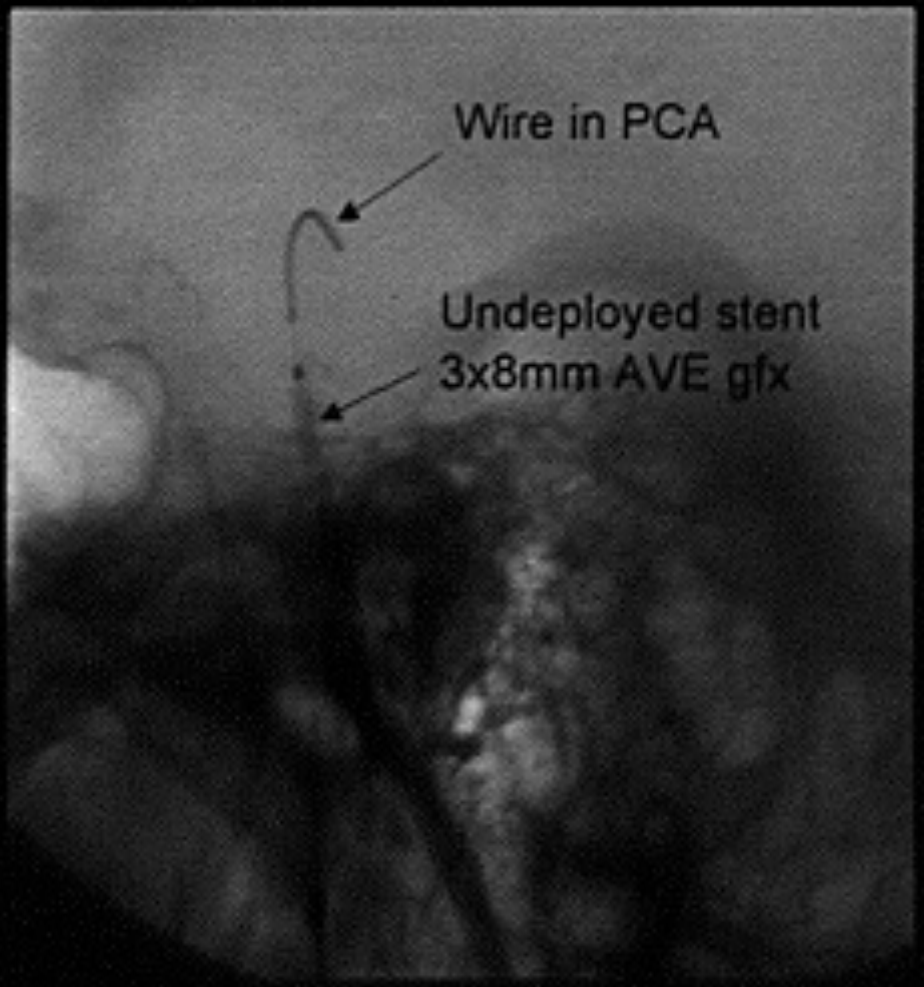
Axial FLAIR MRI

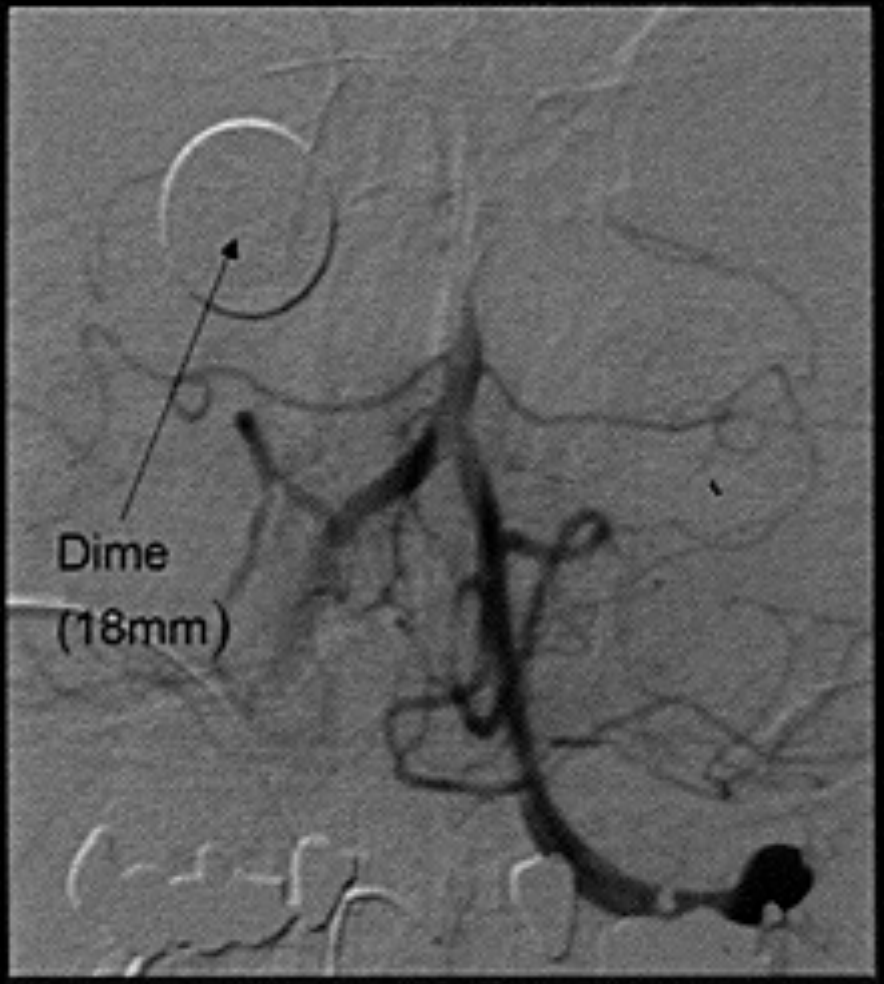


3D TOF MRA



Basilar Angioplasty/Stenting





Basilar Angioplasty/Stenting

Pre-stent

Post AVE gfx 3x8mm

REVASCULARIZATION OCCLUDED CAROTID ARTERY VIDEO

Carotid Stenting

Carotid Stenting

Carotid Atherosclerotic Disease

- Asymptomatic Disease
  - VA CSP 167 (1992):
    - 50% stenosis or greater
    - Surgery reduced subsequent ipsilateral transient neurological events but not mortality or stoke rate
  - ACAS (1995):
    - 60% stenosis or greater
    - Median F/U 2.7 years
    - 5 year risk for ipsilateral stroke or perioperative stroke or death was 5.1% with surgery and 11.0% for medical therapy if perioperative morbidity and mortality was less than 3%

Carotid Atherosclerotic Disease

- NASCET exclusions of high risk patients
  - Age greater than 79
  - Heart, liver, kidney, or lung failure
  - Intracranial lesion more severe than surgically accessible one
  - Cancer likely to cause death within 5 years
  - Cardiac valvular disease or rhythm disorder likely to be associated with cardioembolic stroke
  - Previous ipsilateral CEA
  - Angina or MI, uncontrolled HTN, DM within the previous 6 months
  - Progressive neurologic signs
  - Contralateral CEA within 4 months
  - A major surgical procedure within 30 days

Carotid Atherosclerotic Disease

- Symptomatic Disease
  - NASCET (1991)
    - n = 328 surgical cases
    - 70-99% stenosis
    - Benefits within 2 years were:
      - 17% for ipsilateral stroke
      - 15% for all strokes
      - 16.5% for combined outcome of stroke and death
      - 10.6% for major ipsilateral stroke
      - 9.4% for all major strokes
      - 10.1% for major stroke and death

Carotid Atherosclerotic Disease

- Indications and risks for CEA in the elderly, infirm, previously operated upon patient are unknown
  - The published mortality rate in NASCET was 0.6% while the mortality rate for Medicare patients undergoing CEA during the same period was 3%
  - Diabetic patients undergoing CEA have greater than 10% postoperative morbidity and mortality rates
  - Risk of stroke or death with combined CEA and CABG is 7.4 - 9.4%
  - 14.3% risk or perioperative stroke or death with CEA in the presence of a contralateral carotid artery occlusion (NASCET)

NASCET Complication Rates

- Perioperative morbidity and mortality (30d)
  - Stroke (5.5%)
    - 12 minor (3.6%), 5 major (1.5%), 1 fatal (1.5%)
  - Stroke and death (5.8%)
  - Major stroke and death 2.1% and fatality 0.6%
  - Cranial nerve injury 7.6%
  - Infection 3.4%
  - Hematoma 5.5%
  - MI 0.9%
  - CHF 0.6%

Carotid Atherosclerotic Disease

- Restenosis (defined as 50%) rates for CEA as detected by Doppler US was 10% in first year, 3% in second year, and 1% in third year
- Repeat CEA for restenosis has at least a 10% complication rate especially related to lower cranial nerve injury

Carotid stenting

- Diethirch, et al (1996)
  - 110 patients, 117 vessels
  - Greater than 75% stenosis (mean 86.5%)
  - 72% symptomatic
  - 99% technical success
  - 7 strokes (6%) (2 major [2%], 5 reversible [4%])
  - 1 death (0.9%)
  - Clinical success at 30 days (no technical failure, death, conversation to CEA, stroke, occlusion) 89.1%

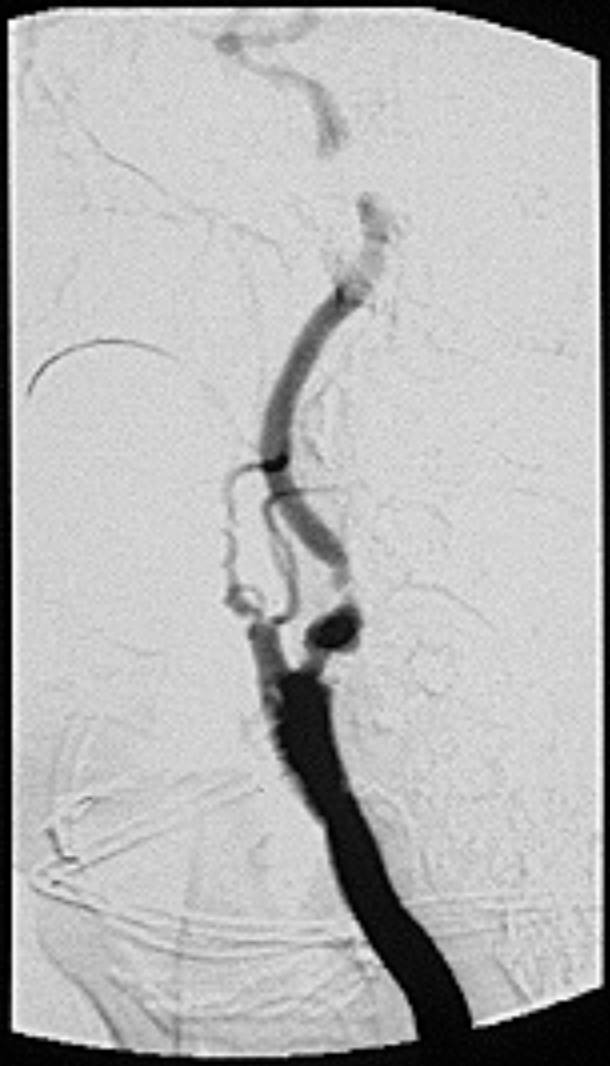
Endovascular Approach to Carotid Atherosclerotic Disease

- Roubin, et al(1996)
  - 146 procedures with 210 stents in 152 vessels
  - 63% symptomatic
  - Technical success 99%
  - Acute thrombosis 0.4%
  - Death 0.6%
  - Major stroke 1.2%
  - Minor stroke 4.8% with residual weakness in 1.2%
  - 6 month FU in 74 eligible patients
  - TIA 1.4%
  - Restenosis 5%

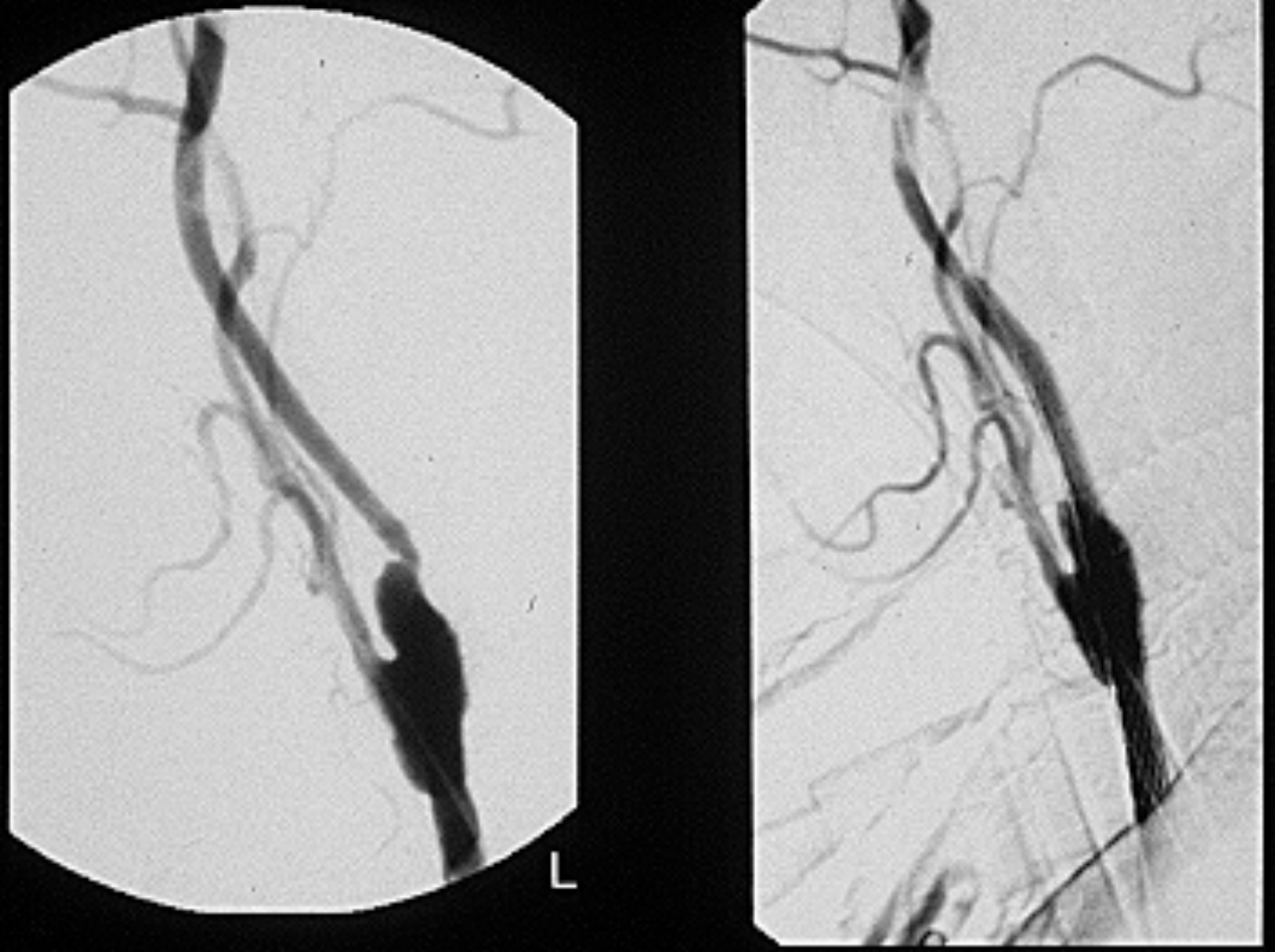
LONG TERM RESULTS OF STENTING VS. CEA

- NEJM 2/18/2016
- Study showed bioequivalency between the two procedures
- 2500 patients followed for 10 years
  - Post procedural ipsilateral stroke incidence
    - 6.9% stenting group
    - 5.6% CEA group
  - No significant differences in MI
  - No significant differences in death rate

