



脳動脈瘤に対する血管内治療と 流体解析によせる期待

深作和明

信州大学

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根来 真

名古屋大学 脳神経外科

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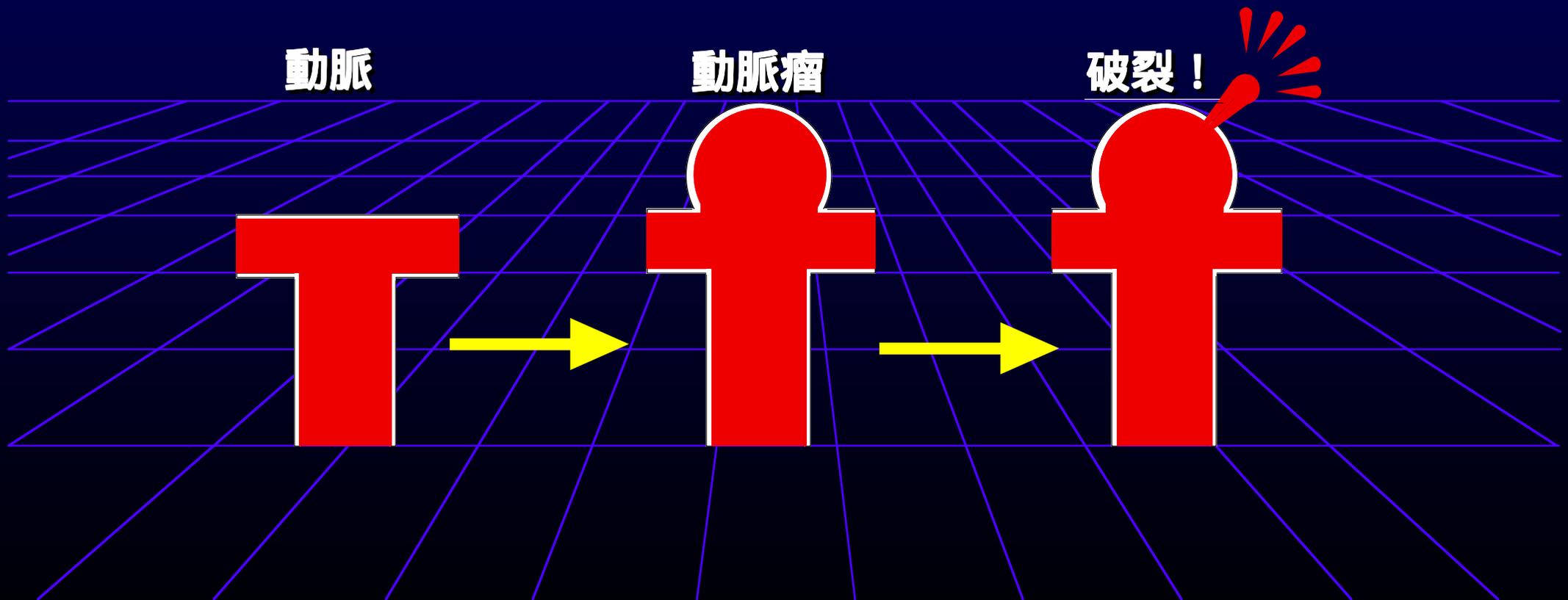
信州大学 一之瀬脳神経外科病院 脳神経外
科

理化学研究所 情報環境室

根来 真

名古屋大学 脳神経外科

脳動脈瘤、クモ膜下出血とは？

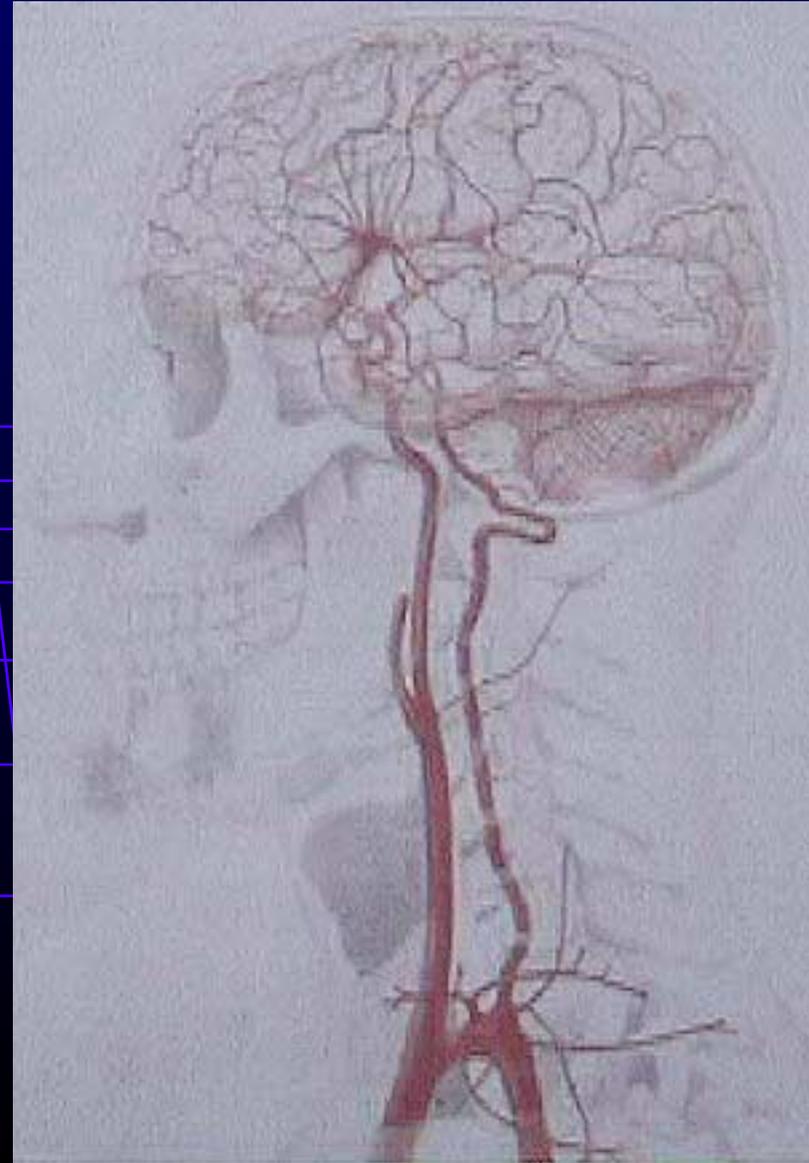
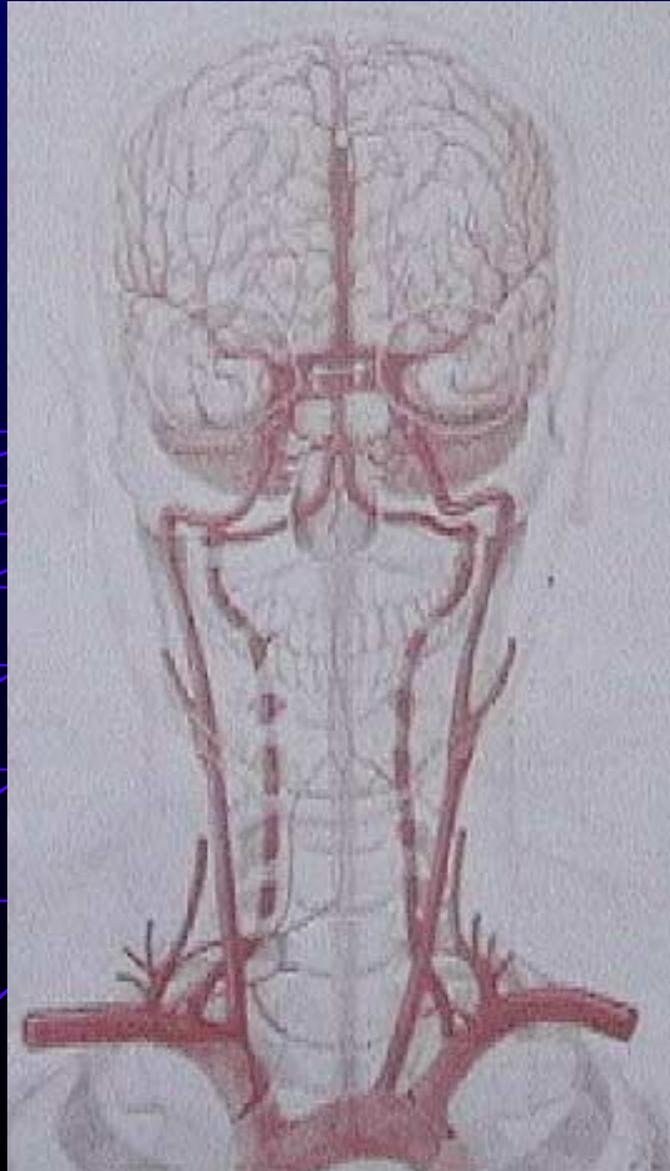


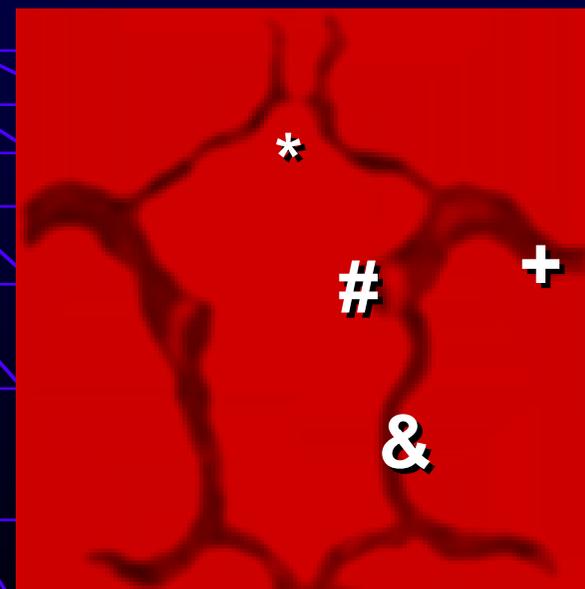
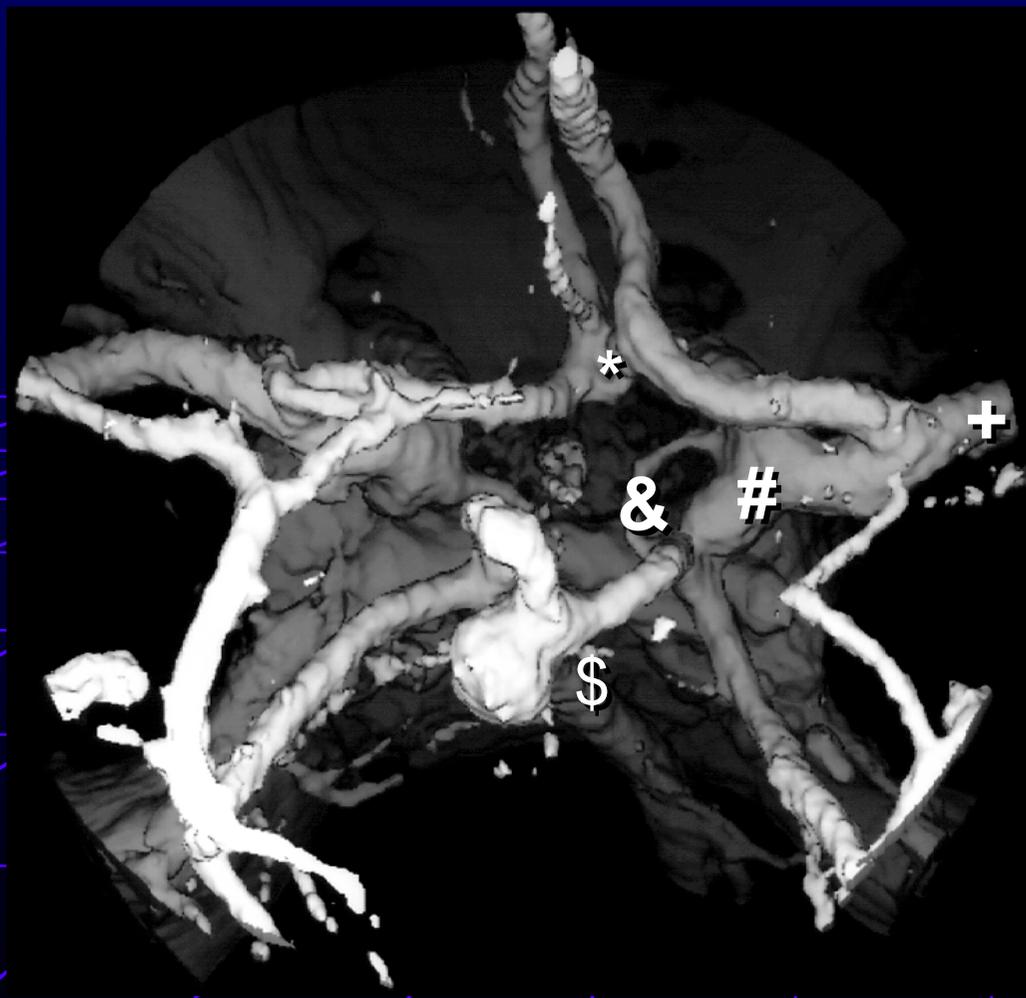
脳への血液供給とその経路

心拍出量の 15 % が脳へ

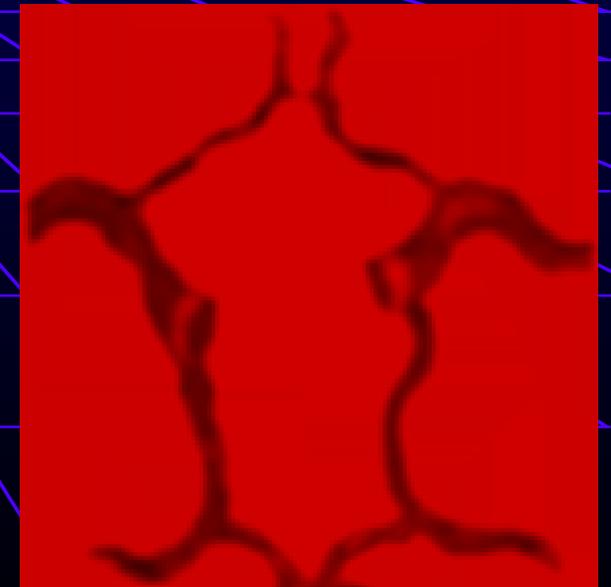
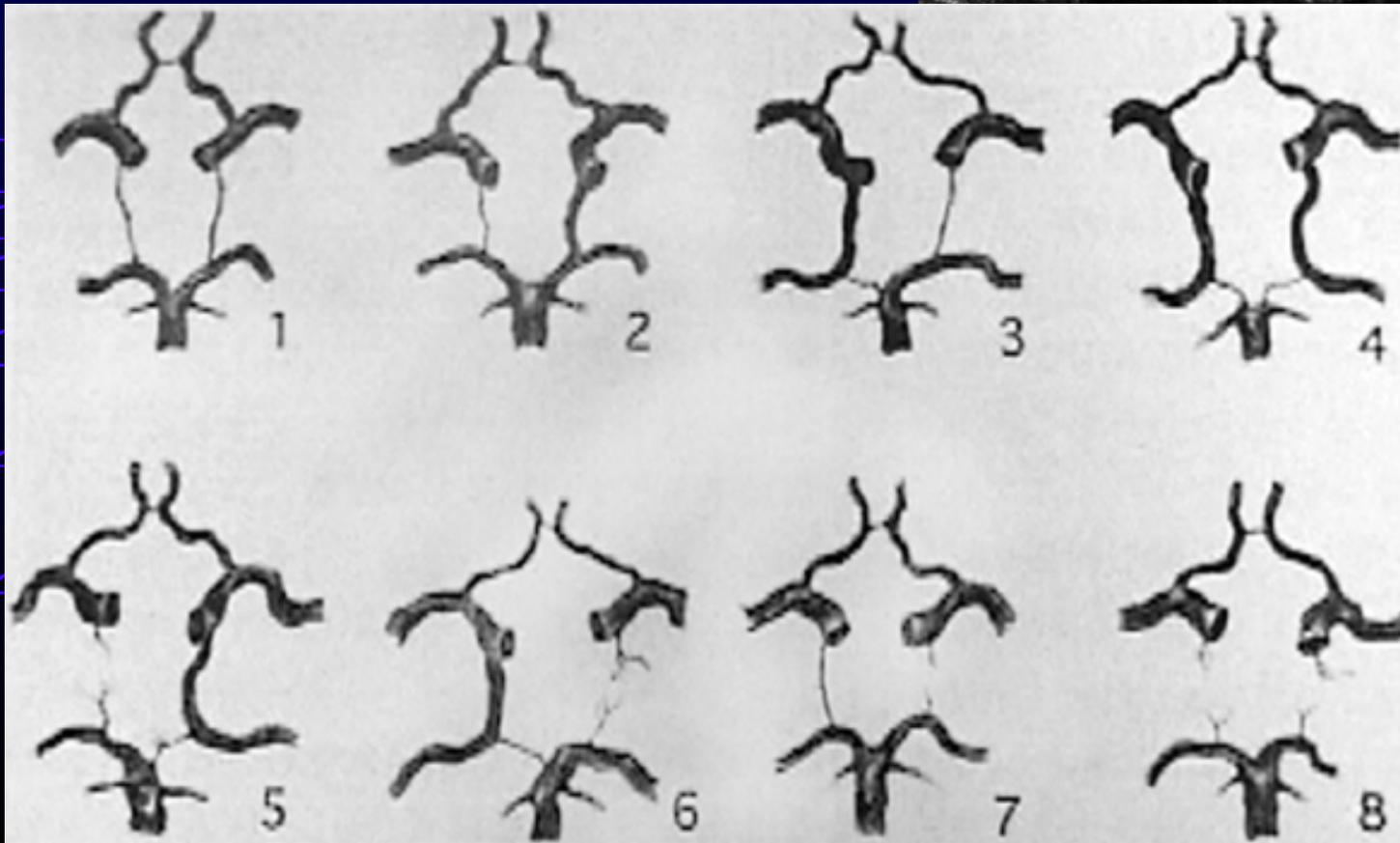
750 ml/min

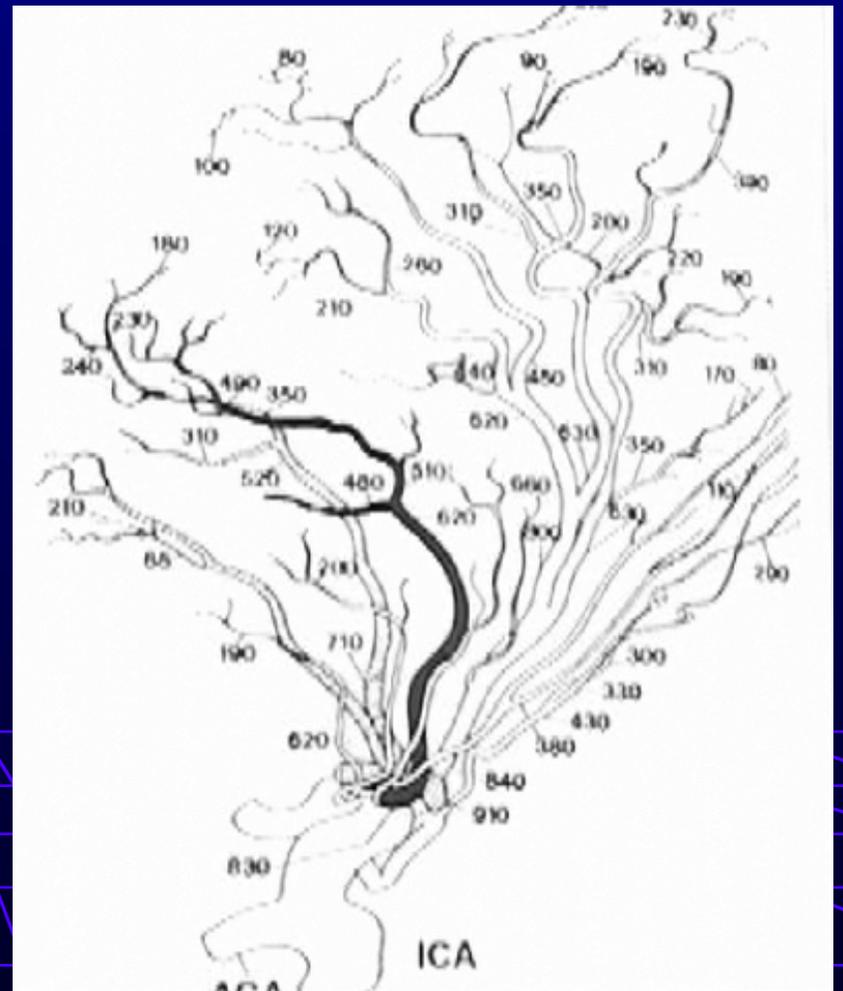
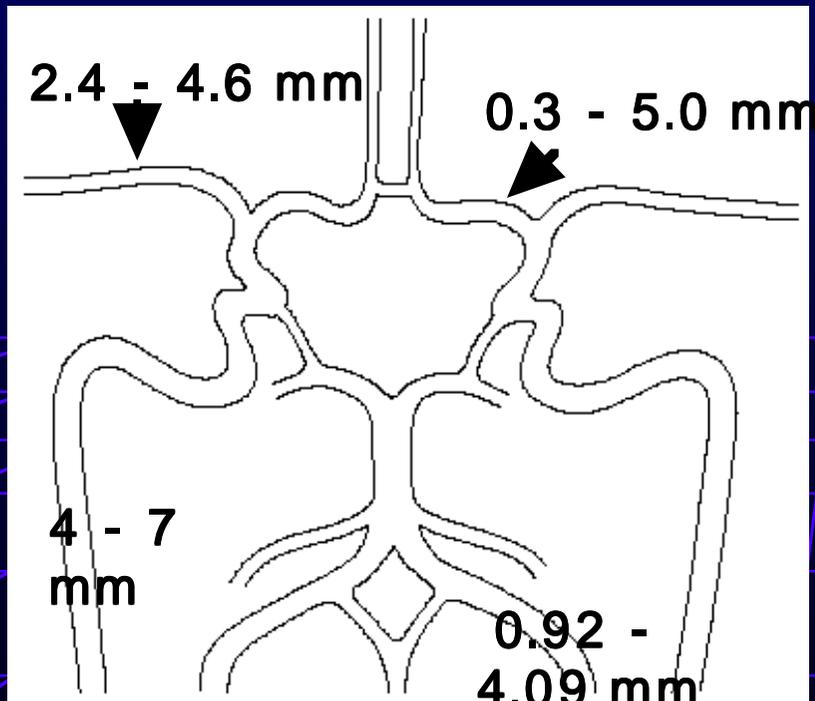
50 ml/100gr brain/min