Carotid Angioplasty and Stenting



Carotid Stenting

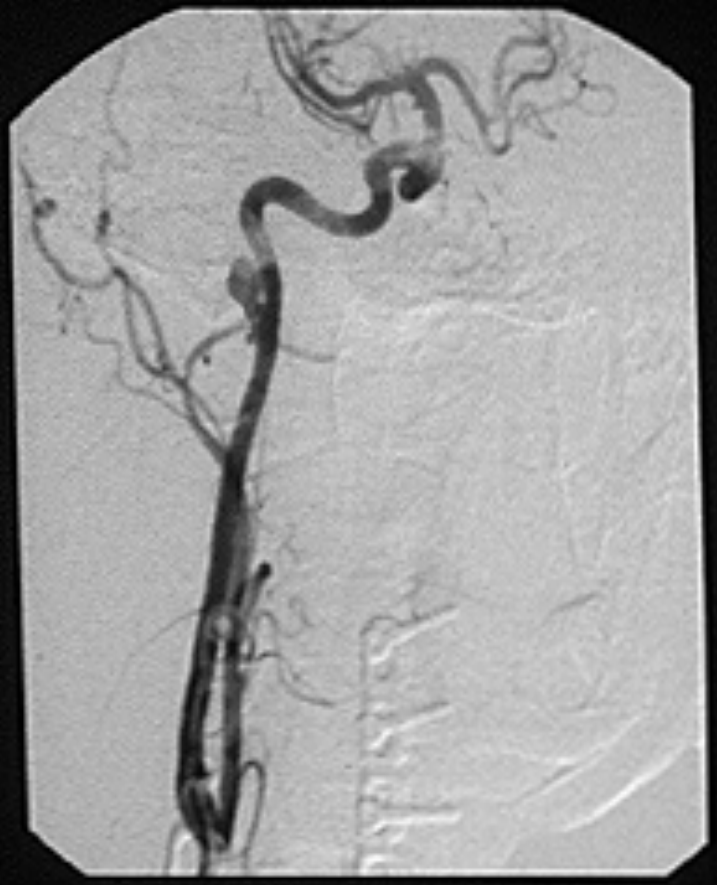


Carotid Stenting

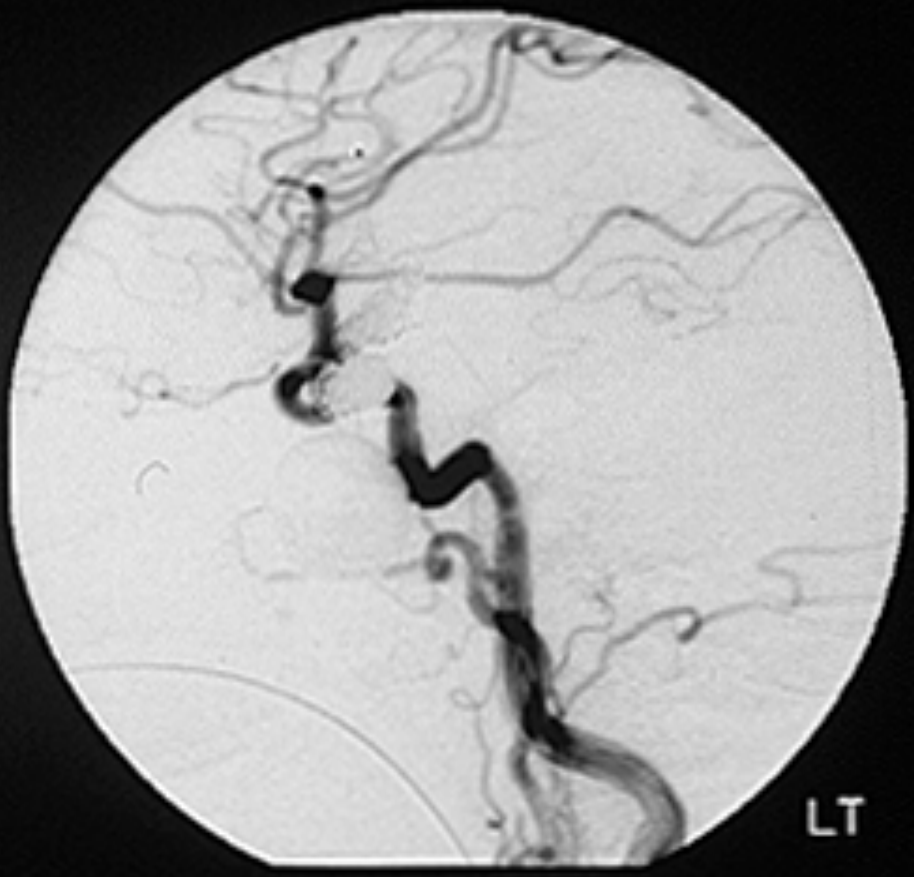
Stenting of Pseudoaneurysm

Stenting of ICA Pseudoaneurysm

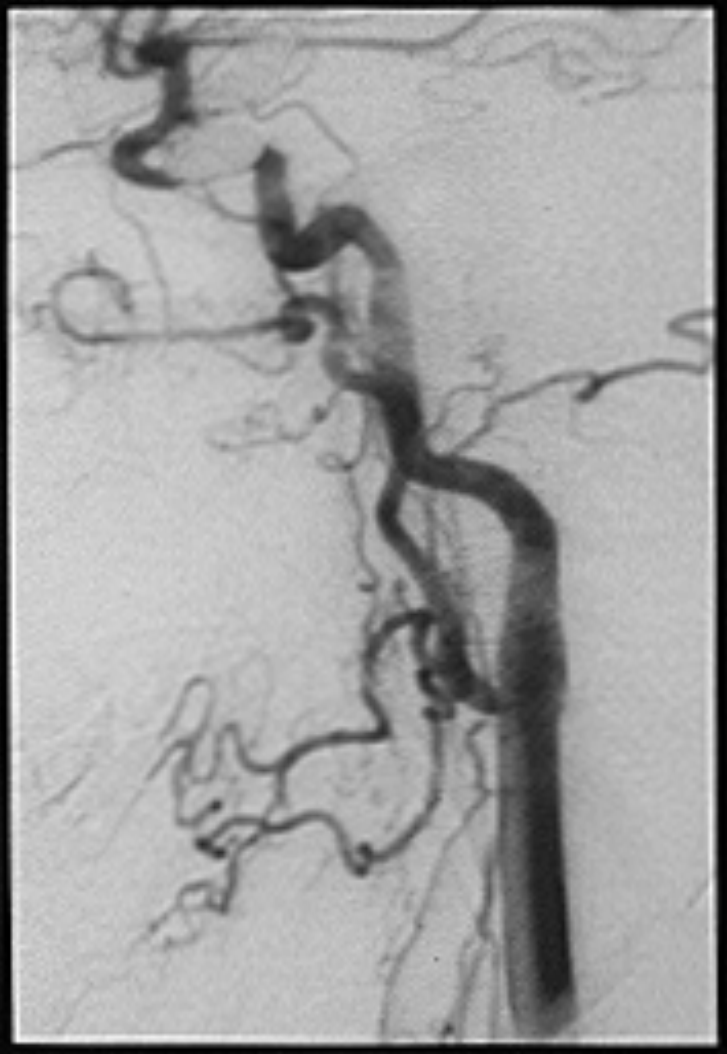
Stenting Pseudoaneurysm



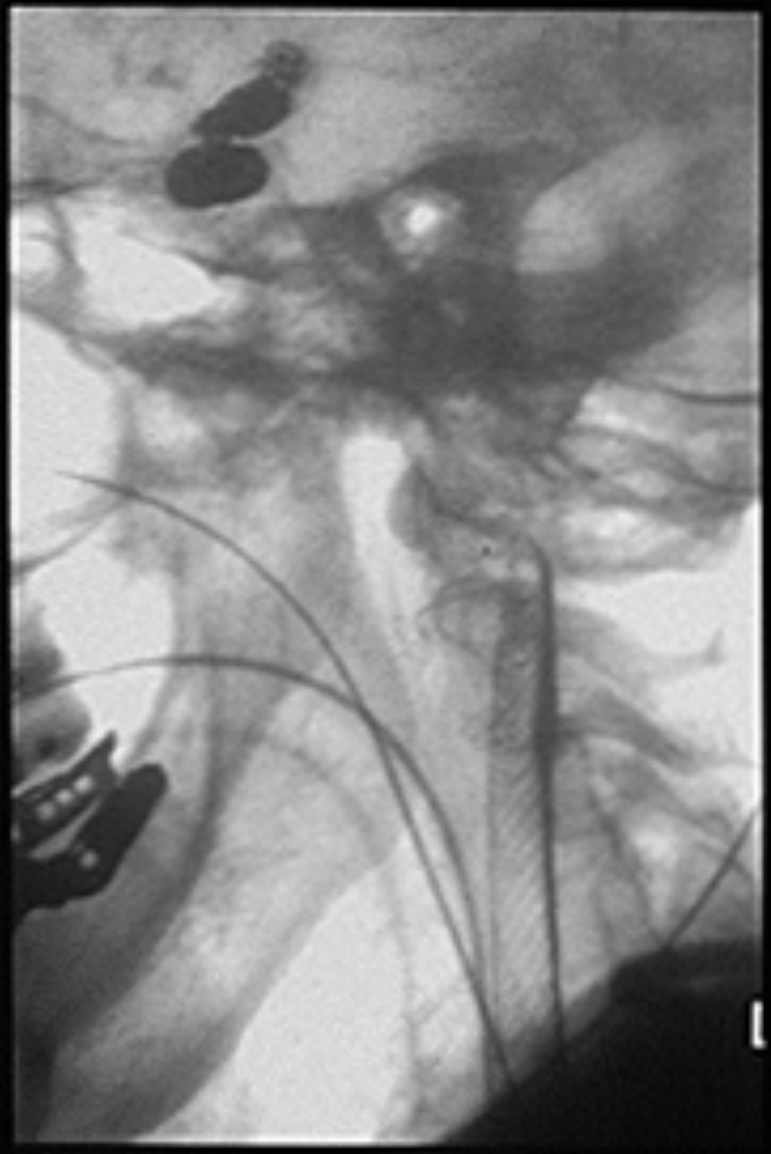
GDC Embolization With Stent Rescue



GDC Embolization With Stent Rescue



GDC Embolization With Stent Rescue



Future Directions

- Randomized controlled study comparing carotid stenting to carotid endarterectomy in low and high risk patients of all ages
- Randomized controlled study comparing aneurysm embolization with aneurysm clipping looking at anatomic as well as functional results and long term protection from hemorrhage
- Training standards to ensure that procedures are not being performed by individuals that lack the capability to manager routine procedural complications
- Better access to stroke patients within the first few hours of an ischemic event

“In times of change
learners inherit the earth
while the learned find themselves beautifully
equipped to deal
with a world that no longer exists”

Eric Hoffer

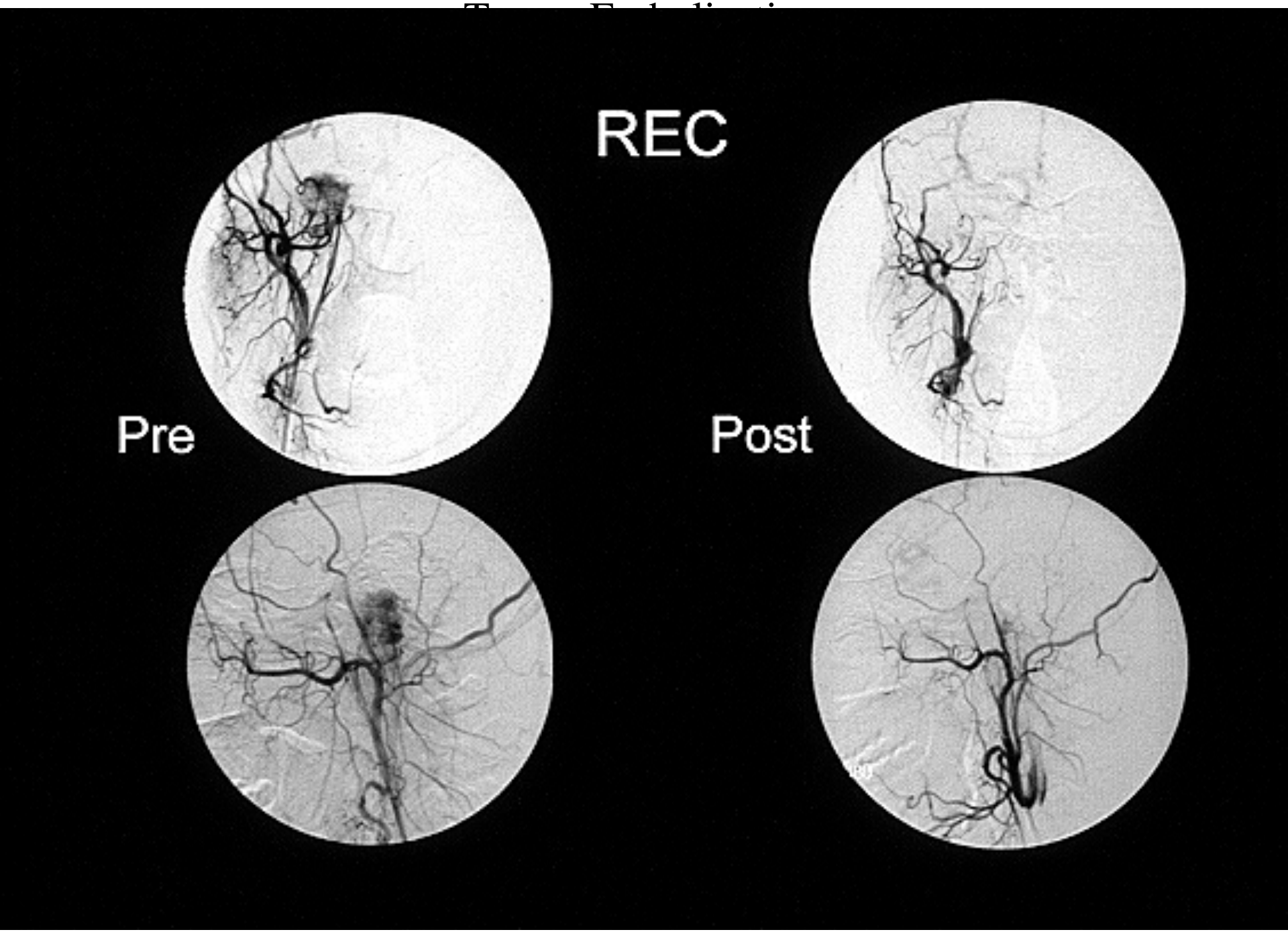
Endovascular Neurosurgery

Otolaryngologic Applications

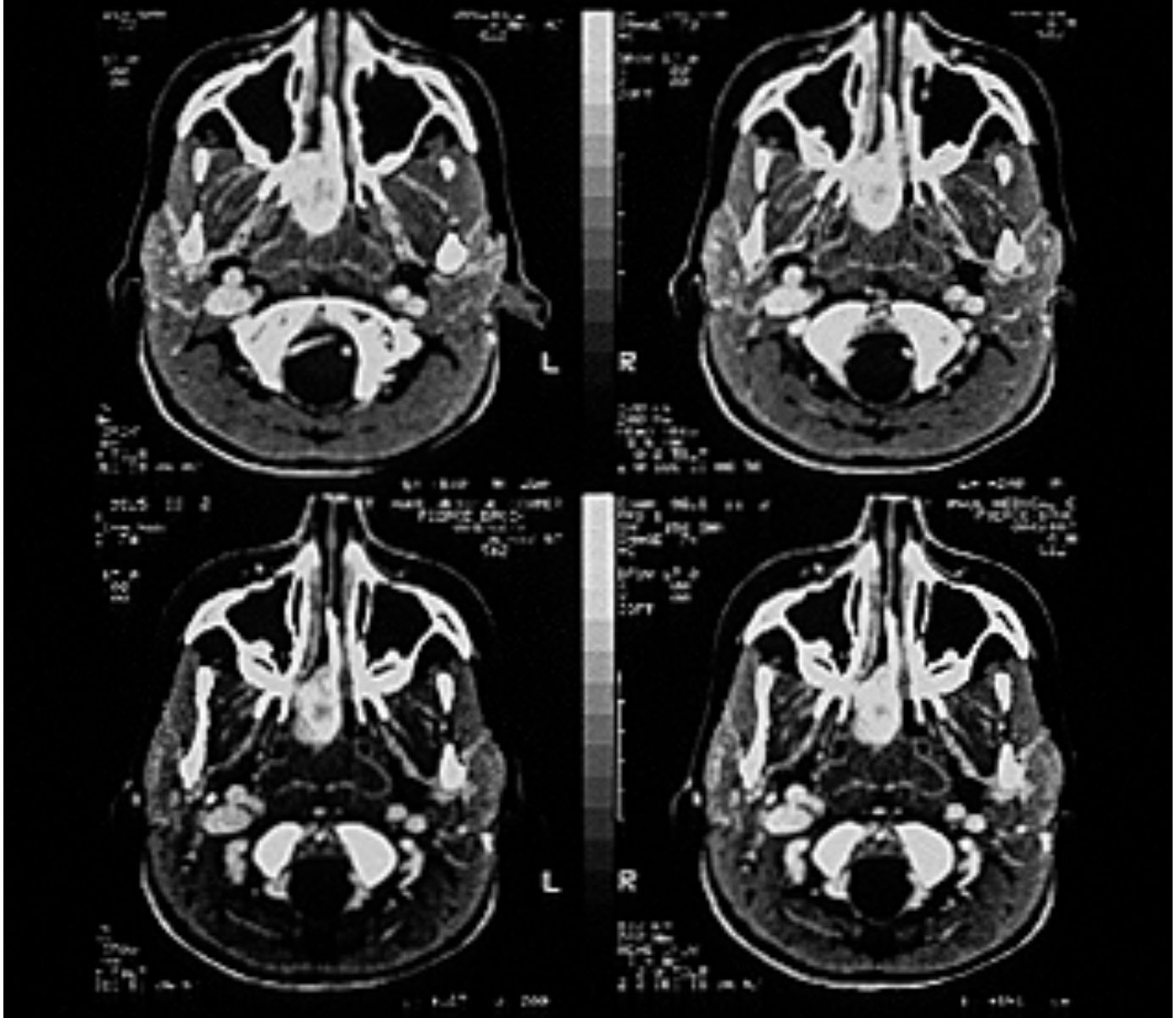
Michael Horowitz, M.D.
Associate Professor of Neurosurgery and Radiology
University of Pittsburgh