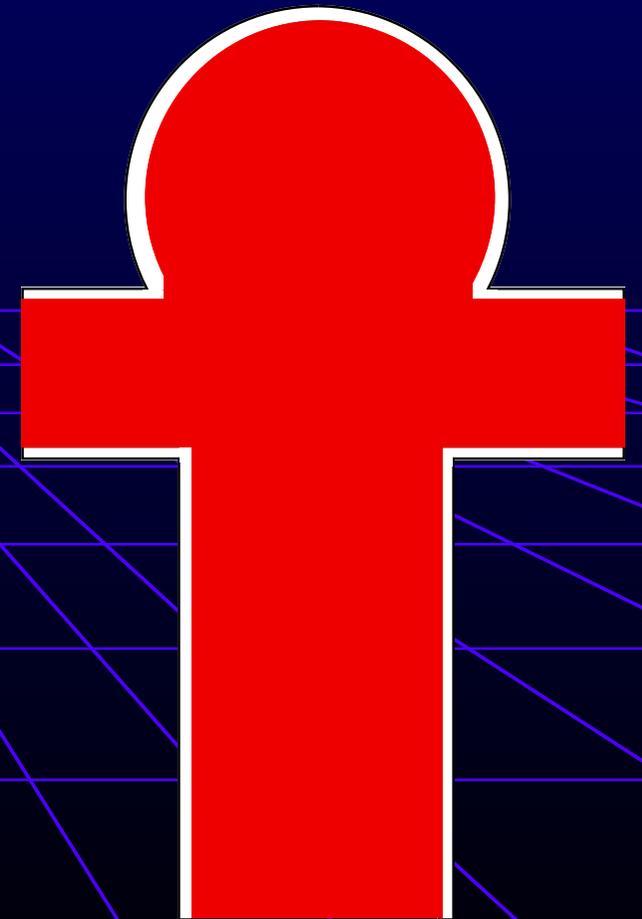


側副血行路 Willis Ring

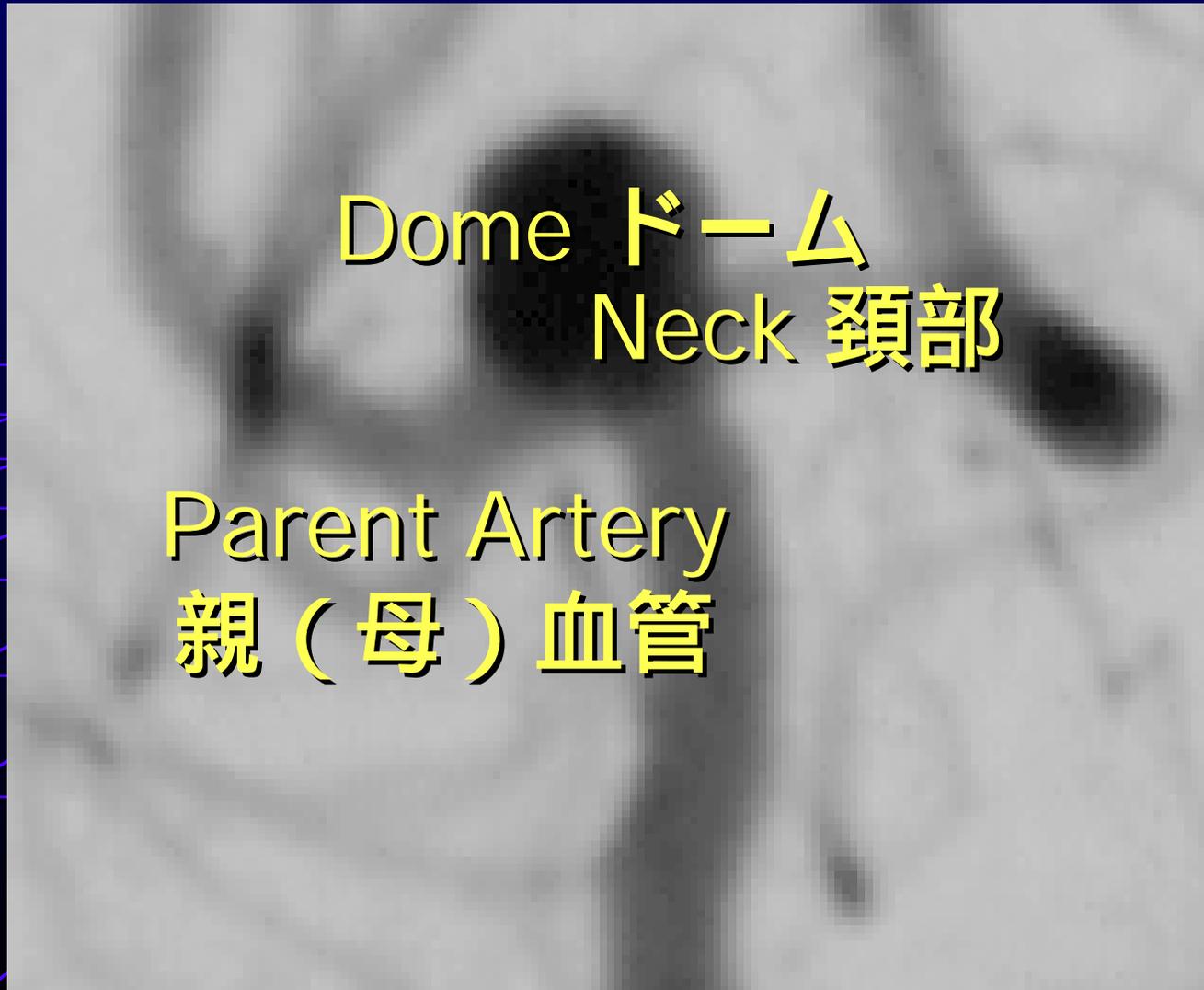




動脈瘤の構造



動脈瘤の構造



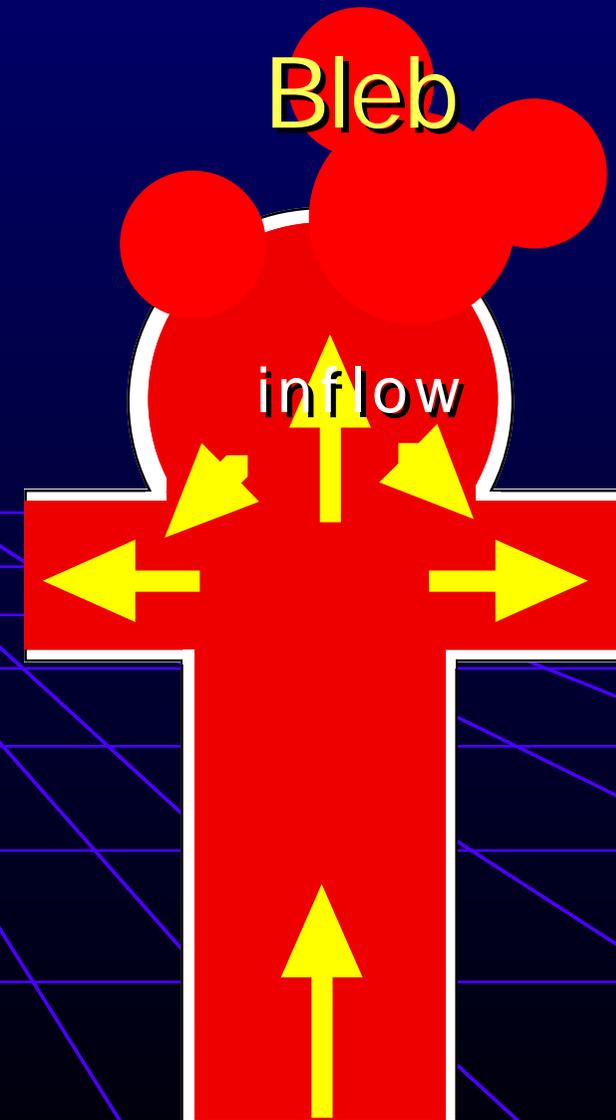
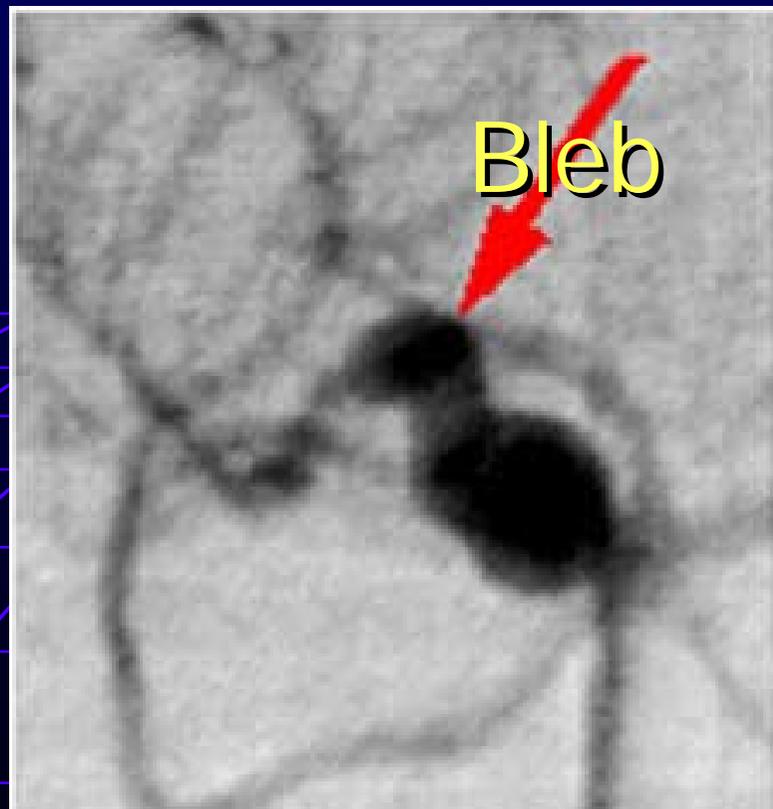
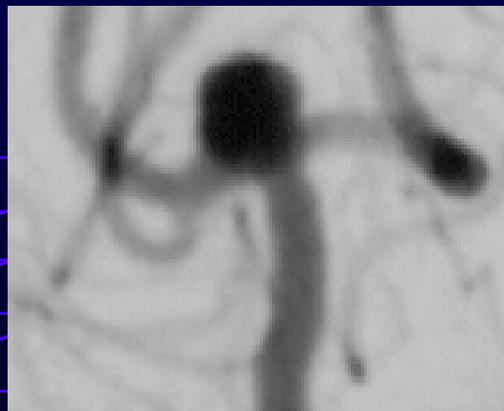
Dome ドーム
Neck 頸部

Parent Artery
親（母）血管

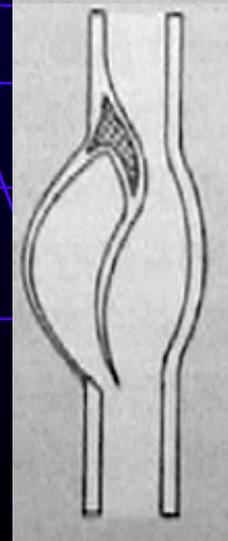
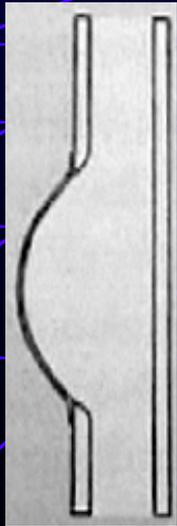
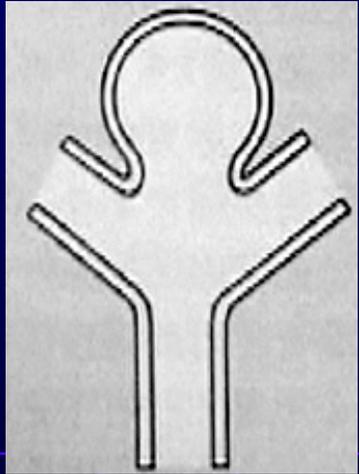


Dome ドーム
Neck 頸部
Parent Artery
親（母）血管

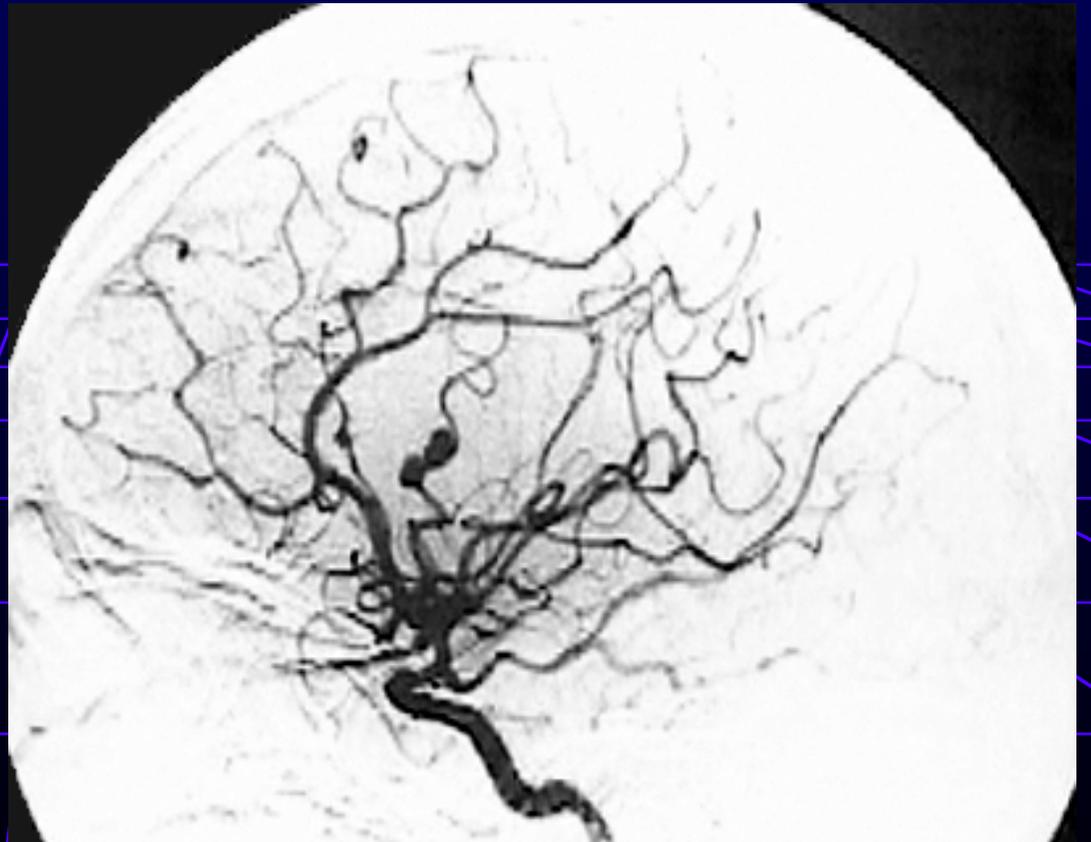
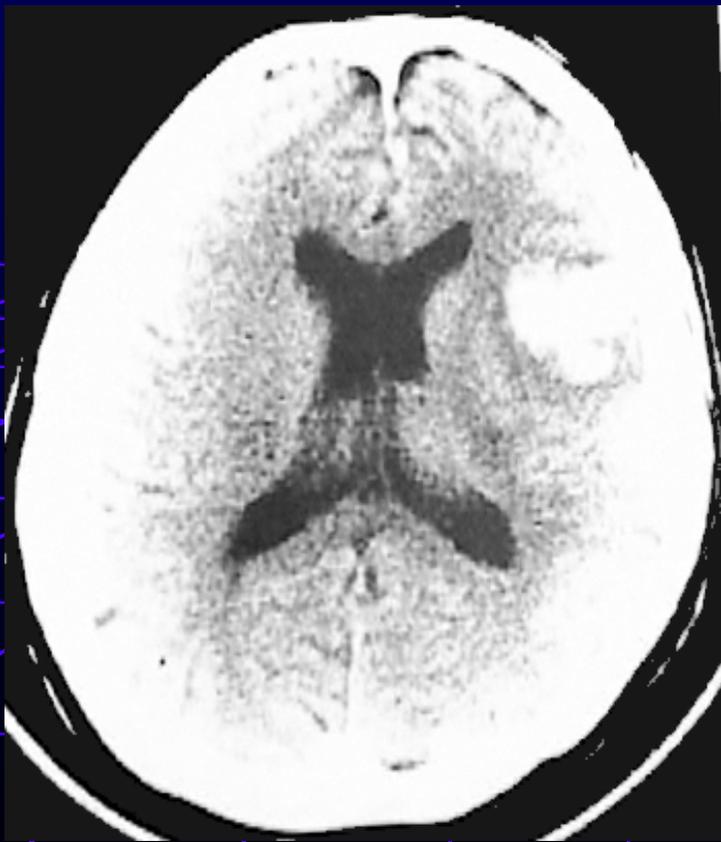
動脈瘤の構造



その他の動脈瘤



その他の脳動脈瘤



脳動脈瘤の臨床上的の問題点

無症状

破裂、クモ膜下出血

増大、腫瘍性の性格を持つ

塞栓源になる

神経などを圧迫し症状を来す

脳動脈瘤の自然経過

	患者数など	破裂率	破裂に関与する因子
Yasui 1997	234 症例 1969 - 92	2.3 % / Yr	多発
Rinkel 1998	3907 Pt-Yr	1.9 % / yr	症候性、女性、 大きなもの、 後頭蓋、多発
ISUIA 1998	727 症例、非出血 バイアス強	0.05 % /Yr (<1 cm) 1 % / Yr (>1 cm)	サイズ
ISUIA 1998	722 症例 バイアス強	0.5 % /Yr (<1 cm) 1 % / Yr (>1 cm)	なし
Juvela 2000	142 Pt, 181 An	1.3 % /Yr	喫煙 年令 サイズ

クモ膜下出血の経過

146 万人

SAH 78 例 (5.3 人 / 10 万人)

Sudden Death 15 %

外科的治療対象外 27 %

死亡率 37 %

1984 年 スウェーデン

1621 人 (1961 - 1983)