Procedures Performed

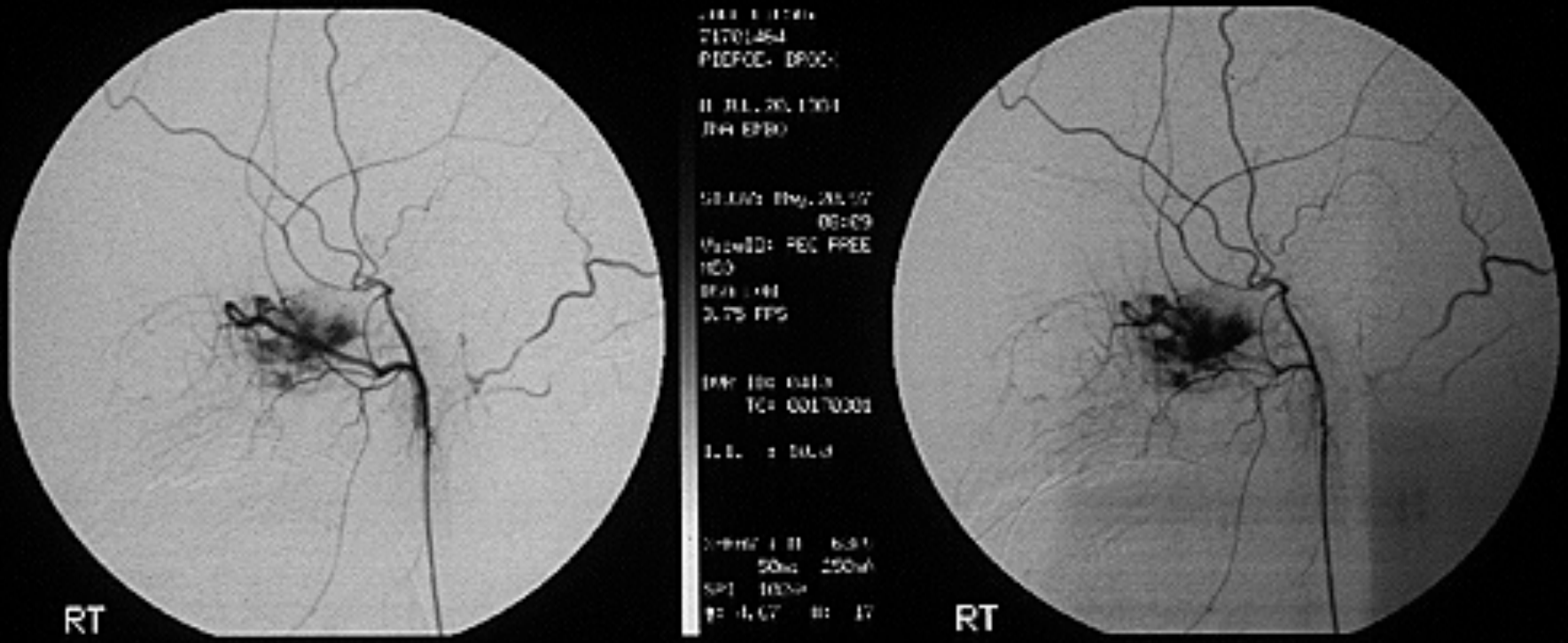
- Interventional Procedures For ENT
  - **Balloon test occlusions**
  - **Vessel sacrifice and embolization**
  - **Tumor and AVM embolization**
  - **Percutaneous Sclerotherapy**
  - **Chemotherapy**