動脈瘤破裂 18 例

出血源不明の SAH 4 例

35 % は 8 hrs 以内の死亡

久山町研究

クモ膜下出血の経過

10 - 20 / 10 万人 / Yr

脳血管障害の 10 %

出血性脳血管障害の 50 - 60 %

SAH 発症後

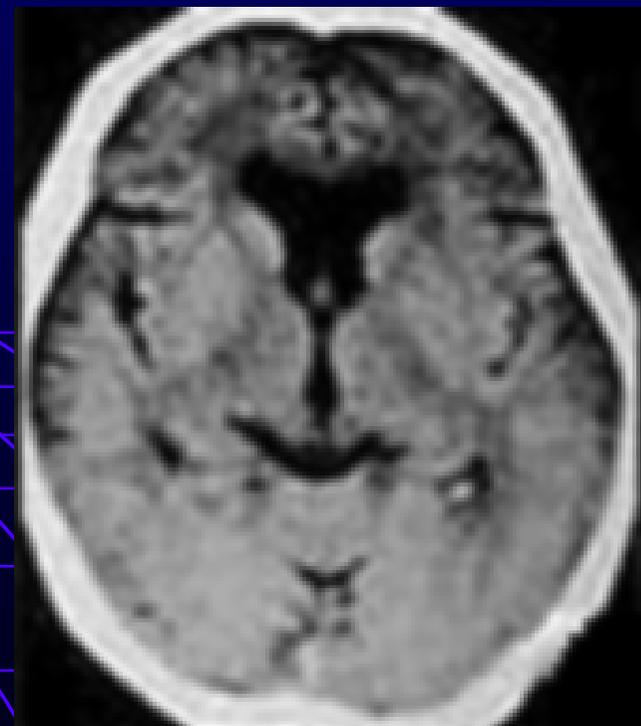
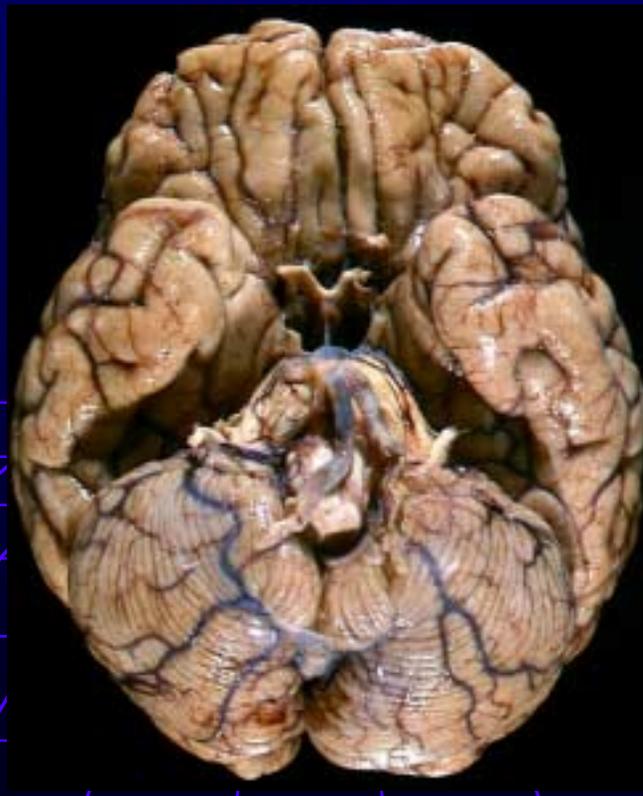
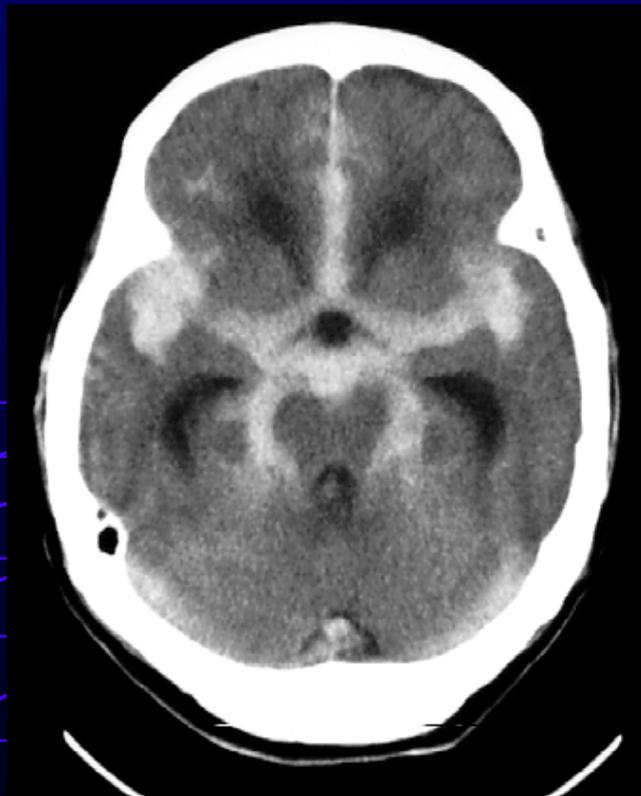
死亡：32 - 67 %

社会復帰困難：30 %

10 - 50 % は病院に着かない？

発症年令 40 - 50 台

クモ膜下出血の診断



他、腰椎穿刺、MRI など

脳動脈瘤の診断

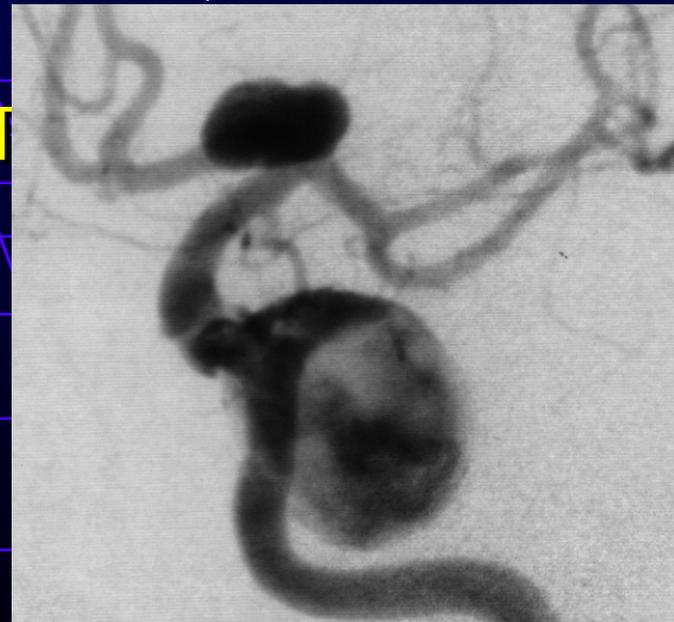
脳動脈瘤の診断

カテーテル法による血管撮影

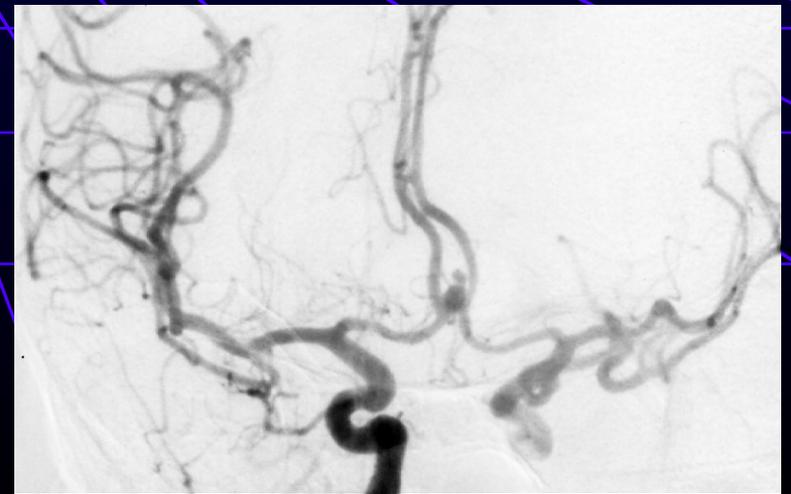
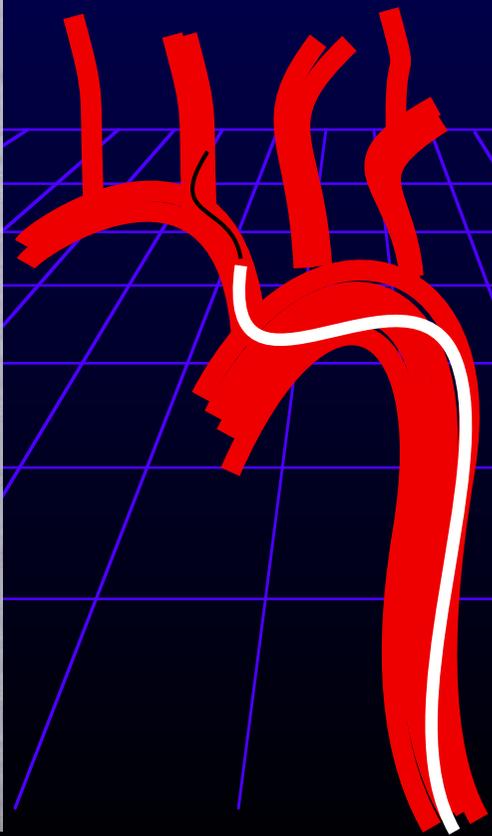
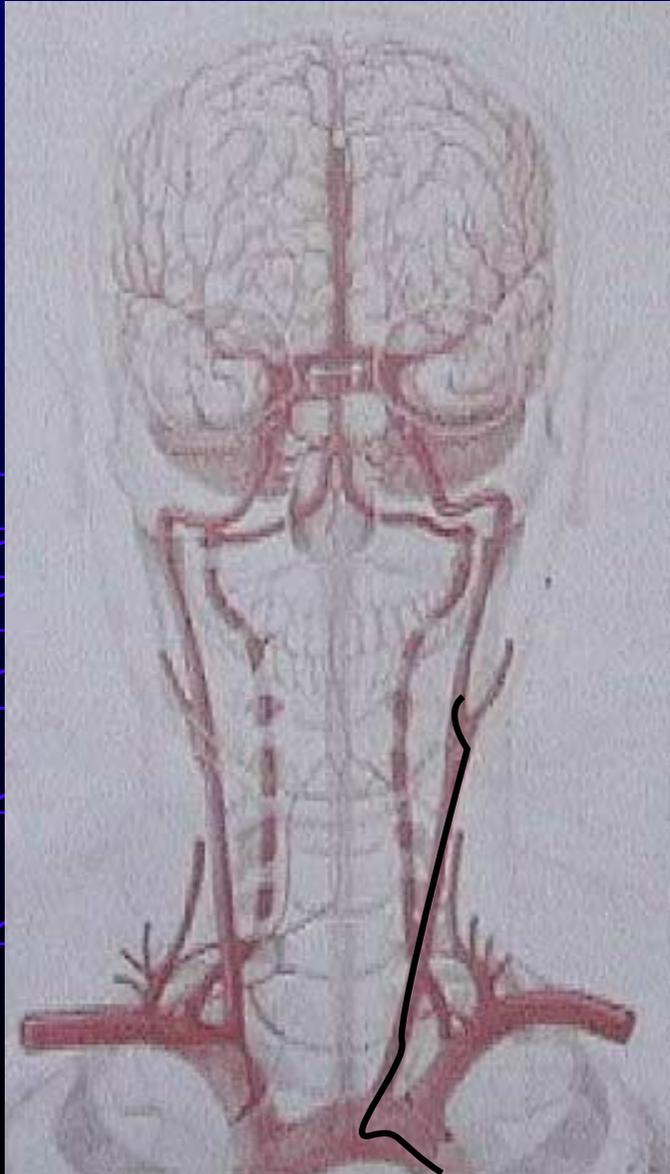
迅速で正確
Risk を伴う

3D CT 血管撮影 (3D CT)