REC
Pre
Post

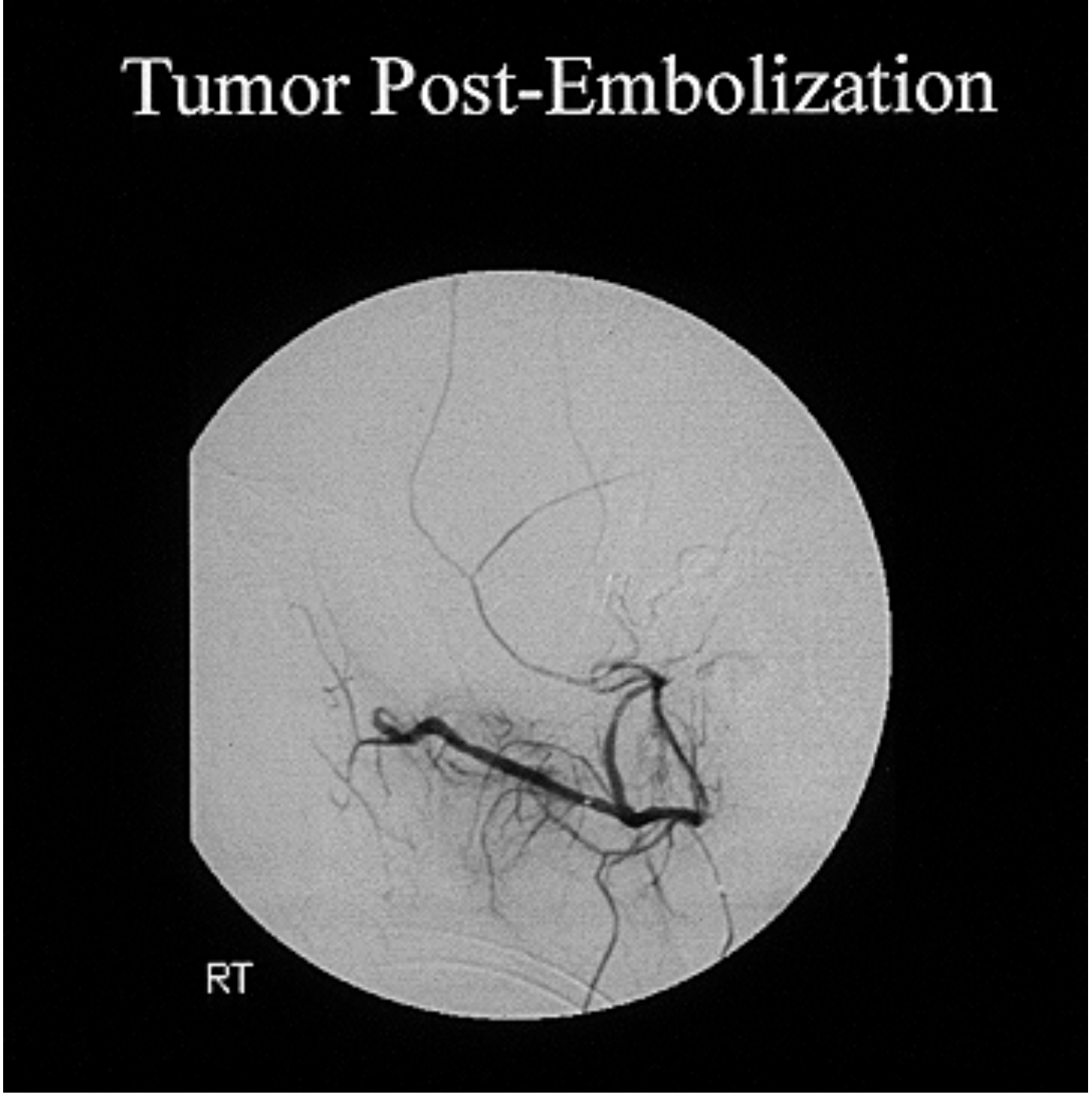
Tumor Embolization



Tumor Blush Pre-Embolization



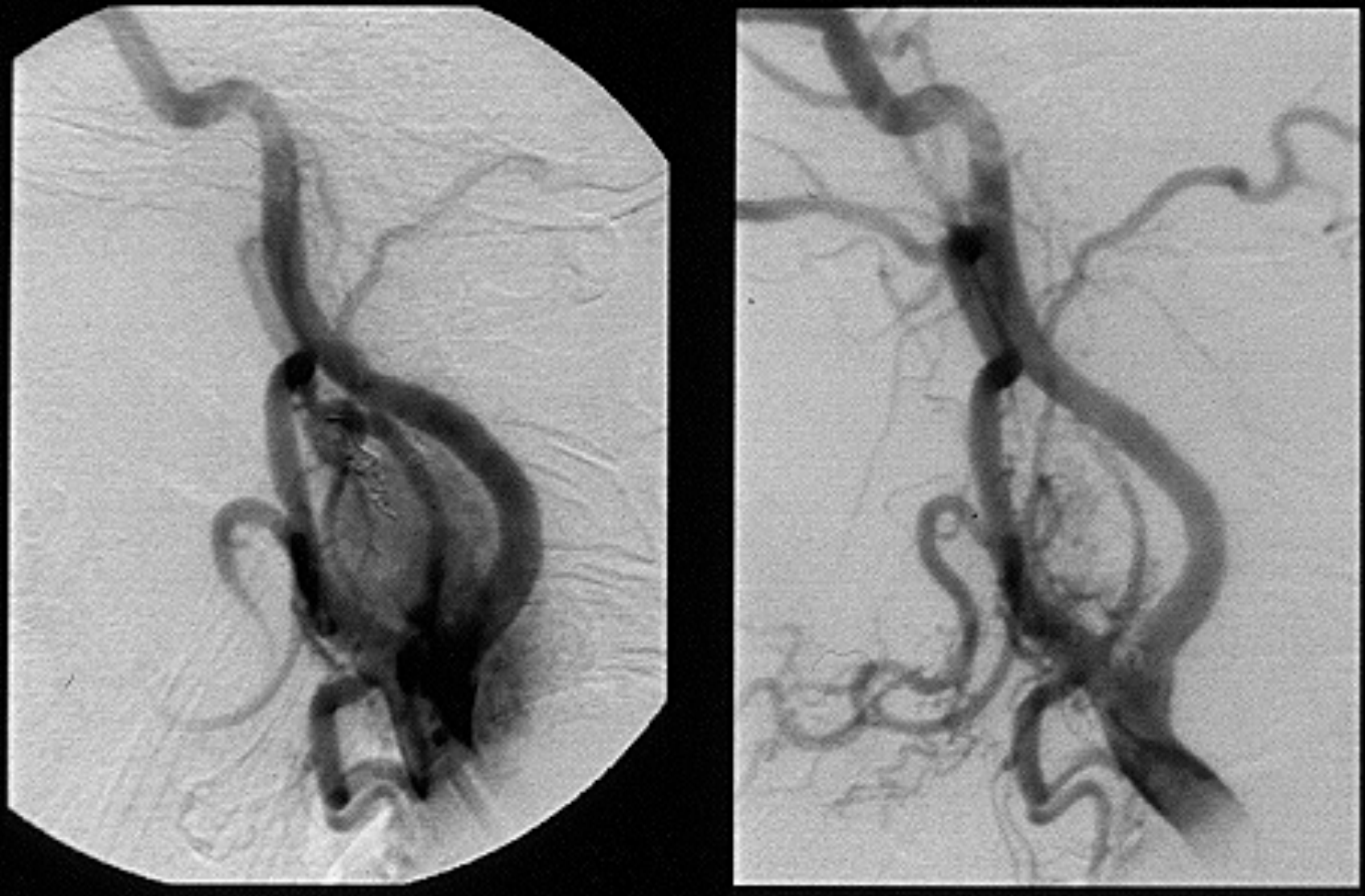
Tumor Post-Embolization



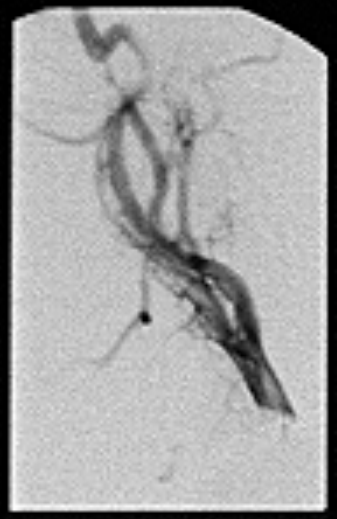
Tumor Embolization-Glomus

Pre Embo

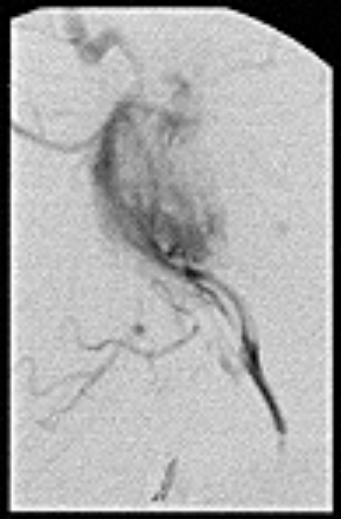
Post Embo

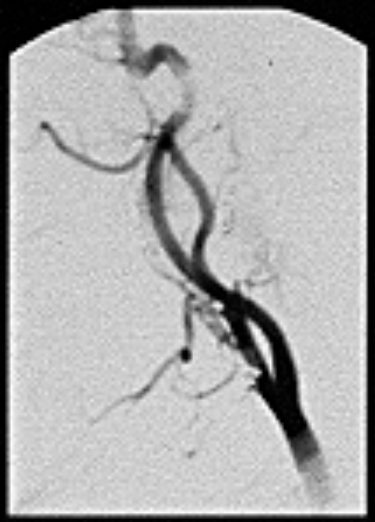


Glomus Vagale Embo

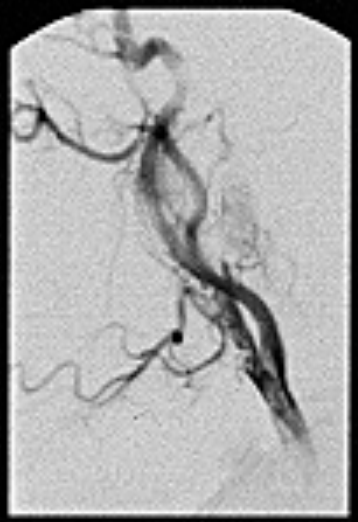


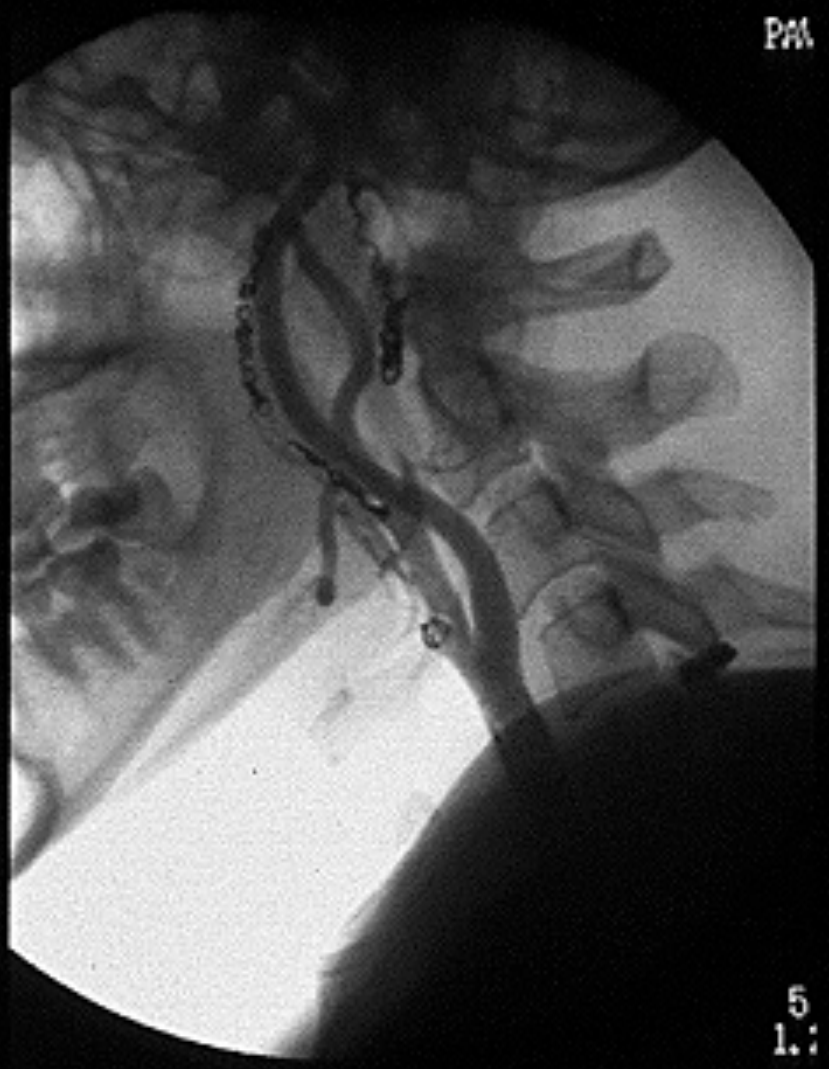
Pre





Post

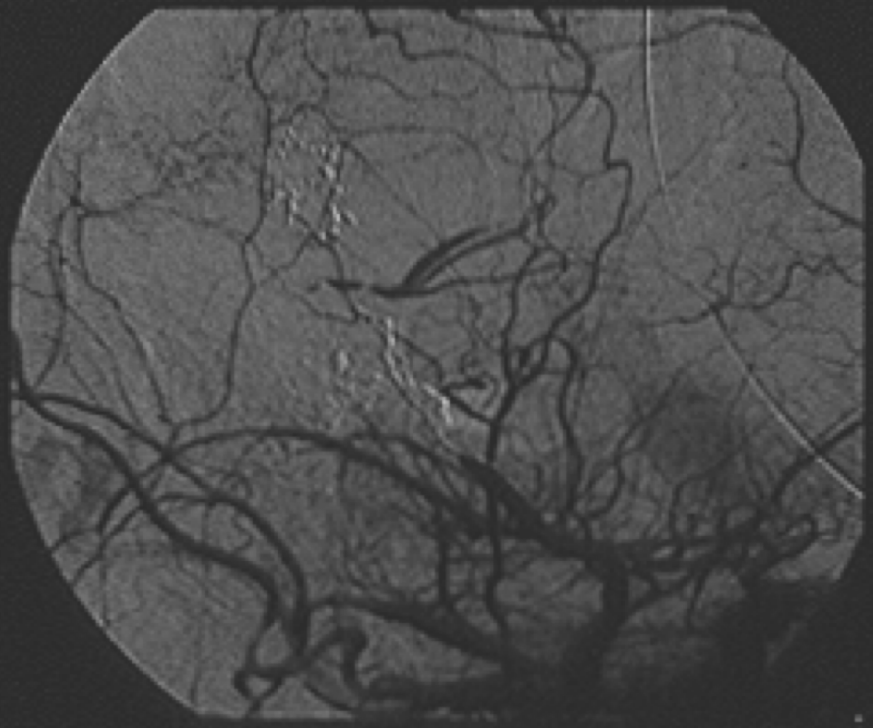




Embolization For Epistaxis

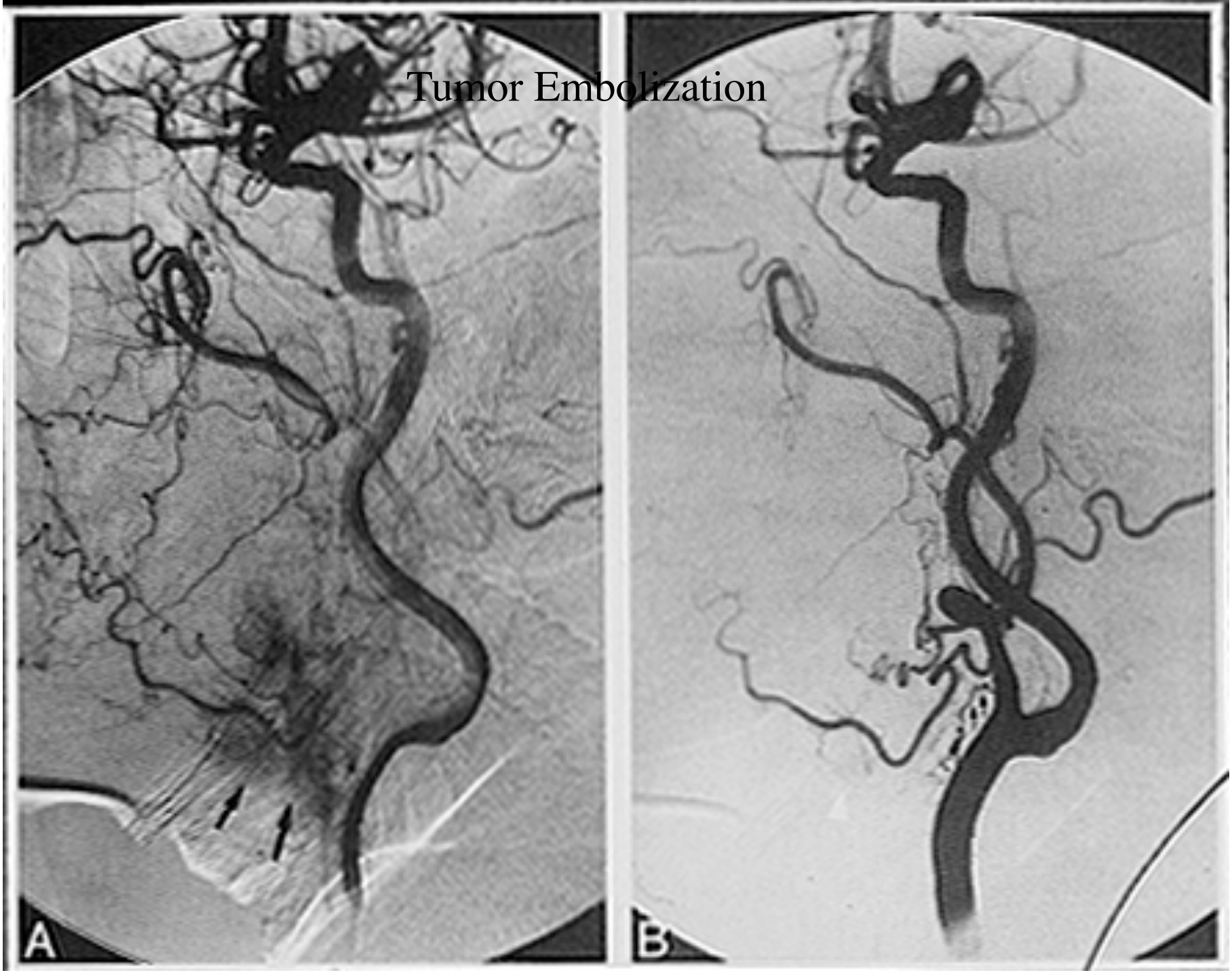
Embolization Facial A-V Fistula Post GSW

Embolization Facial A-V Fistula Post GSW

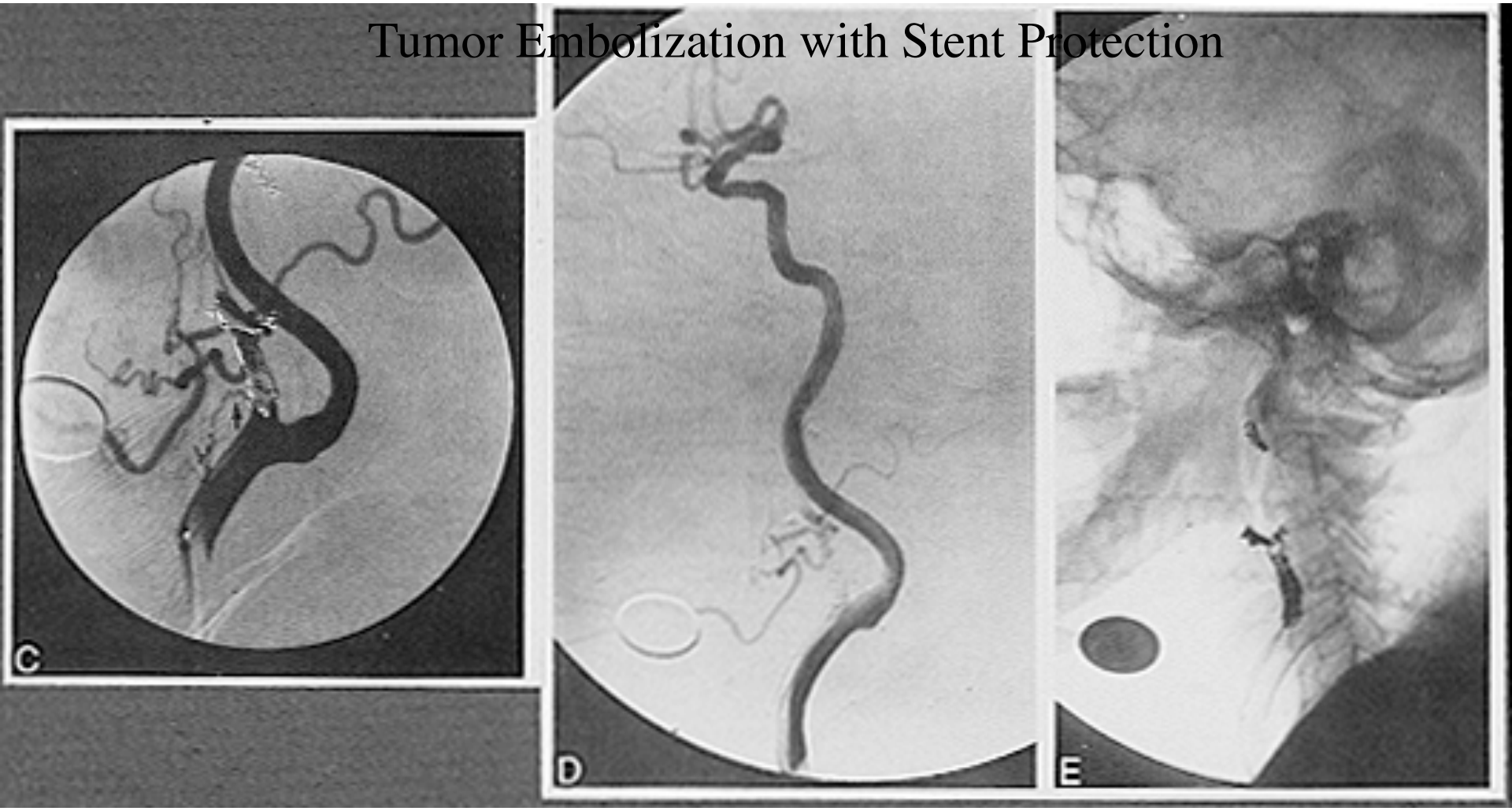


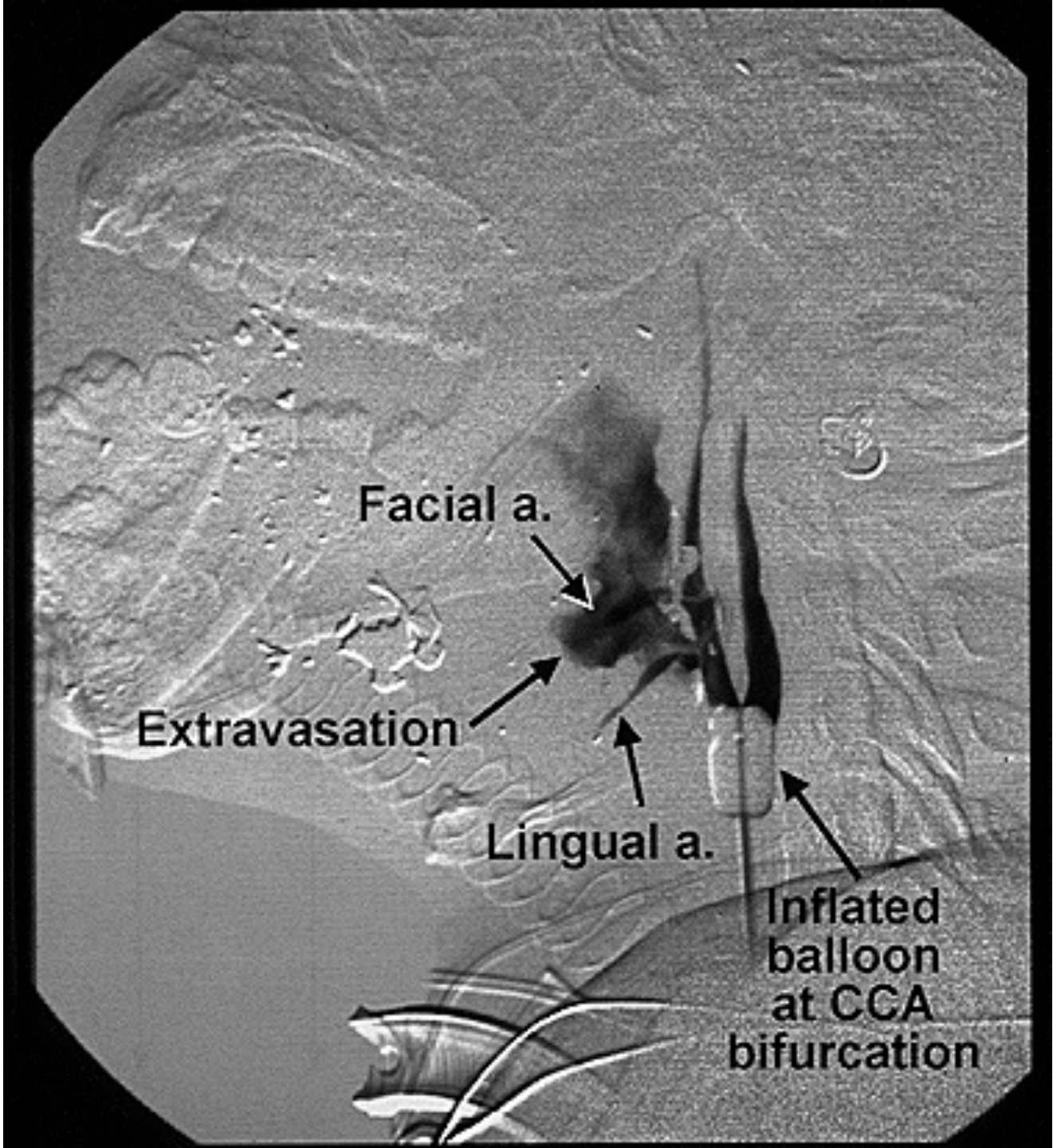
Trial Balloon Occlusion

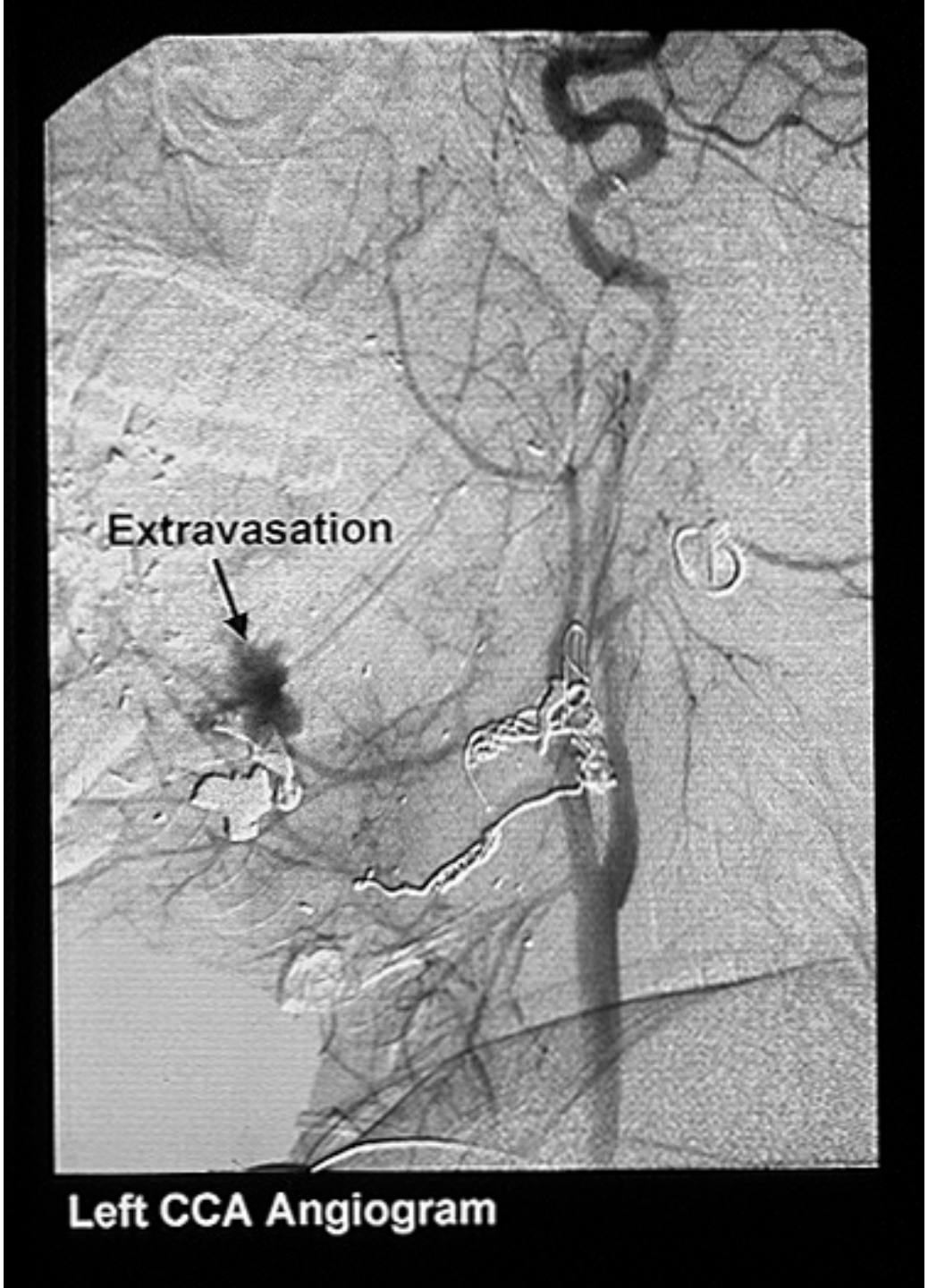
Tumor Embolization

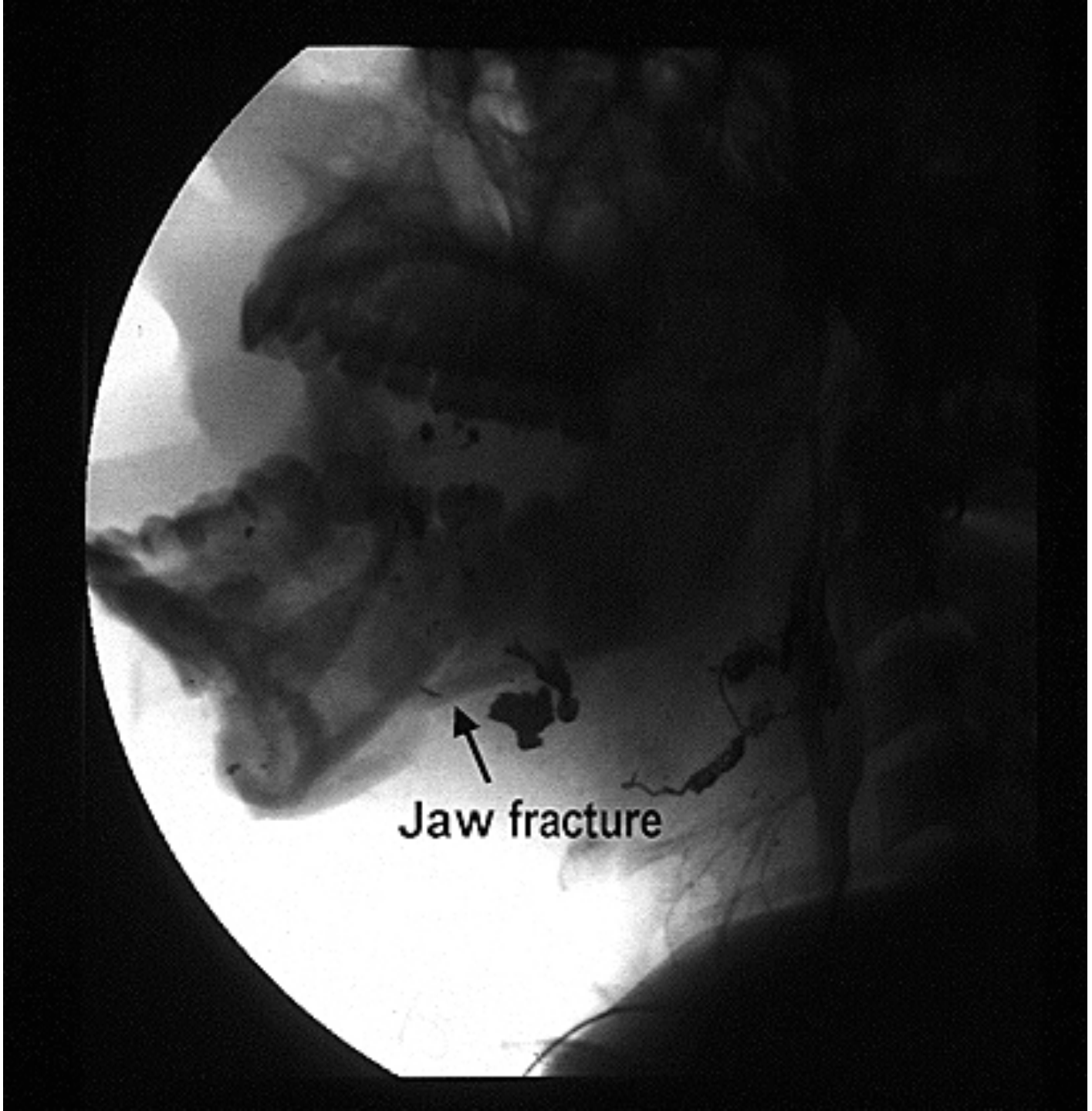


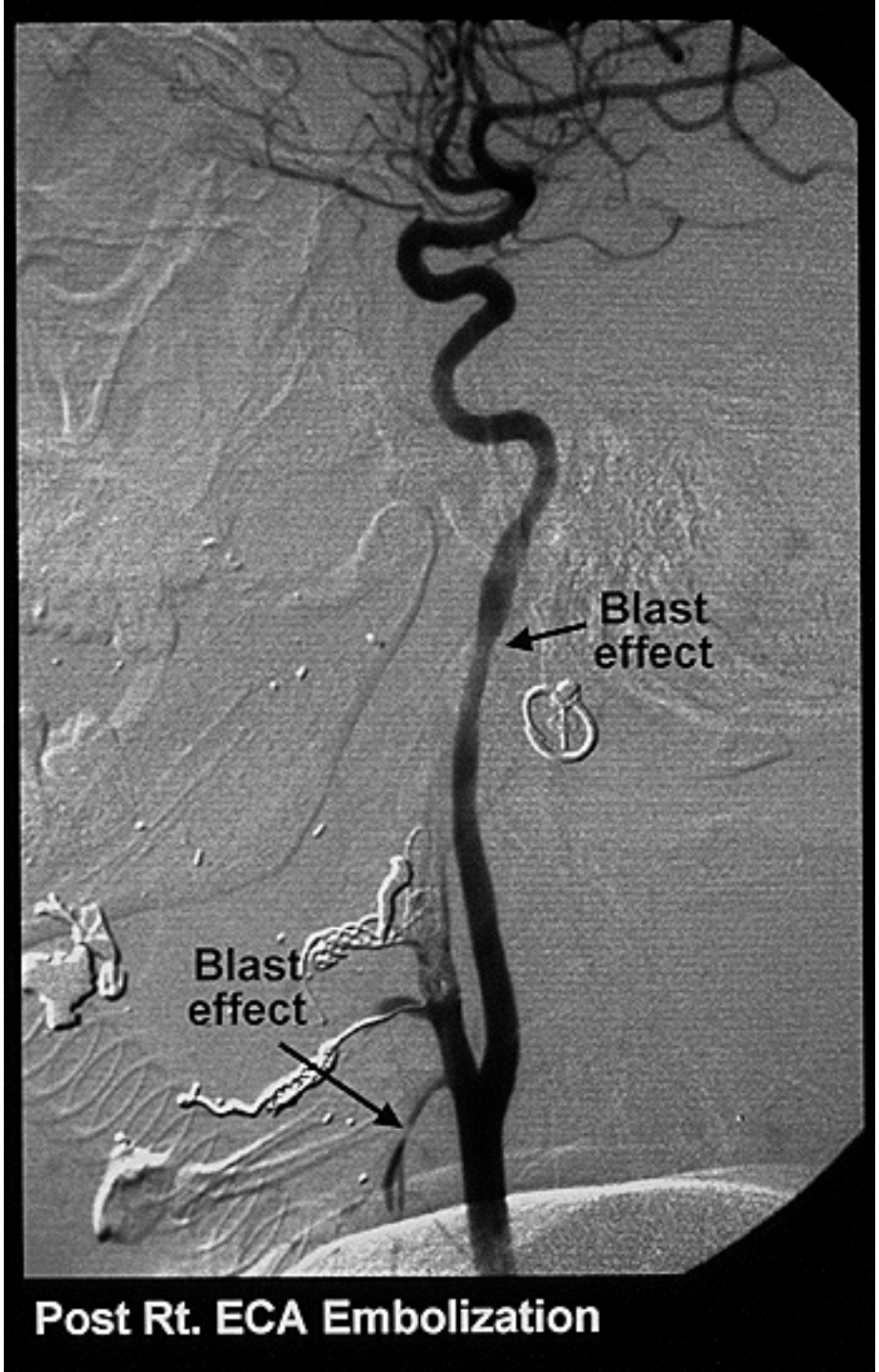
Tumor Embolization with Stent Protection




Facial a.
Extravasation
Lingual a.
Inflated balloon at CCA bifurcation

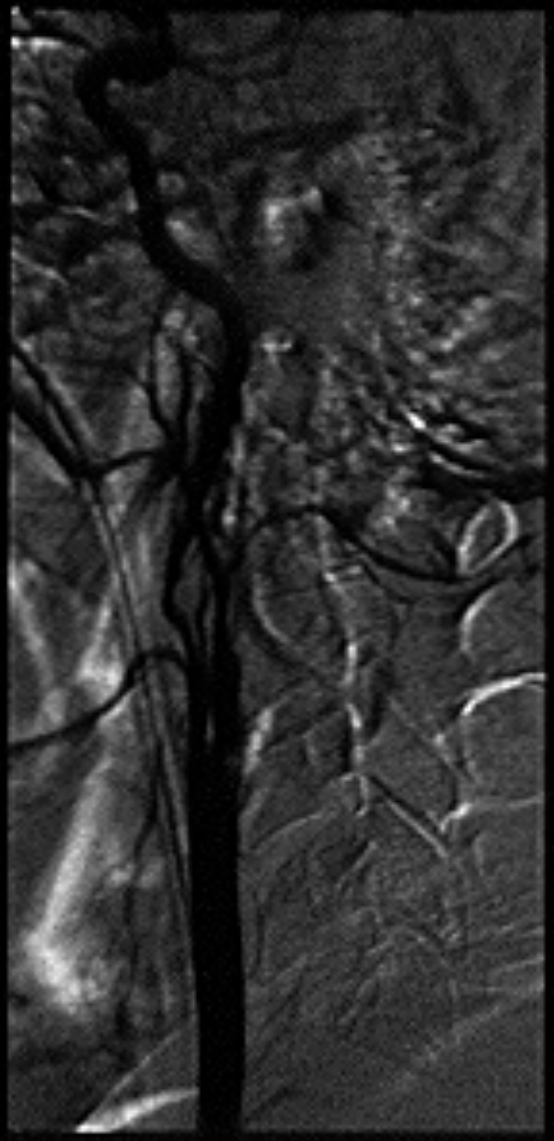

Extravasation
Left CCA Angiogram

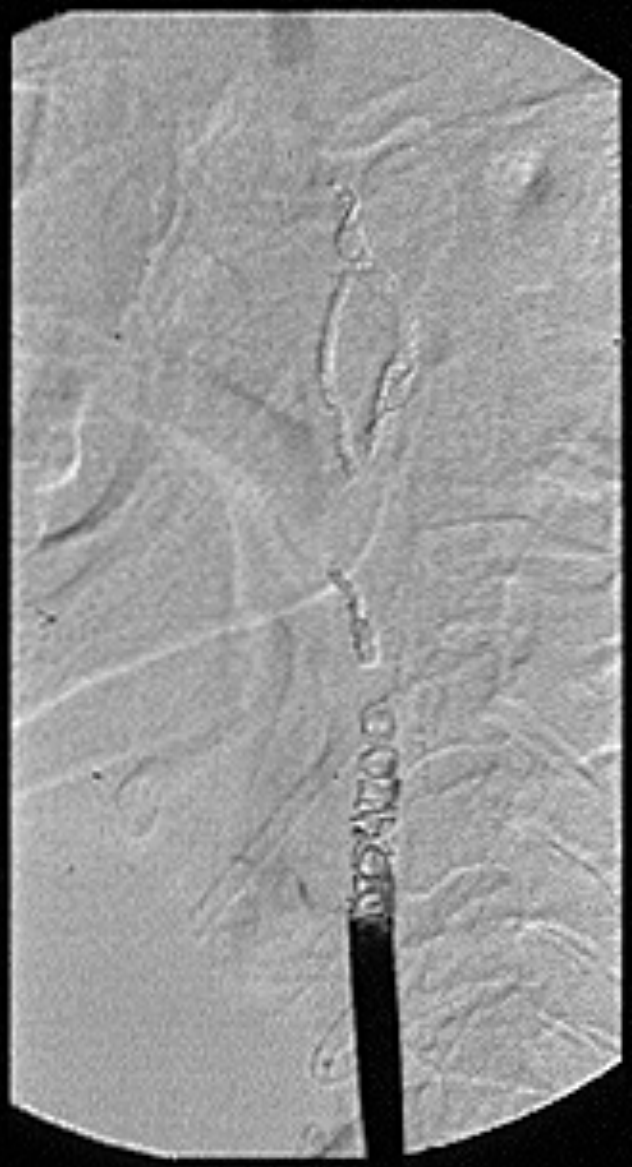

Jaw fracture


Blast
effect
Blast
effect
Post Rt. ECA Embolization

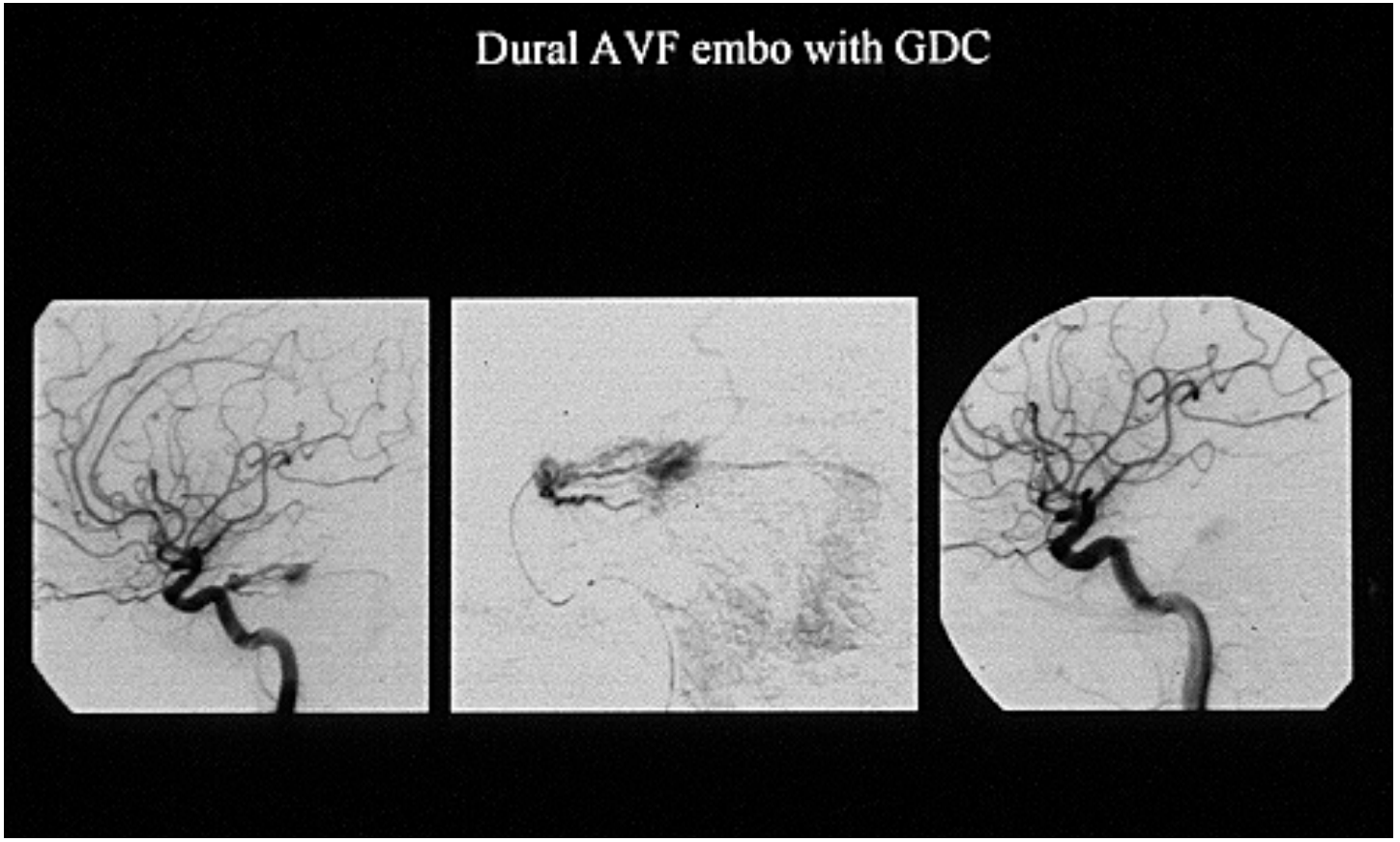
Left CCA Post-embolization

Tumor encased vessels- carotid sacrifice post TBO





Stenting of Pseudoaneurysm


Dural AVF embo with GDC

Intra-arterial Chemotherapy for Head and Neck Cancer

- 24,000 US individuals diagnosed/year
- 8,000-13,000 die annually
- Long term survival SCC 15-70%
- Surgical Procedures
  - Disfiguring
  - Disabling
  - Fewer than 30% with advanced disease cured with surgery and XRT alone

IA Chemotherapy for Head and Neck Cancer

- Reported for last 4 decades (over 70 publications)
- Goal: maximal tumor kill with minimization of sided effects
- Head and neck cancer ideally suited for IAC
  - Locally aggressive
  - Rare widespread metastases
  - Definable and accessible arterial supply (ECA)
  - Responds to anti-neoplastic agents
  - Good delivery systems (catheters,pumps)

Origins of IAC for Head and Neck Cancer

- 1948- Farber used IV methotrexate for children with acute leukemia
- IVC for head and neck cancer
  - Response rates 10-57%
  - Median time to response 10 days
  - Median duration of response 3-4 months

Problems with IVC

- Systemic side-effects with high dose treatment
- Non-maximal delivery of drug to tumor

IAC History (continued)

- 1960s- combination IVC begun
  - Using drugs with non-overlapping toxicities to increase cell kill
  - Synergistic results of multiple agents
  - Minimization of tumor resistance
  - Response rate for head and neck cancer initially 12-50%

IAC

- Bierman (1949)- Nitrogen mustard
- Klopp (1950)
  - Inadvertent injection of nitrogen mustard into brachial artery instead of brachial vein
  - Soft tissues of arm responded with vesiculation and ulceration
  - What would happen to tumors???