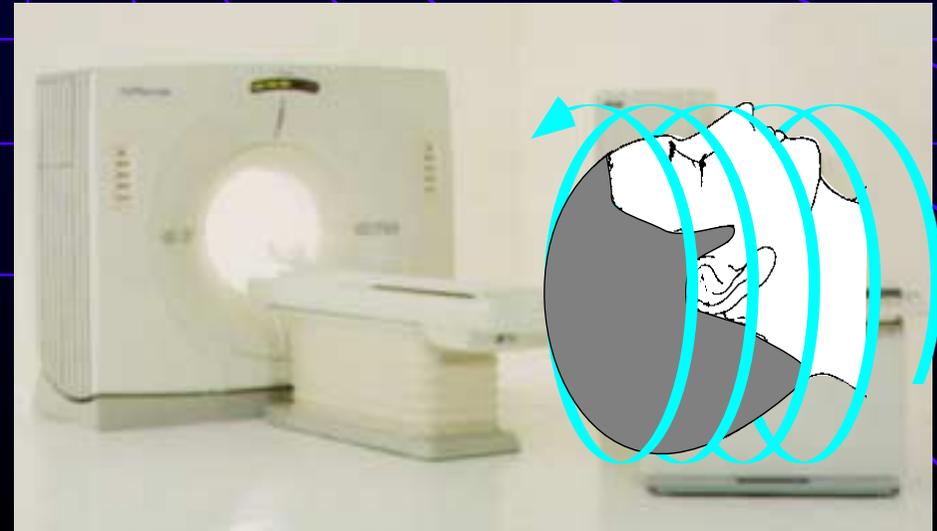
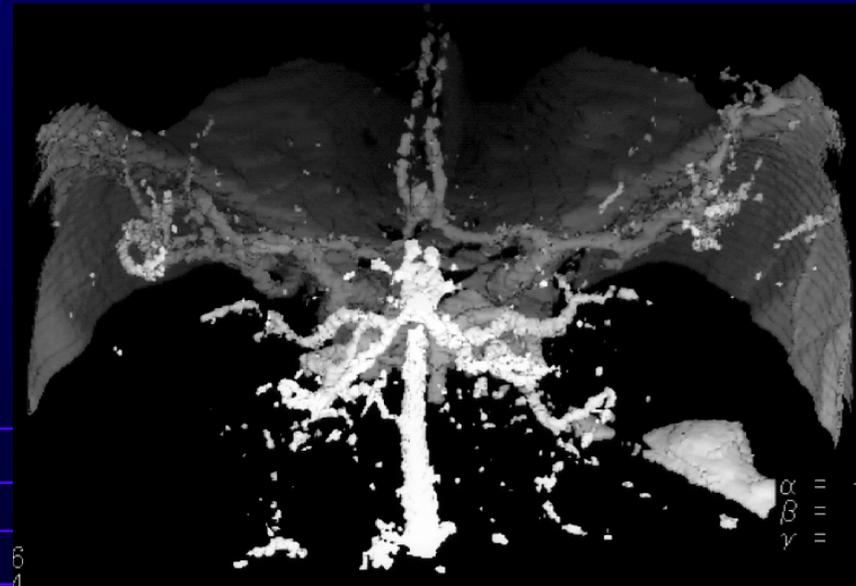
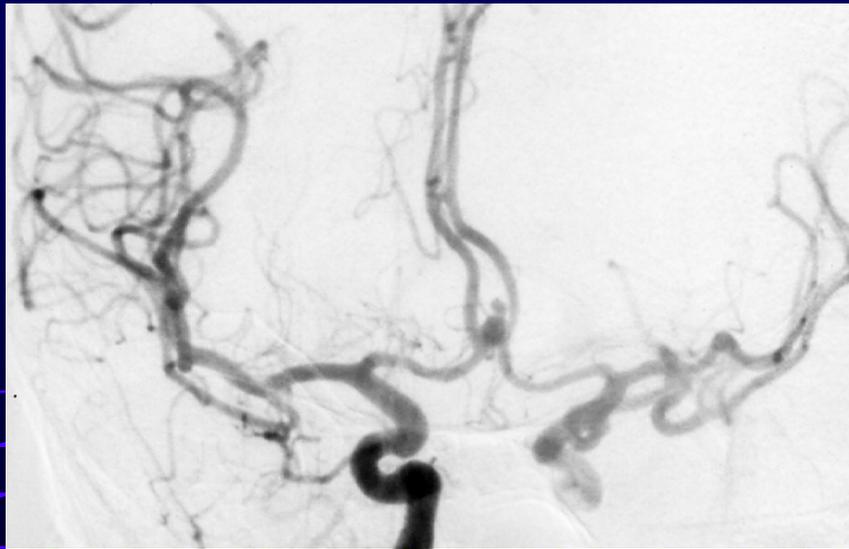
MR 血管撮影 (MRA)



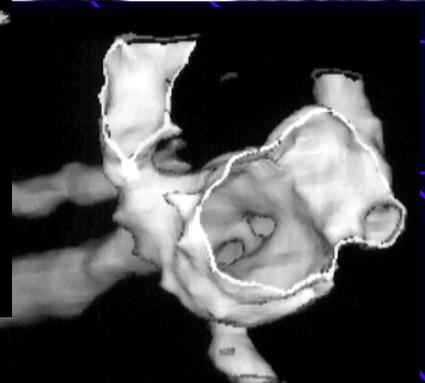
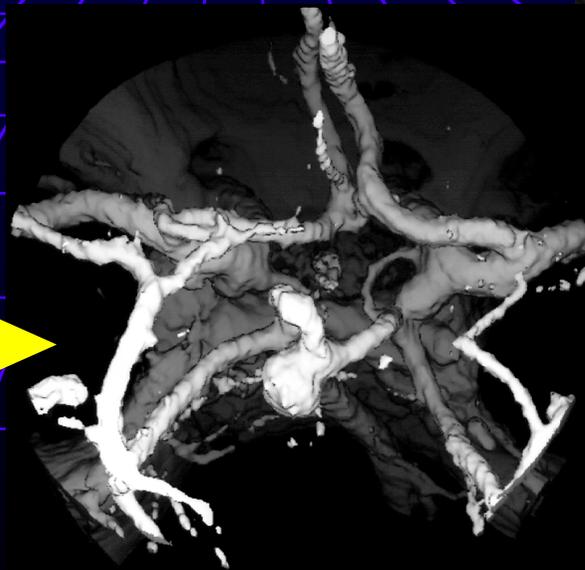
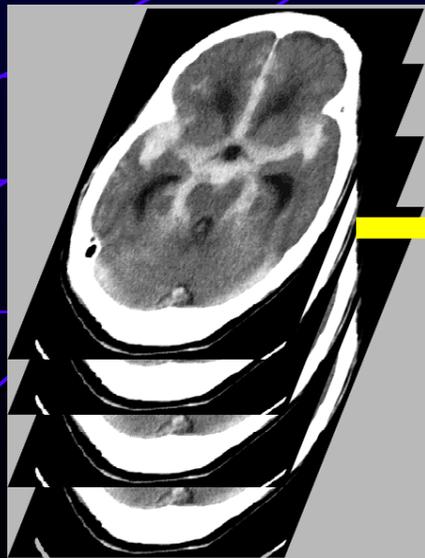
脳動脈瘤の診断 血管撮影



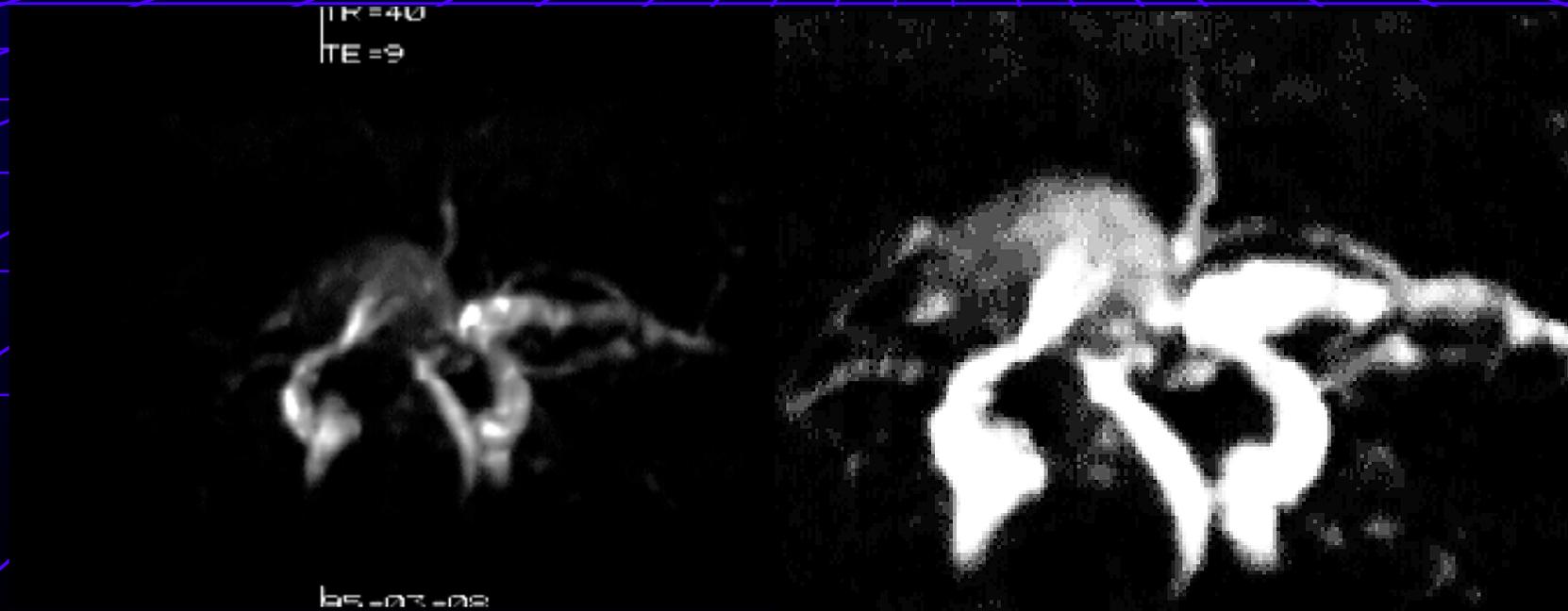
脳動脈瘤の診断 (3D CTA)



脳動脈瘤の診断



脳動脈瘤の診断 (MRA)



脳動脈瘤の治療

母血管閉塞

外科的母血管閉塞

母血管塞栓術

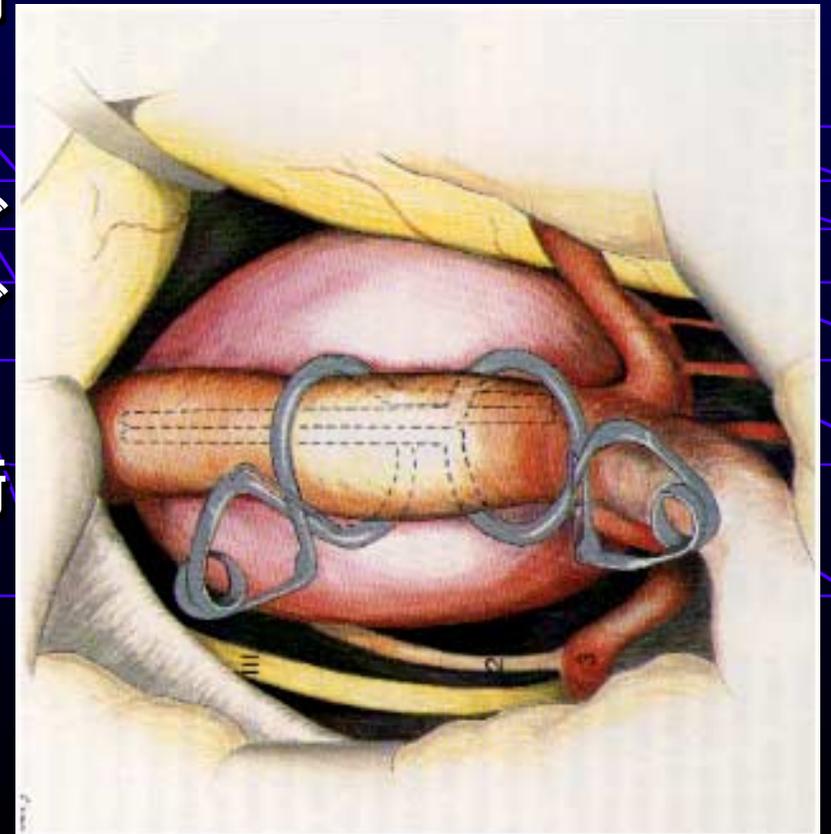
直達術

クリッピング

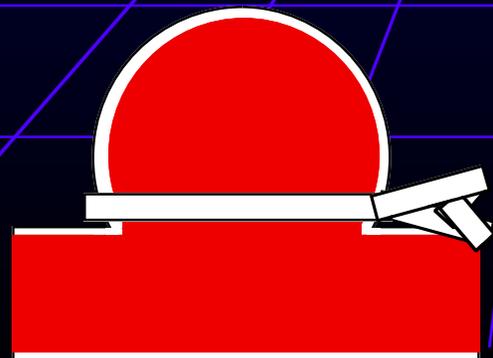
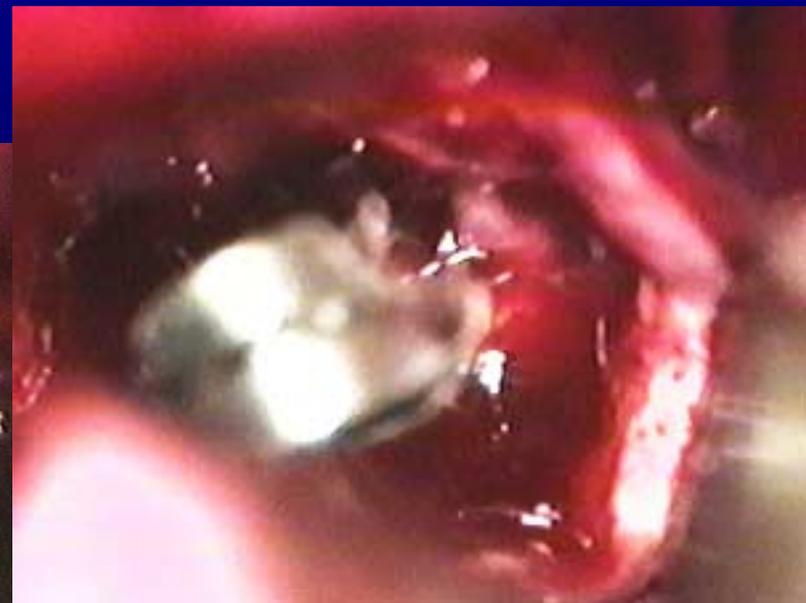
コーティング