Experimental Work

- Klopp
  - Created tumors in rabbit testes
  - Injected IA nitrogen mustard
  - 7-10 days later tumor necrosis seen

Human Experimentation

- Klopp
  - 7 patients with head and neck cancer
  - Complete and permanent pain relief within 48 hours of first treatment
  - All tumors developed central liquifaction and decreased in size
  - Ulcerated squamous cell cancers became soft and flattened with three cases demonstrating near complete epithelialization

IAC

- Sullivan (1959)
  - Felt nitrogen mustard was too destructive of normal tissues
  - Tried IA Methotrexate
  - 66% responded

Subsequent work with IAC

- **Suciu (1966)**
  - 12% complete remission; 38% regression
- **Probert (1969):** Vinblasatine + XRT
  - 69% complete regression; 23% partial regression (92% response)
- **Auersperg (1974):** IAC + XRT
  - 71% showed 50-100% tumor regression (27% complete)
- **Freckman (1972)**
  - 45% response rate
- 14.5 mean duration of response
  - Median survival of responders 16.9 months (4.4 months fo non responders

IAC (continued)

- Holtje (1976)
  - 90% complete remission
  - 22% had remission last 9-61 months
- Becker (1977): IAC + XRT/Surgery
  - 72% two year survival (47% prior to IAC)
  - 55% five year survival (30% before IAC)

IAC (continued)

- Matras (1978): IAC vs. IVC
  - IAC 64.5% complete or partial remission for mean duration of 9.7 months
  - IVC 20% complete or partial remission for mean duration of 3 months
  - IAC resulted in some remissions without XRT while IVC required XRT for remissions

IAC (continued)

- Moseley (1980): IAC + XRT/Surgery
  - 60% survival at 50 months
  - After median FU of 24 months only one resected patient suffered a local recurrence

IAC (continued)

- **Baker (1981, 1982, 1983)**
  - IAC with implanted pump
  - 4-104+ week infusions
  - Advantages
    - High tumor concentrations of drug using IA route
    - Reduction in systemic toxicity using IA route
    - Ensure availability of chemotherapy to a tumor region when collateral pathways open up (tumor flow to all regions is not constant)
    - Exposure of cells throughout cell cycle and exposure of cells that are asynchronous
    - Ability for patients to undergo chemotherapy as an outpatient

IAC (continued)

- **Straehler-Pohl (1982):** Chemo +XRT/Surg
  - 80% response rate
  - 54% better results than with XRT alone
- **Szepesi (1973-1982)**
  - 66 patients with inoperable neoplasms treated with IAC + XRT
  - 17% complete remission with disease free survival 56+ months and median survival 82 months
  - 48% partial remission

IAC (continued)

- Galmarini (1985)
  - 29% complete remission
  - 58% partial remission
- Inuyama (1985)
  - 47% complete response
  - 40% partial response
  - 83% thirty month survival

IAC (continued)

- **Molinari (1985):** IAC + XRT/Surgery
  - IAC response
    - 74% tumor regression > 50%
    - 41% tumor regression >75%
  - IAC +XRT
    - Five year survival for those in >75% group was 60%
    - 50% of those who underwent IAC and subsequent surgery were initially felt to be inoperable but became candidates when tumor size was reduced
    - Five year survival in initial inoperable group was 7% with median survival of 16 months
    - Five year survival in those undergoing IAC and planned surgery (surgical candidates prior to IAC) was 60%

IAC (Molinari continued)

- IAC/planned surgery group had 25% local recurrence
- In the IAC/Surgery group if no local recurrences were experienced by three years, it was rare to have a local recurrence and death was secondary to a second primary tumor
- Control group having surgery and no initial IAC had 42% local recurrence

IAC (continued)

- **Lee (1984)** 57.1% response
- **Inuyama (1986)** 26% complete response; 42% partial response
- **Cheung (1980s)** IAC + IVC: 94% response; median response >39 months
- **Lee (1989)** 91% tumor response rate; 33% avoided surgery due to degree of tumor regression
- **Shimuzu (1980s)** 100% response rate; 20% cure rate
- **Claudio (1990)** 76-88% response rate for unresectable tumors; after IAC 72% became resectable
- **Robbins (1992)** 67% complete response rate in previusly untreated patients; 20% response rate in recurrent disease; 56% survival at 9.5 months

IAC (continued)

- **Robbins (1997)** Complete response with XRT+IAC in 75%
- **Simunek (1993)** 70% response for lingual cancer with 39% complete remission
- **Korogi ((1995)** 38% complete response; 54% partial response (>50% reduction in tumor size)
- **Benazzo (1996)** 96% complete/partial reponse
- **Scheel (1996, 1999)** Five year survival in inoperable cases was 39%; 50% complete remission for oral cancer
- **Kerber (1997)** 93% complete tumor regression
- **Kovacs (1999)** 80.6% partial/complete remission; 61% survival at 22 months
- **Hirai (1999)** 95% response rate with 24% complete remission; IAC+Surgery 91% three year survival; IAC + XRT 40%

IAC (continued)

- **Nakasato (2000)** 88% complete remission for superselective catheterization; 80% for subselective catheterization; local recurrence greater for subselective than superselective catheterization (13% v 6%)
- **Fuwa (2000)** 66% complete response; 36.2 month median survival; 2,3,5 year survivals 73%, 63%, 59%; mean progression free survival 25 months
- **Furutani (2002)** 95% response rate; three year local control rates 80%; three year progression free survival rate 53.2%; overall three year survival rate 59%
- **Robbins (2003)** IAC + XRT 80% complete response at primary site; 79% response to tumor that spread to neck; five year survival 54%

IAC Complications

- Stomatitis
- Tissue necrosis
- Thrombosis
- Stroke
- TIA
- Local swelling
- Tinnitus
- Impaired hearing and taste
- Throbocytopenia
- Leukopenia
- Sepsis
- Renal failure

IAC Complications

- **Gemmete (2003):** N=385
  - 5.7% insignificant groin hematomas
  - 0.5% external iliac occlusions requiring bypass
  - 0.5% asymptomatic common carotid occlusions
  - 10.6% chemotaxic events
    - 7.5% mucosal
    - 2.3% hematologic
    - 0.5% otologic
    - 0.25% GI
  - 1.5% neurologic events (0.75% permanent, 0.75% transient)

IAC Complications

- Newman (2002): IAC/XRT vs. IVC/XRT
  - No differences in terms of swallowing except for less aspiration on 1-3 cc samples with IAC

Goals

- Develop IAC Protocols and a 5 Year Study
- Organize with PCI, ENT, and NS

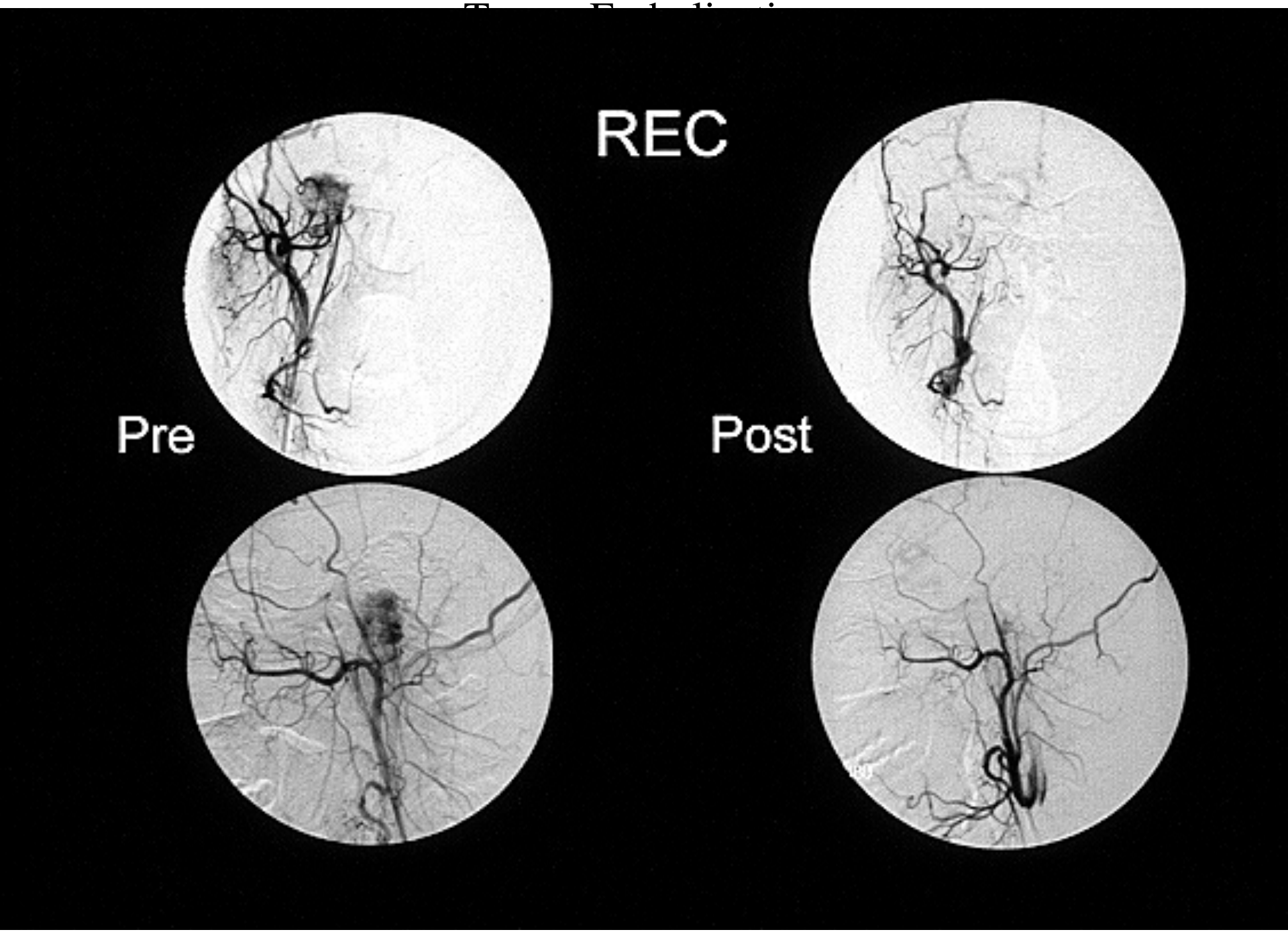
Endovascular Neurosurgery

Head and Neck Tumors

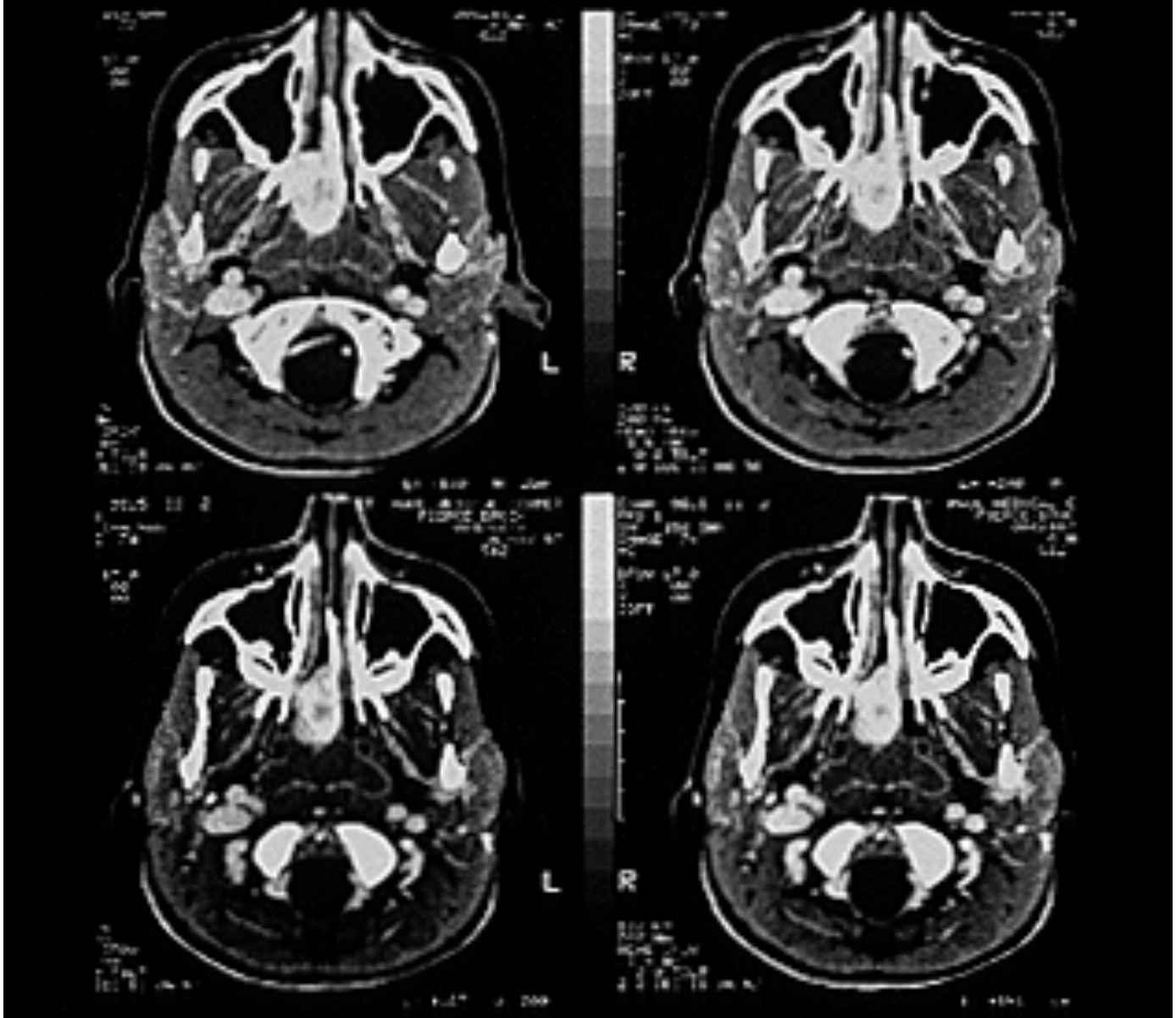
Michael Horowitz, M.D.
Associate Professor of Neurosurgery and Radiology
University of Pittsburgh

Procedures Performed

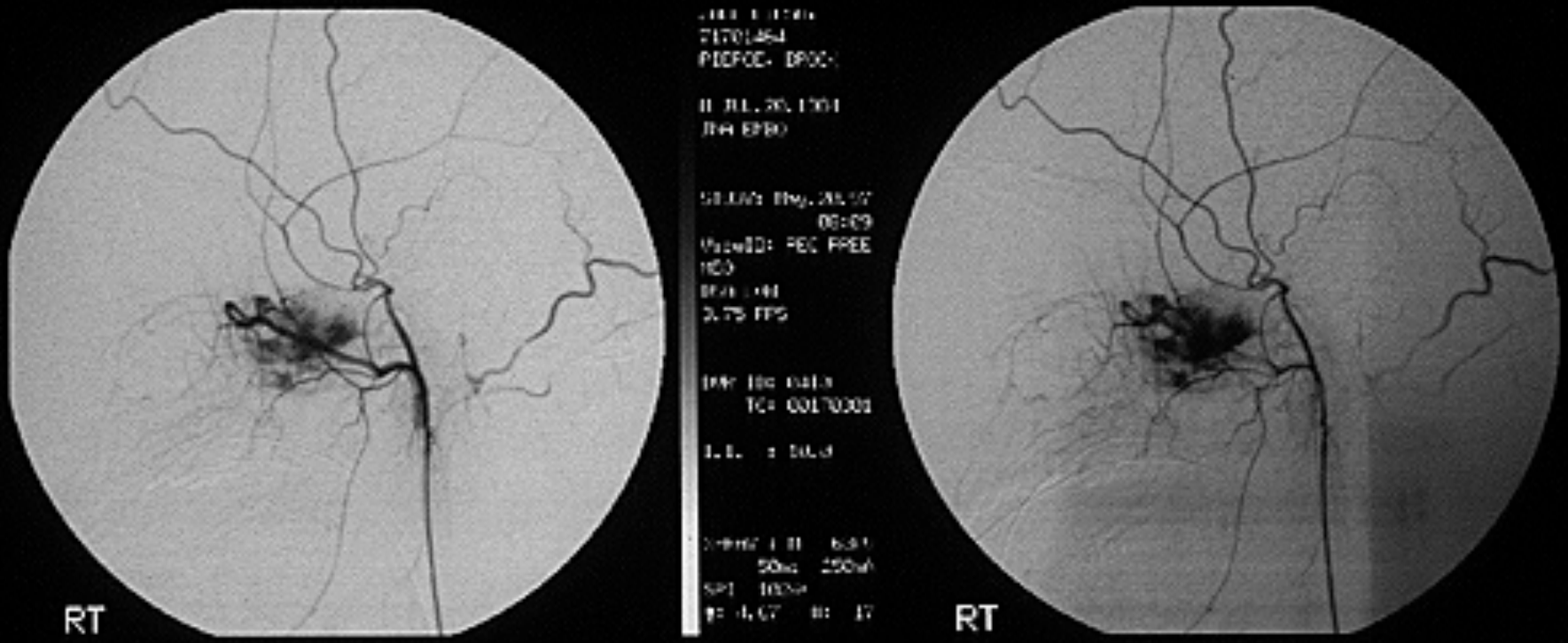
- Interventional Procedures
  - **Balloon test occlusions**
  - **Vessel sacrifice and embolization**
  - **Tumor embolization**
  - **Chemotherapy**


REC
Pre
Post

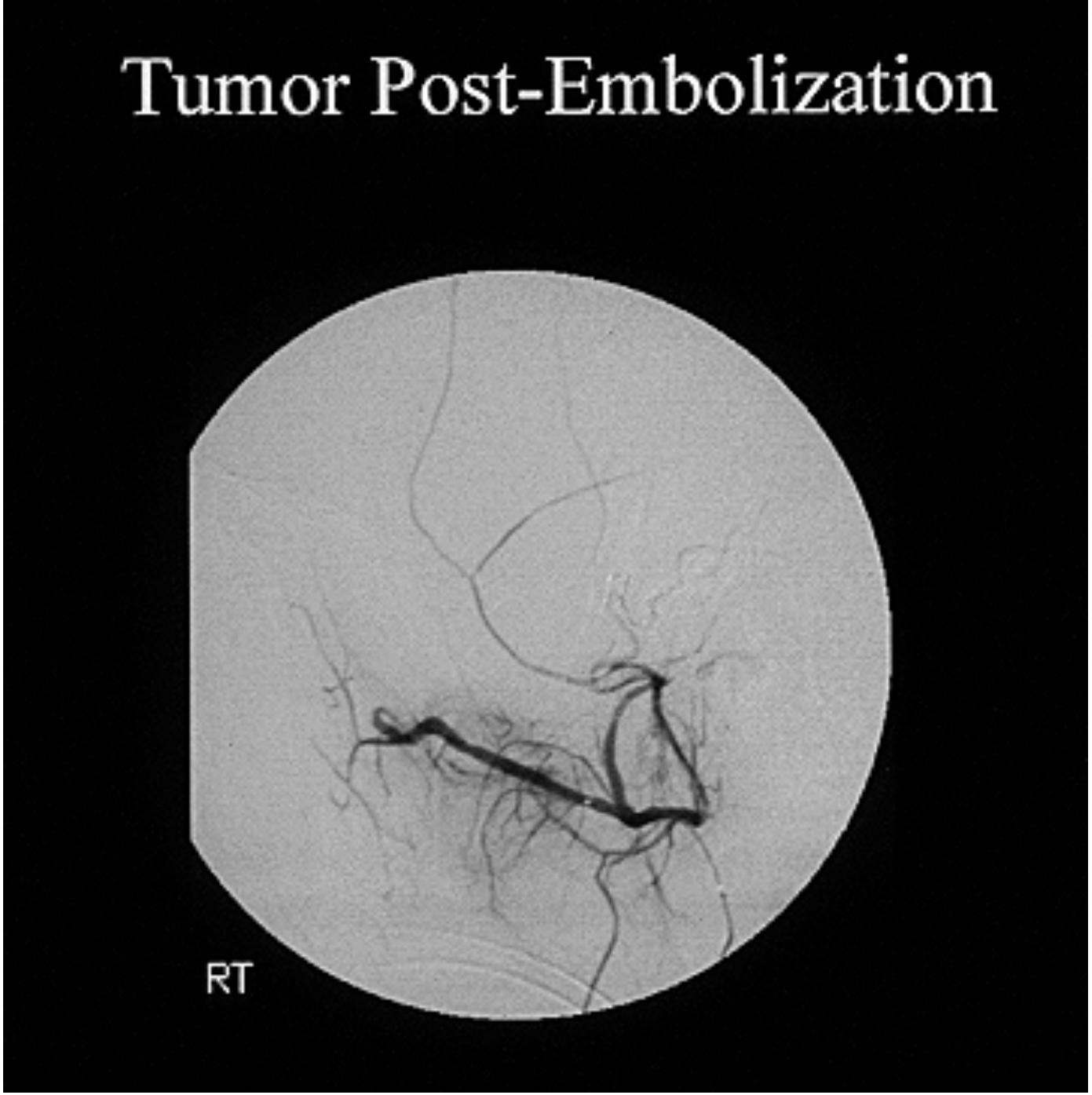
Tumor Embolization



Tumor Blush Pre-Embolization



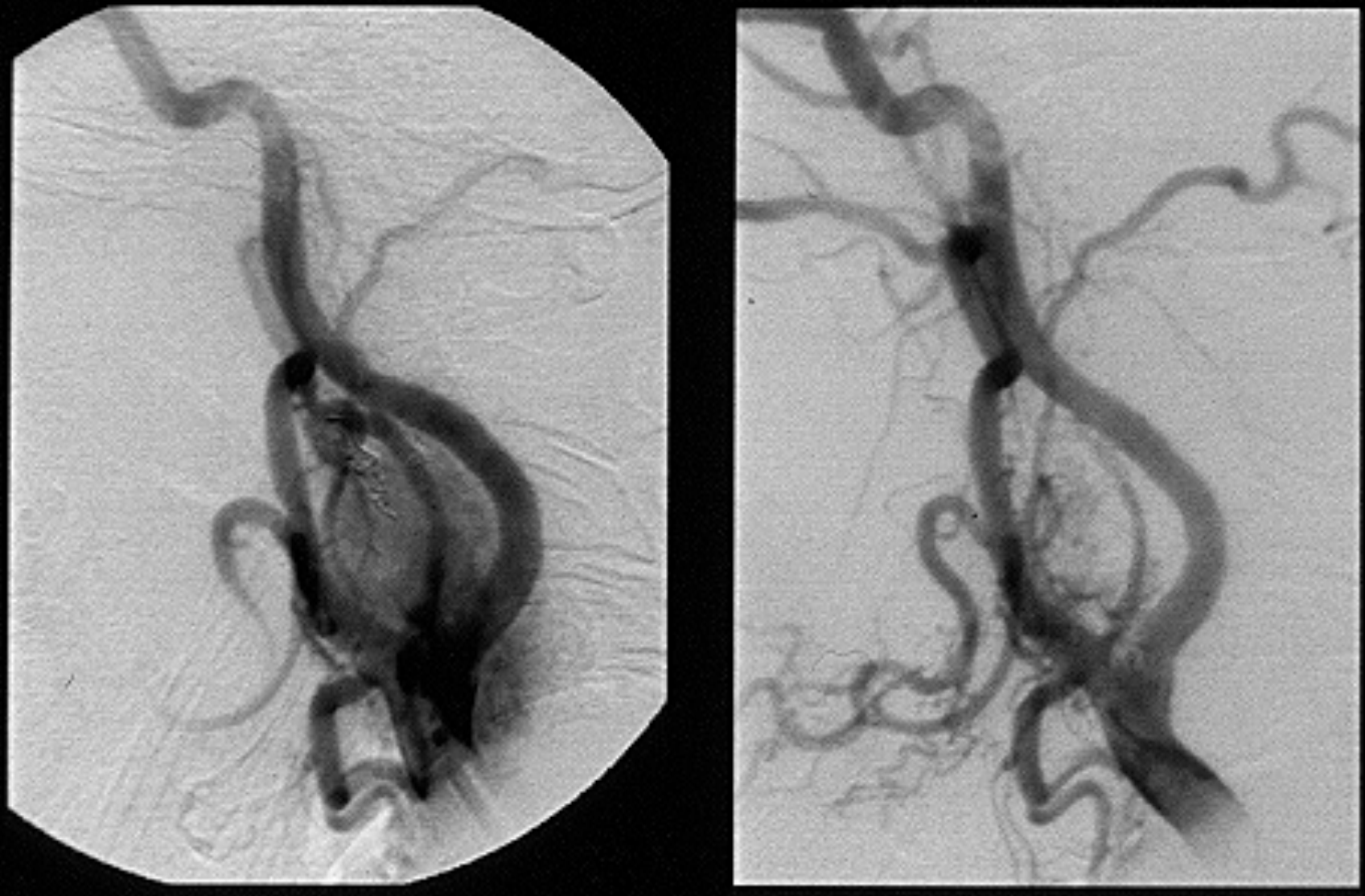
Tumor Post-Embolization



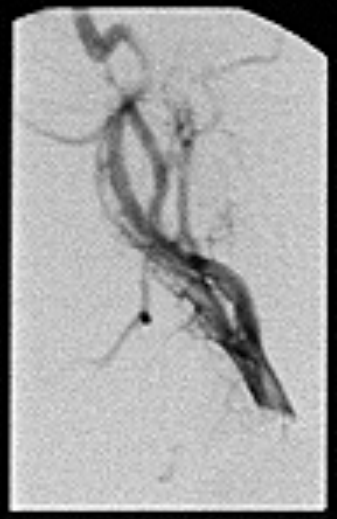
Tumor Embolization-Glomus

Pre Embo

Post Embo



Glomus Vagale Embo



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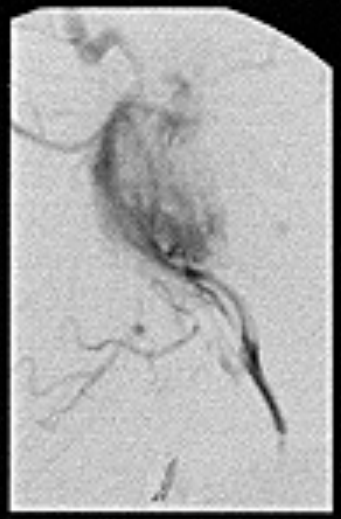

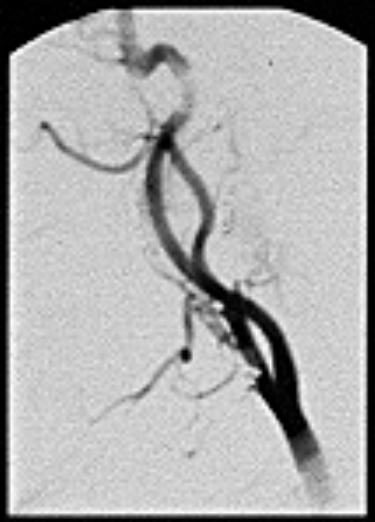

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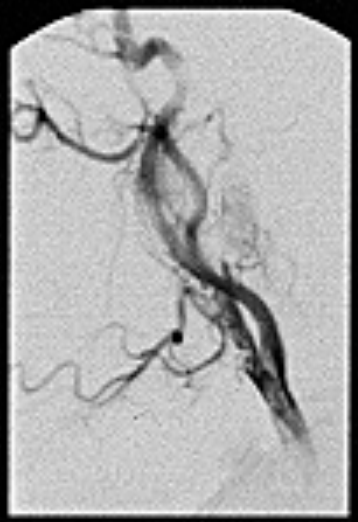
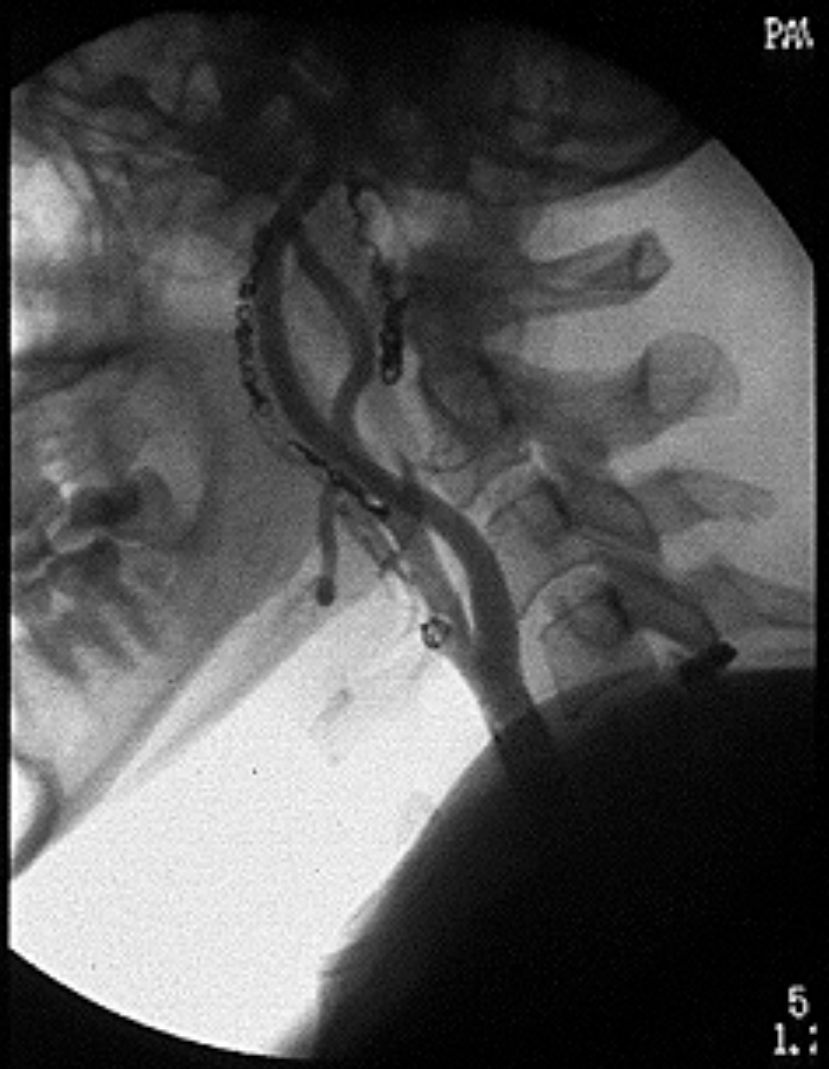
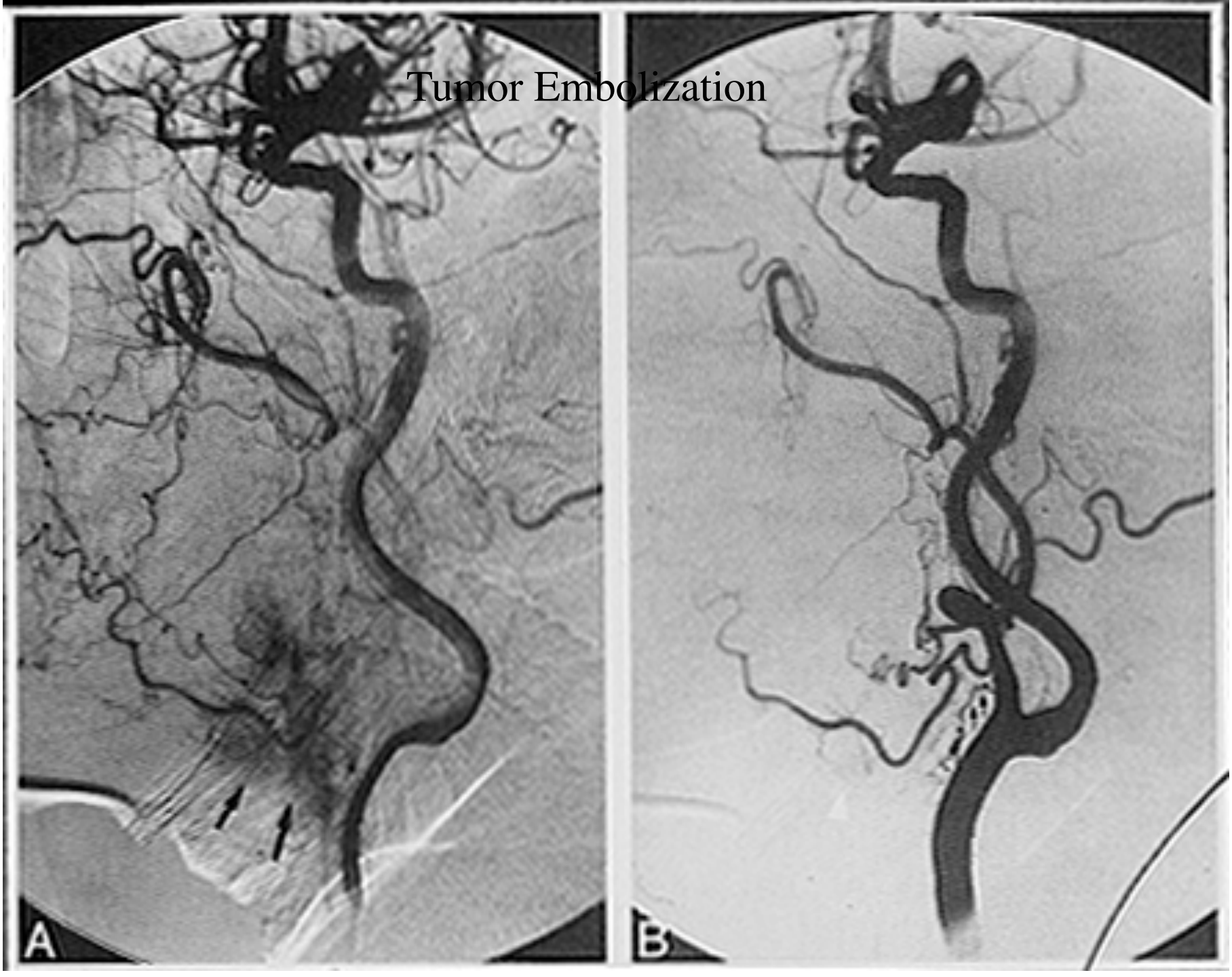