被包術

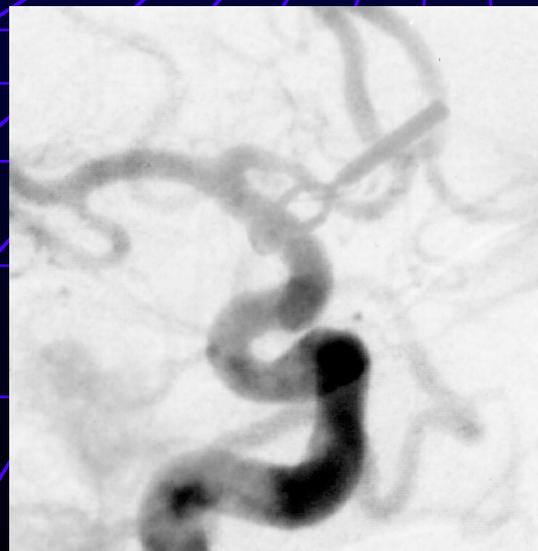
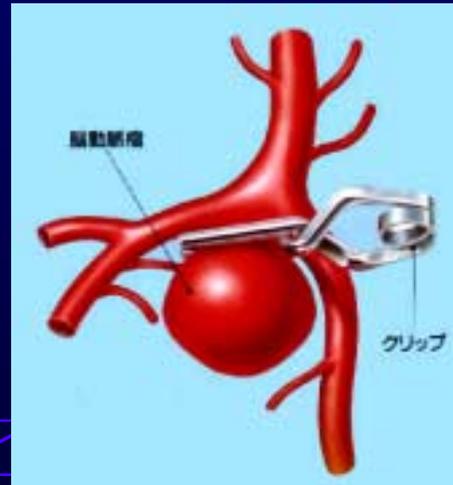
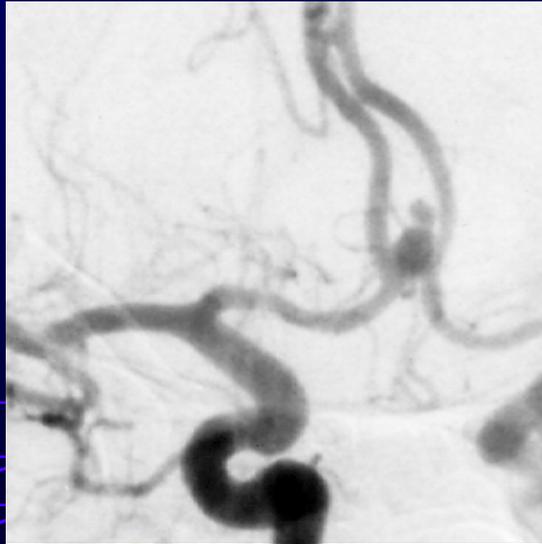
コイル塞栓術



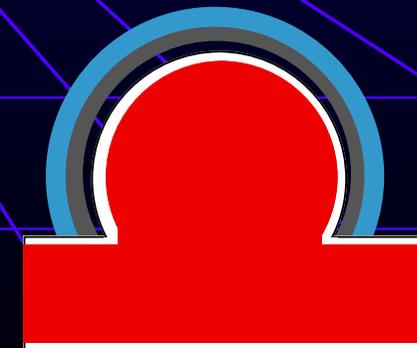
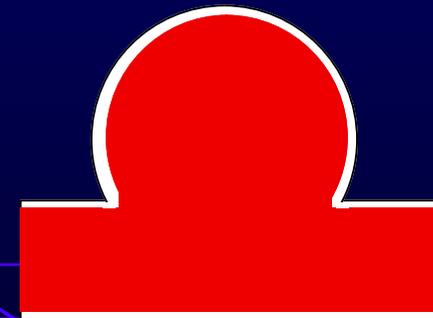
クリッピング



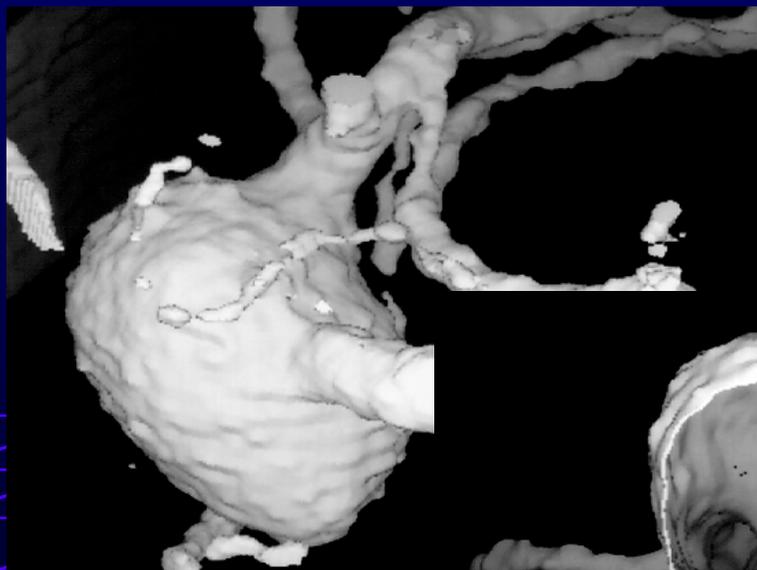
クリッピング



コーティング



血管内手術



血管内手術

術式

直達術

動脈瘤そのもの进行处理する

動脈瘤と近位血管を合わせて処理する

近位血管閉塞

塞栓物質

プラチナコイル

離脱式

非離脱式（フリーコイル）

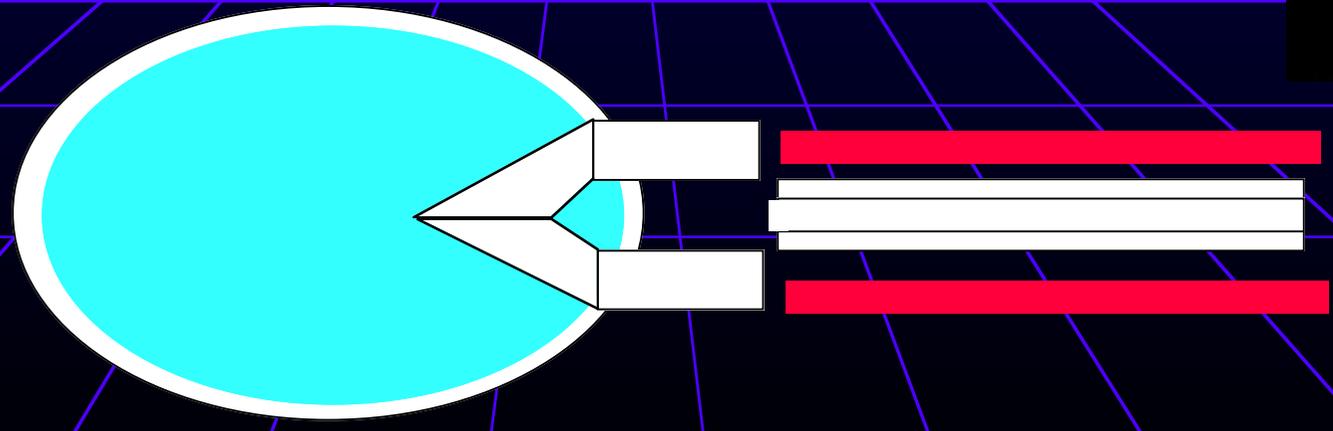
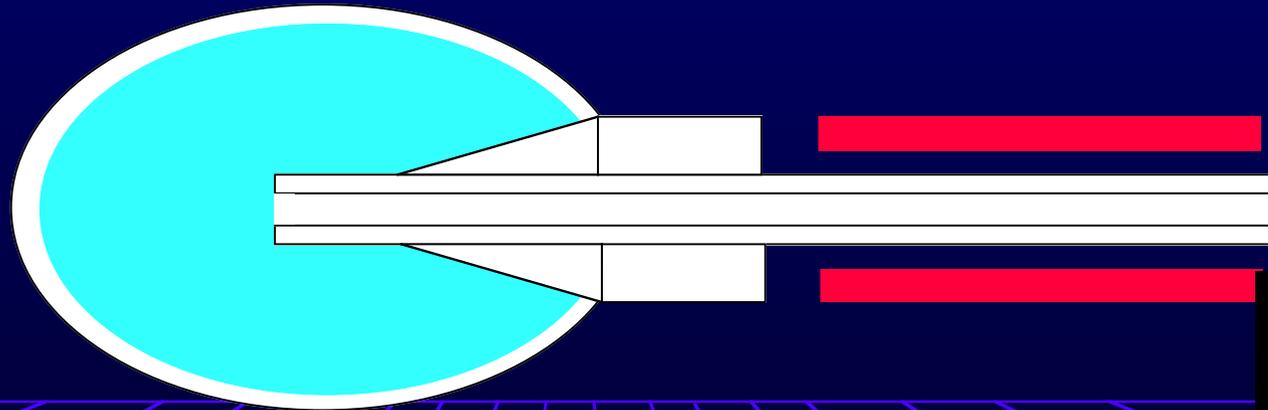
離脱式バルーン

液体塞栓物質

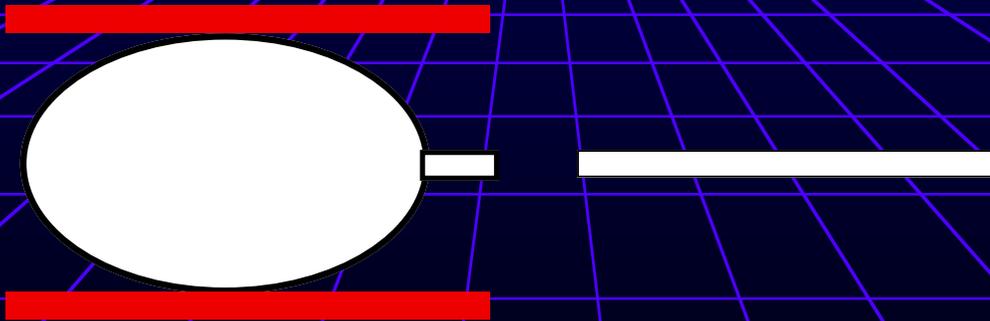
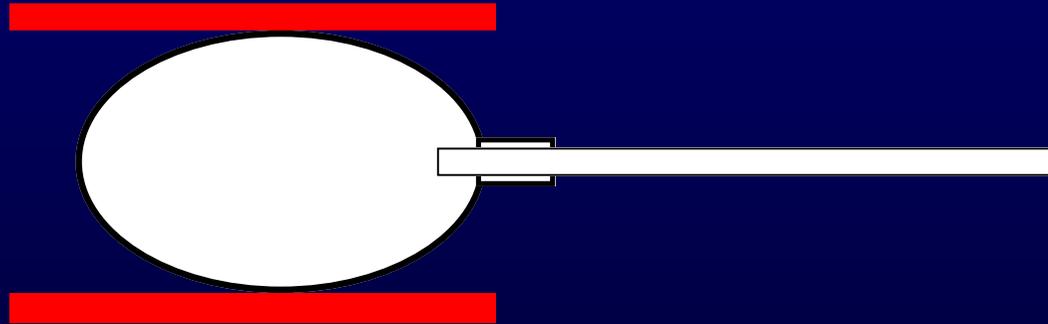
析出型

NBCA??