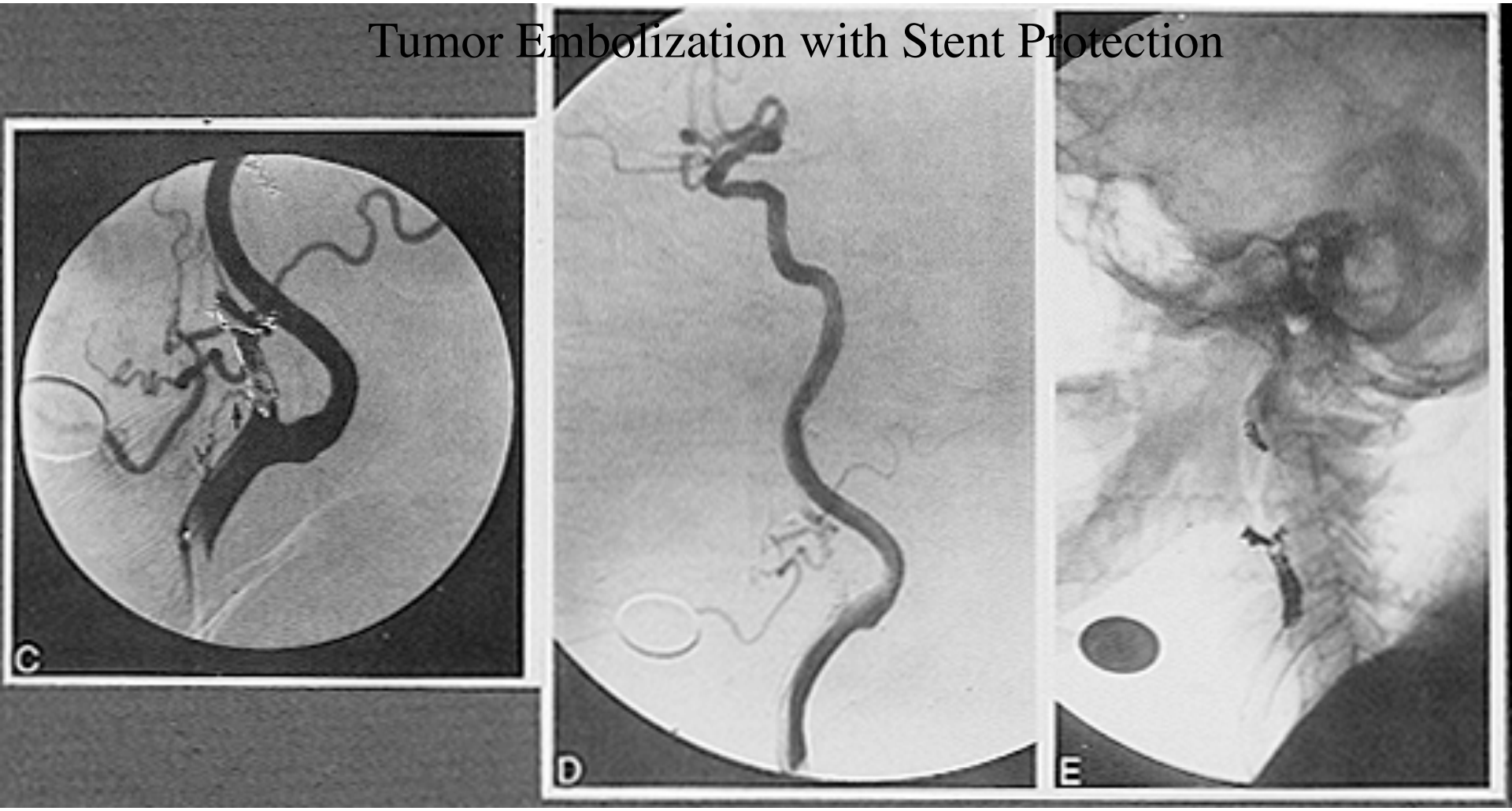


Trial Balloon Occlusion

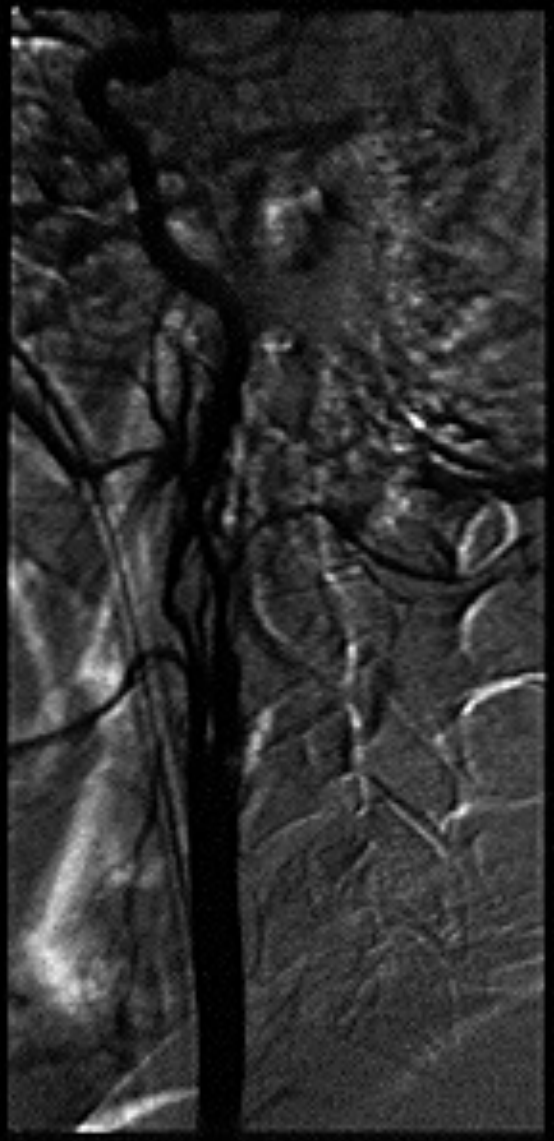
Tumor Embolization

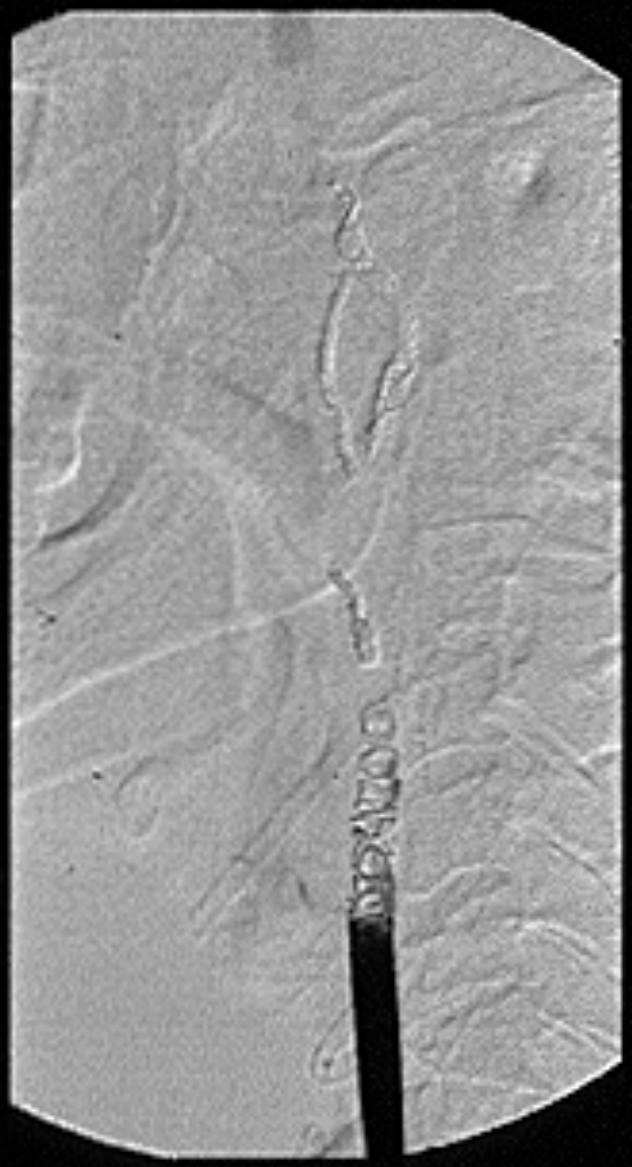


Tumor Embolization with Stent Protection



Tumor encased vessels- carotid sacrifice post TBO





Stenting of Pseudoaneurysm

Intra-arterial Chemotherapy for Head and Neck Cancer

- 24,000 US individuals diagnosed/year
- 8,000-13,000 die annually
- Long term survival SCC 15-70%
- Surgical Procedures
  - Disfiguring
  - Disabling
  - Fewer than 30% with advanced disease cured with surgery and XRT alone

IA Chemotherapy for Head and Neck Cancer

- Reported for last 4 decades (over 70 publications)
- Goal: maximal tumor kill with minimization of sided effects
- Head and neck cancer ideally suited for IAC
  - Locally aggressive
  - Rare widespread metastases
  - Definable and accessible arterial supply (ECA)
  - Responds to anti-neoplastic agents
  - Good delivery systems (catheters,pumps)

Origins of IAC for Head and Neck Cancer

- 1948- Farber used IV methotrexate for children with acute leukemia
- IVC for head and neck cancer
  - Response rates 10-57%
  - Median time to response 10 days
  - Median duration of response 3-4 months

Problems with IVC

- Systemic side-effects with high dose treatment
- Non-maximal delivery of drug to tumor

IAC History (continued)

- 1960s- combination IVC begun
  - Using drugs with non-overlapping toxicities to increase cell kill
  - Synergistic results of multiple agents
  - Minimization of tumor resistance
  - Response rate for head and neck cancer initially 12-50%

IAC

- Bierman (1949)- Nitrogen mustard
- Klopp (1950)
  - Inadvertent injection of nitrogen mustard into brachial artery instead of brachial vein
  - Soft tissues of arm responded with vesiculation and ulceration
  - What would happen to tumors???

Experimental Work

- Klopp
  - Created tumors in rabbit testes
  - Injected IA nitrogen mustard
  - 7-10 days later tumor necrosis seen

Human Experimentation

- Klopp
  - 7 patients with head and neck cancer
  - Complete and permanent pain relief within 48 hours of first treatment
  - All tumors developed central liquifaction and decreased in size
  - Ulcerated squamous cell cancers became soft and flattened with three cases demonstrating near complete epithelialization

IAC

- Sullivan (1959)
  - Felt nitrogen mustard was too destructive of normal tissues
  - Tried IA Methotrexate
  - 66% responded

Subsequent work with IAC

- **Suciu (1966)**
  - 12% complete remission; 38% regression
- **Probert (1969):** Vinblasatine + XRT
  - 69% complete regression; 23% partial regression (92% response)
- **Auersperg (1974):** IAC + XRT
  - 71% showed 50-100% tumor regression (27% complete)
- **Freckman (1972)**
  - 45% response rate
- 14.5 mean duration of response
  - Median survival of responders 16.9 months (4.4 months fo non responders

IAC (continued)

- Holtje (1976)
  - 90% complete remission
  - 22% had remission last 9-61 months
- Becker (1977): IAC + XRT/Surgery
  - 72% two year survival (47% prior to IAC)
  - 55% five year survival (30% before IAC)

IAC (continued)

- Matras (1978): IAC vs. IVC
  - IAC 64.5% complete or partial remission for mean duration of 9.7 months
  - IVC 20% complete or partial remission for mean duration of 3 months
  - IAC resulted in some remissions without XRT while IVC required XRT for remissions

IAC (continued)

- Moseley (1980): IAC + XRT/Surgery
  - 60% survival at 50 months
  - After median FU of 24 months only one resected patient suffered a local recurrence

IAC (continued)

- **Baker (1981, 1982, 1983)**
  - IAC with implanted pump
  - 4-104+ week infusions
  - Advantages
    - High tumor concentrations of drug using IA route
    - Reduction in systemic toxicity using IA route
    - Ensure availability of chemotherapy to a tumor region when collateral pathways open up (tumor flow to all regions is not constant)
    - Exposure of cells throughout cell cycle and exposure of cells that are asynchronous
    - Ability for patients to undergo chemotherapy as an outpatient

IAC (continued)

- **Straehler-Pohl (1982):** Chemo +XRT/Surg
  - 80% response rate
  - 54% better results than with XRT alone
- **Szepesi (1973-1982)**
  - 66 patients with inoperable neoplasms treated with IAC + XRT
  - 17% complete remission with disease free survival 56+ months and median survival 82 months
  - 48% partial remission

IAC (continued)

- Galmarini (1985)
  - 29% complete remission
  - 58% partial remission
- Inuyama (1985)
  - 47% complete response
  - 40% partial response
  - 83% thirty month survival

IAC (continued)

- **Molinari (1985):** IAC + XRT/Surgery
  - IAC response
    - 74% tumor regression > 50%
    - 41% tumor regression >75%
  - IAC +XRT
    - Five year survival for those in >75% group was 60%
    - 50% of those who underwent IAC and subsequent surgery were initially felt to be inoperable but became candidates when tumor size was reduced
    - Five year survival in initial inoperable group was 7% with median survival of 16 months
    - Five year survival in those undergoing IAC and planned surgery (surgical candidates prior to IAC) was 60%

IAC (Molinari continued)

- IAC/planned surgery group had 25% local recurrence
- In the IAC/Surgery group if no local recurrences were experienced by three years, it was rare to have a local recurrence and death was secondary to a second primary tumor
- Control group having surgery and no initial IAC had 42% local recurrence

IAC (continued)

- **Lee (1984)** 57.1% response
- **Inuyama (1986)** 26% complete response; 42% partial response
- **Cheung (1980s)** IAC + IVC: 94% response; median response >39 months
- **Lee (1989)** 91% tumor response rate; 33% avoided surgery due to degree of tumor regression
- **Shimuzu (1980s)** 100% response rate; 20% cure rate
- **Claudio (1990)** 76-88% response rate for unresectable tumors; after IAC 72% became resectable
- **Robbins (1992)** 67% complete response rate in previusly untreated patients; 20% response rate in recurrent disease; 56% survival at 9.5 months

IAC (continued)

- **Robbins (1997)** Complete response with XRT+IAC in 75%
- **Simunek (1993)** 70% response for lingual cancer with 39% complete remission
- **Korogi ((1995)** 38% complete response; 54% partial response (>50% reduction in tumor size)
- **Benazzo (1996)** 96% complete/partial reponse
- **Scheel (1996, 1999)** Five year survival in inoperable cases was 39%; 50% complete remission for oral cancer
- **Kerber (1997)** 93% complete tumor regression
- **Kovacs (1999)** 80.6% partial/complete remission; 61% survival at 22 months
- **Hirai (1999)** 95% response rate with 24% complete remission; IAC+Surgery 91% three year survival; IAC + XRT 40%

IAC (continued)

- **Nakasato (2000)** 88% complete remission for superselective catheterization; 80% for subselective catheterization; local recurrence greater for subselective than superselective catheterization (13% v 6%)
- **Fuwa (2000)** 66% complete response; 36.2 month median survival; 2,3,5 year survivals 73%, 63%, 59%; mean progression free survival 25 months
- **Furutani (2002)** 95% response rate; three year local control rates 80%; three year progression free survival rate 53.2%; overall three year survival rate 59%
- **Robbins (2003)** IAC + XRT 80% complete response at primary site; 79% response to tumor that spread to neck; five year survival 54%

IAC Complications

- Stomatitis
- Tissue necrosis
- Thrombosis
- Stroke
- TIA
- Local swelling
- Tinnitus
- Impaired hearing and taste
- Throbocytopenia
- Leukopenia
- Sepsis
- Renal failure

IAC Complications

- **Gemmete (2003):** N=385
  - 5.7% insignificant groin hematomas
  - 0.5% external iliac occlusions requiring bypass
  - 0.5% asymptomatic common carotid occlusions
  - 10.6% chemotaxic events
    - 7.5% mucosal
    - 2.3% hematologic
    - 0.5% otologic
    - 0.25% GI
  - 1.5% neurologic events (0.75% permanent, 0.75% transient)

IAC Complications

- Newman (2002): IAC/XRT vs. IVC/XRT
  - No differences in terms of swallowing except for less aspiration on 1-3 cc samples with IAC

Goals

- Develop IAC Protocols and a 5 Year Study
- Organize with PCI, ENT, and NS