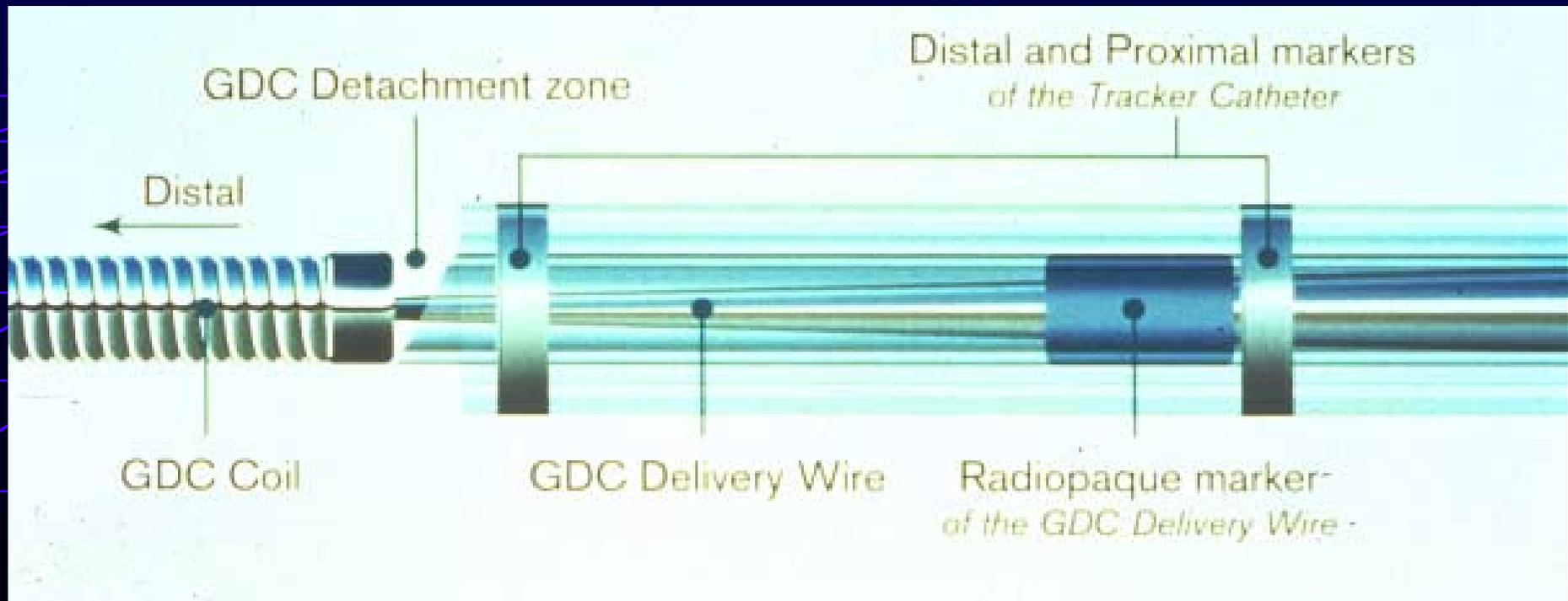
離脱式バルーン



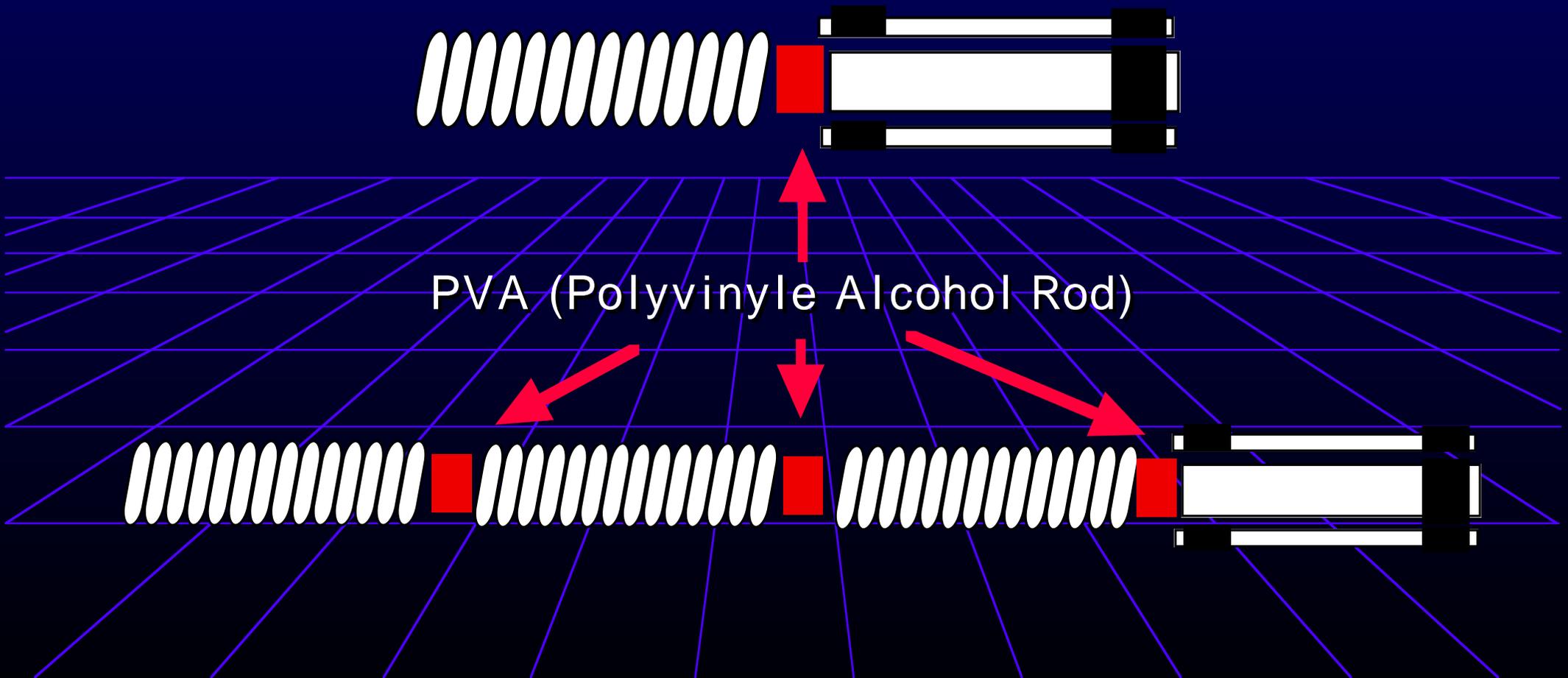
離脱式バルーン



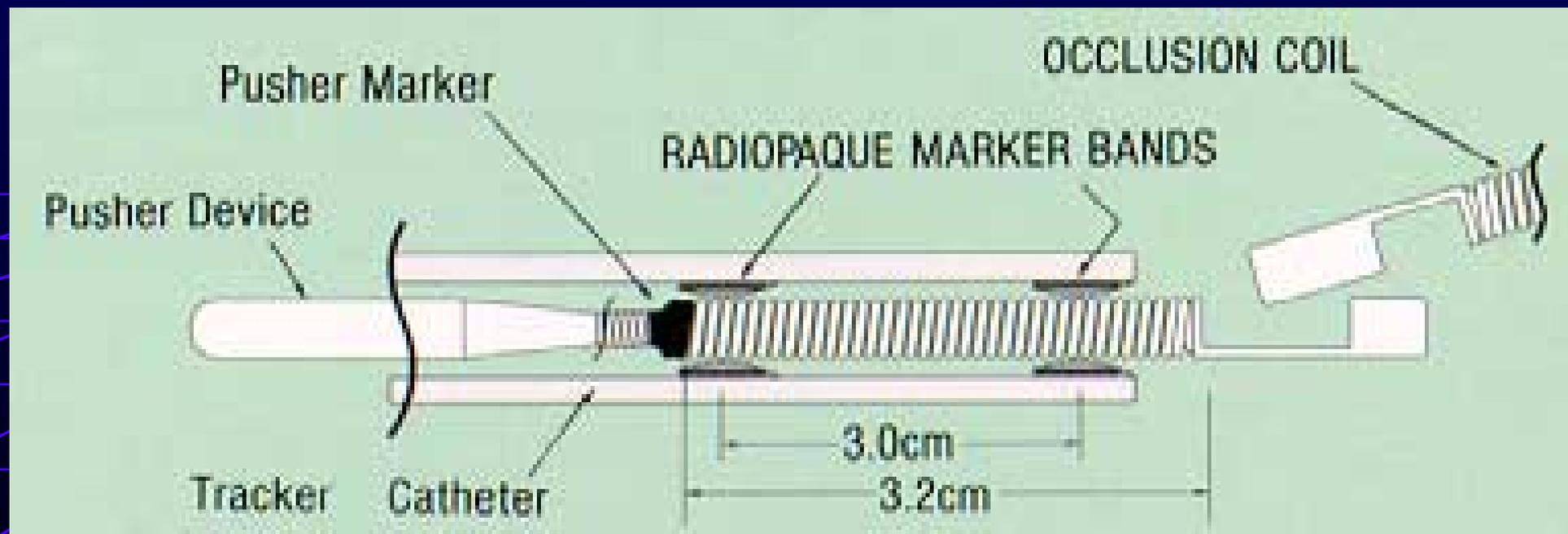
離脱式コイル



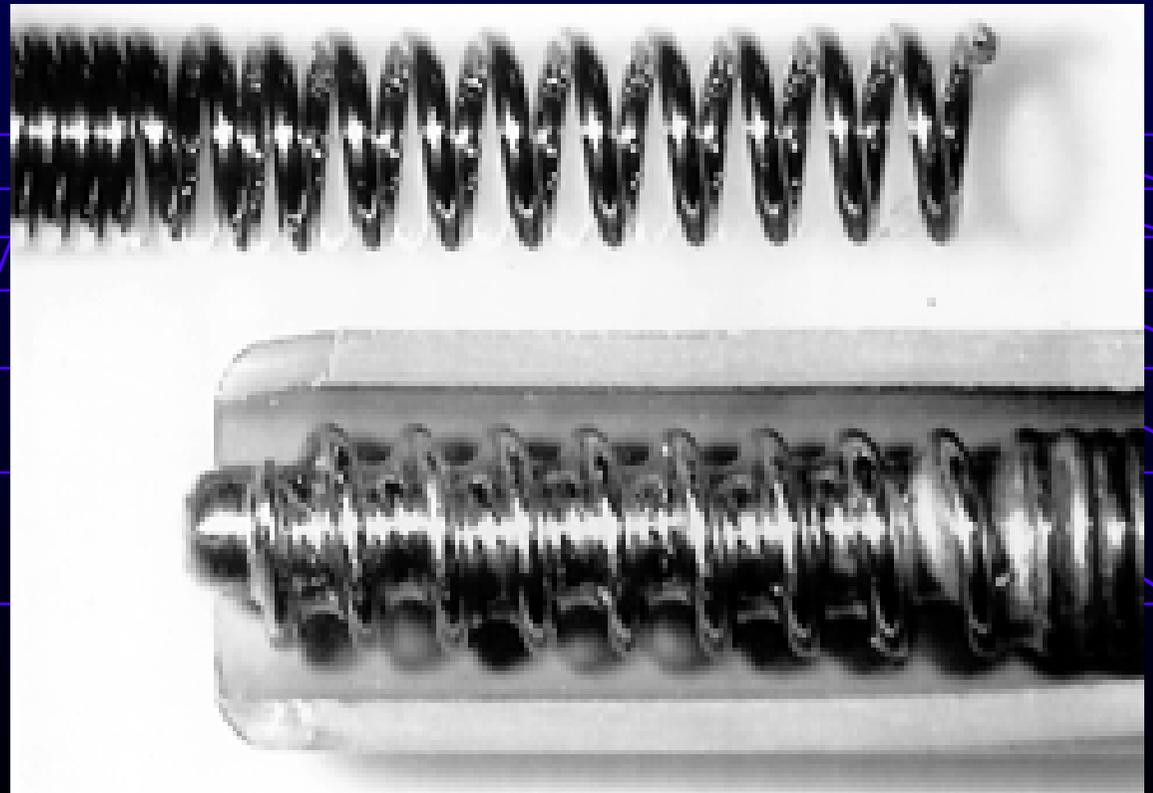
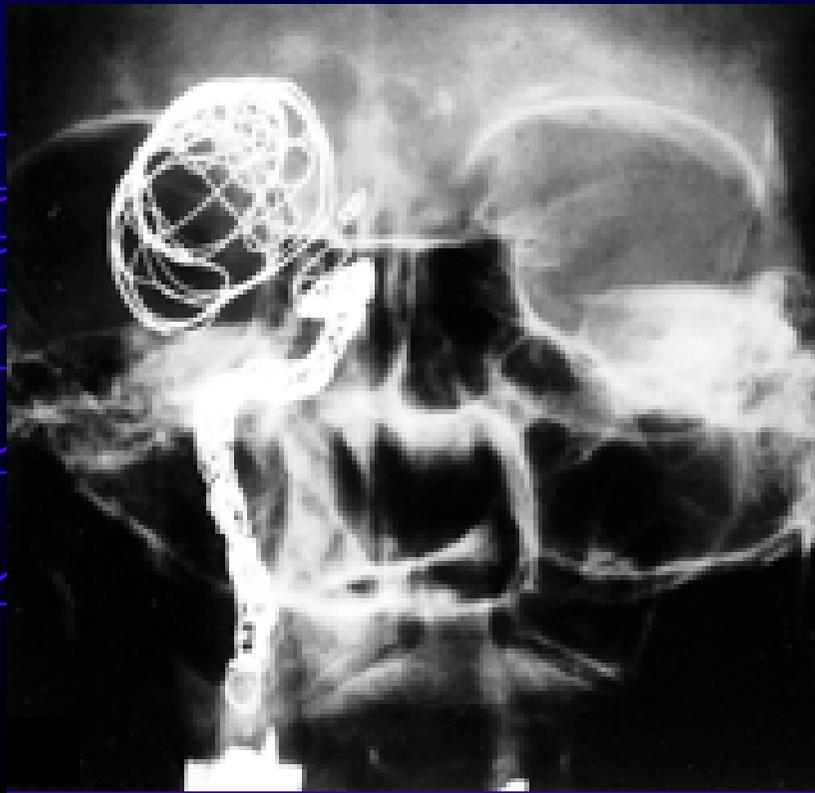
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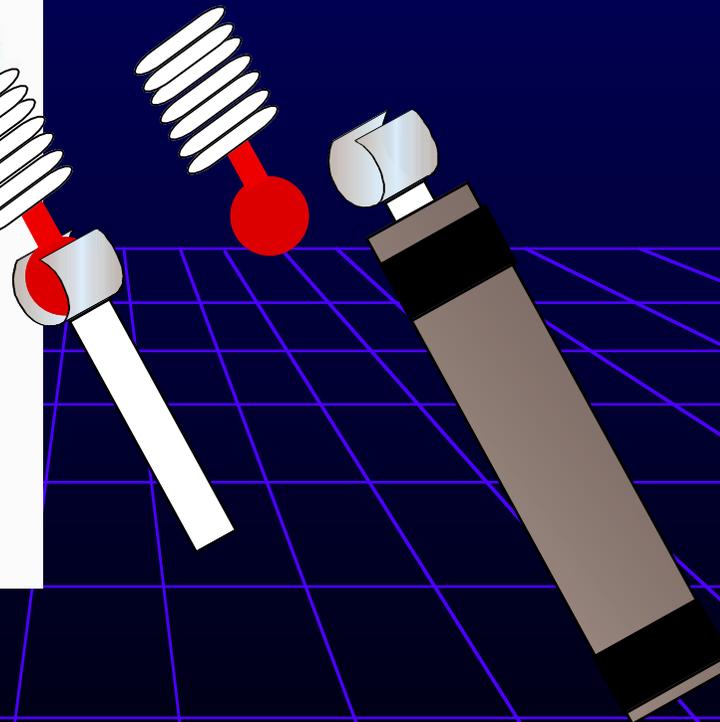
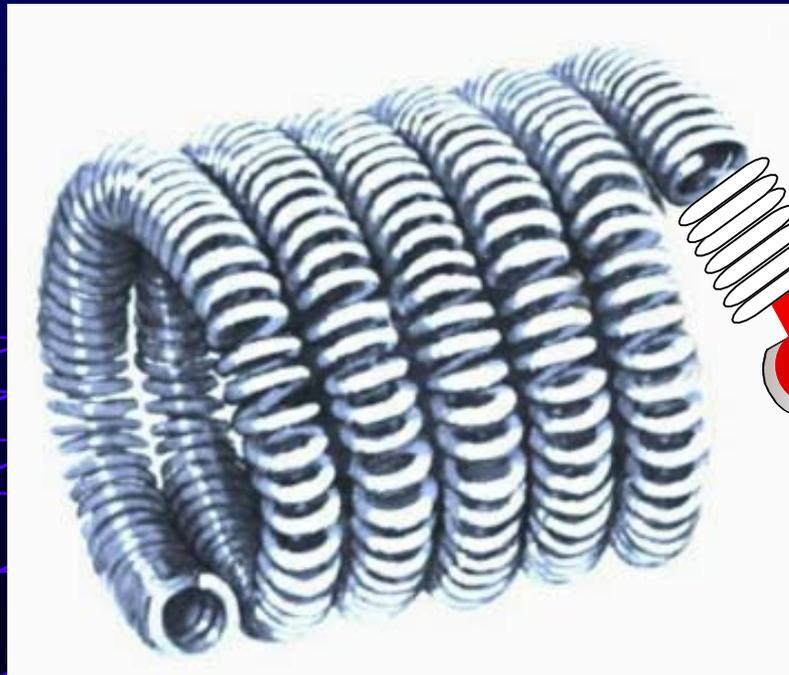
離脱式コイル



離脱式コイル



離脱式コイル



フリー（非離脱式）コイル

BRAIDED OCCLUSION DEVICE (BOD)

Size	Length
3mm	8mm*
5mm	14mm*
7mm	20mm*
10mm	28mm*

TRACKER[®]-18 COILS (FPC)

Size	Length
2mm	10mm*
4mm	20mm*
6mm	30mm*
8mm	40mm*

TRACKER[®]-18 VEIN OF GALEN COILS (FPC)

Size	Length
20mm	100mm*
30mm	100mm*

TRACKER[®]-10 COILS (FPC)

Size	Length
2mm	7mm*
5mm	7mm*
8mm	7mm*

液体塞栓物質

EVAL (Ethylene Vinyl Alcohol)

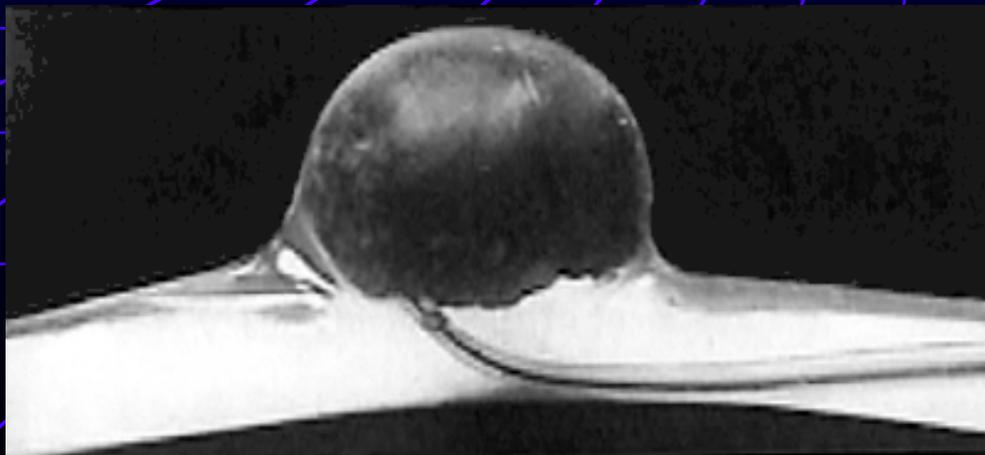
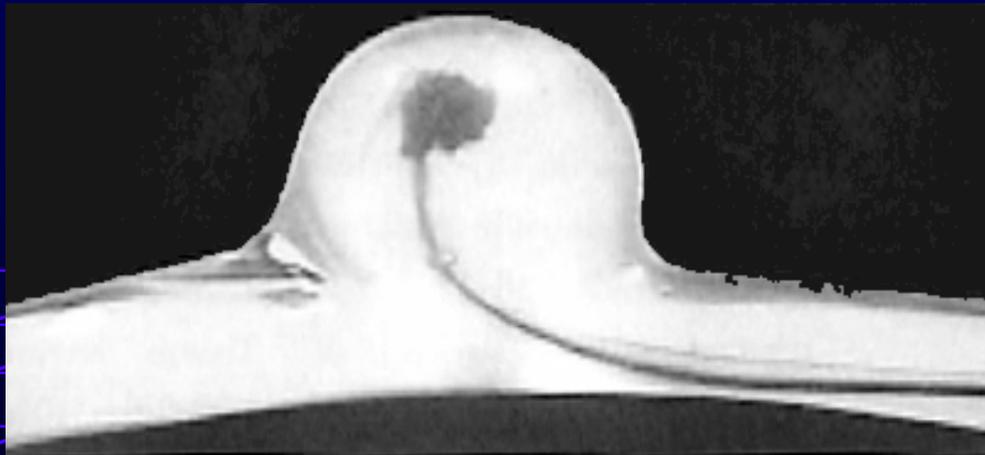
Onyx

CAP (Cellulose Acetate Polymer)

Magnetic Guiding Embolus

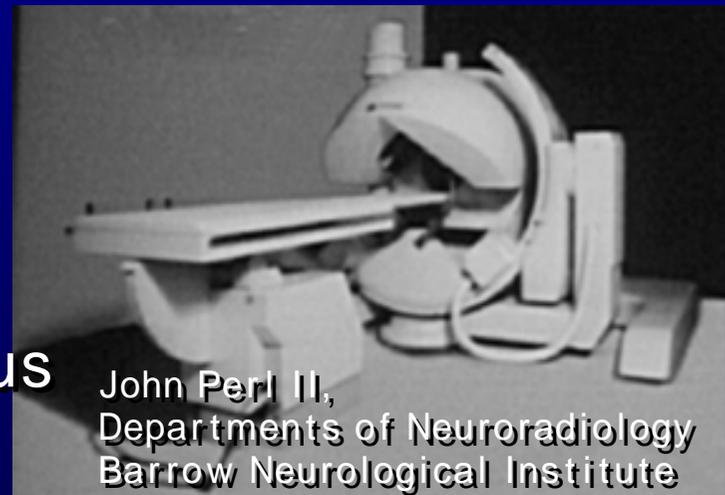
液体塞栓物質

Onyx

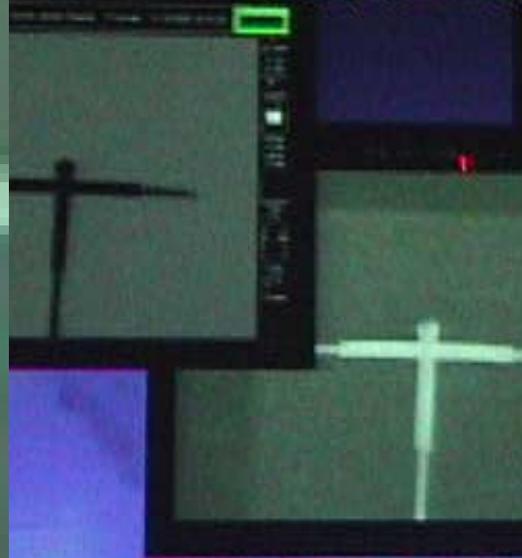


液体塞栓物質

Magnetic Guiding Embolus



Magnetic Liquid Embolus
Aneurysm Treatment



magnetically shapeable liquid embolic
be delivered and fixed in an aneurysm
remodeling.

In-Vivo

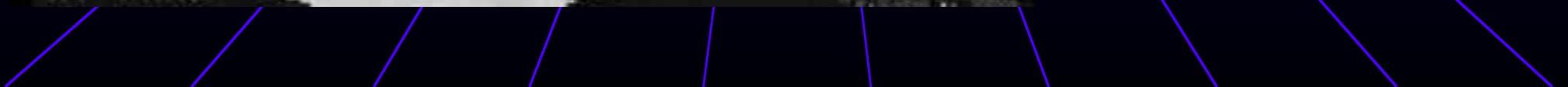
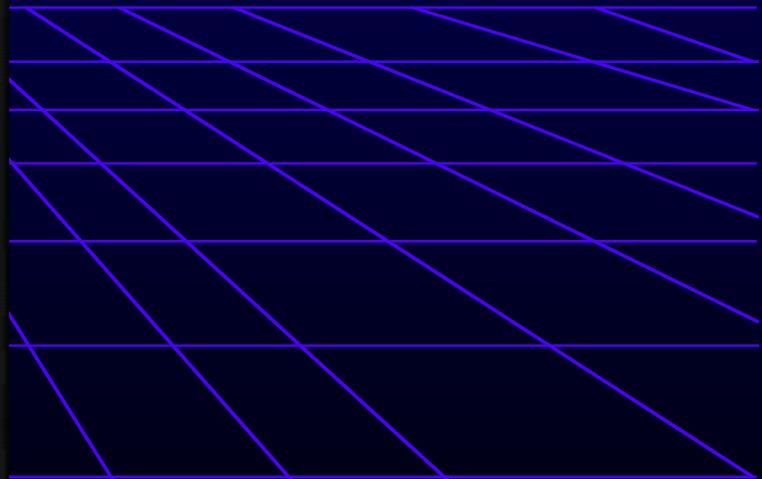


基本的セットアップ



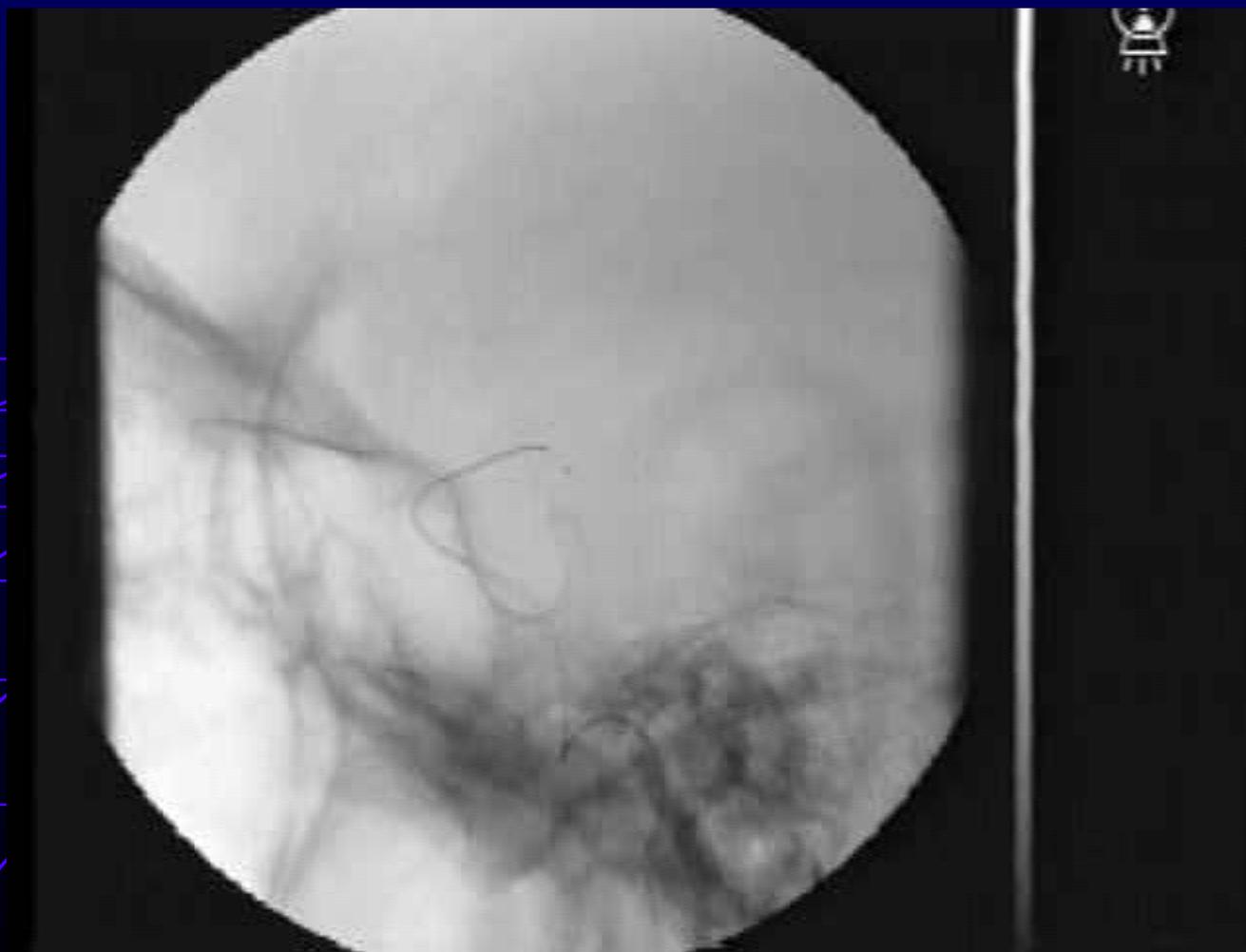
基本的セットアップ

DSA, 透視, Roadmap



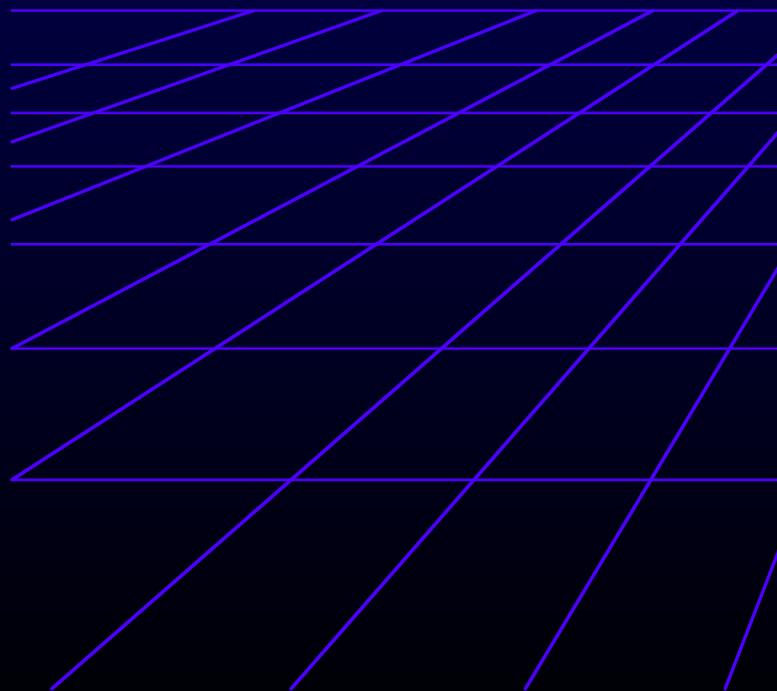
基本的セットアップ

DSA, 透視, Roadmap

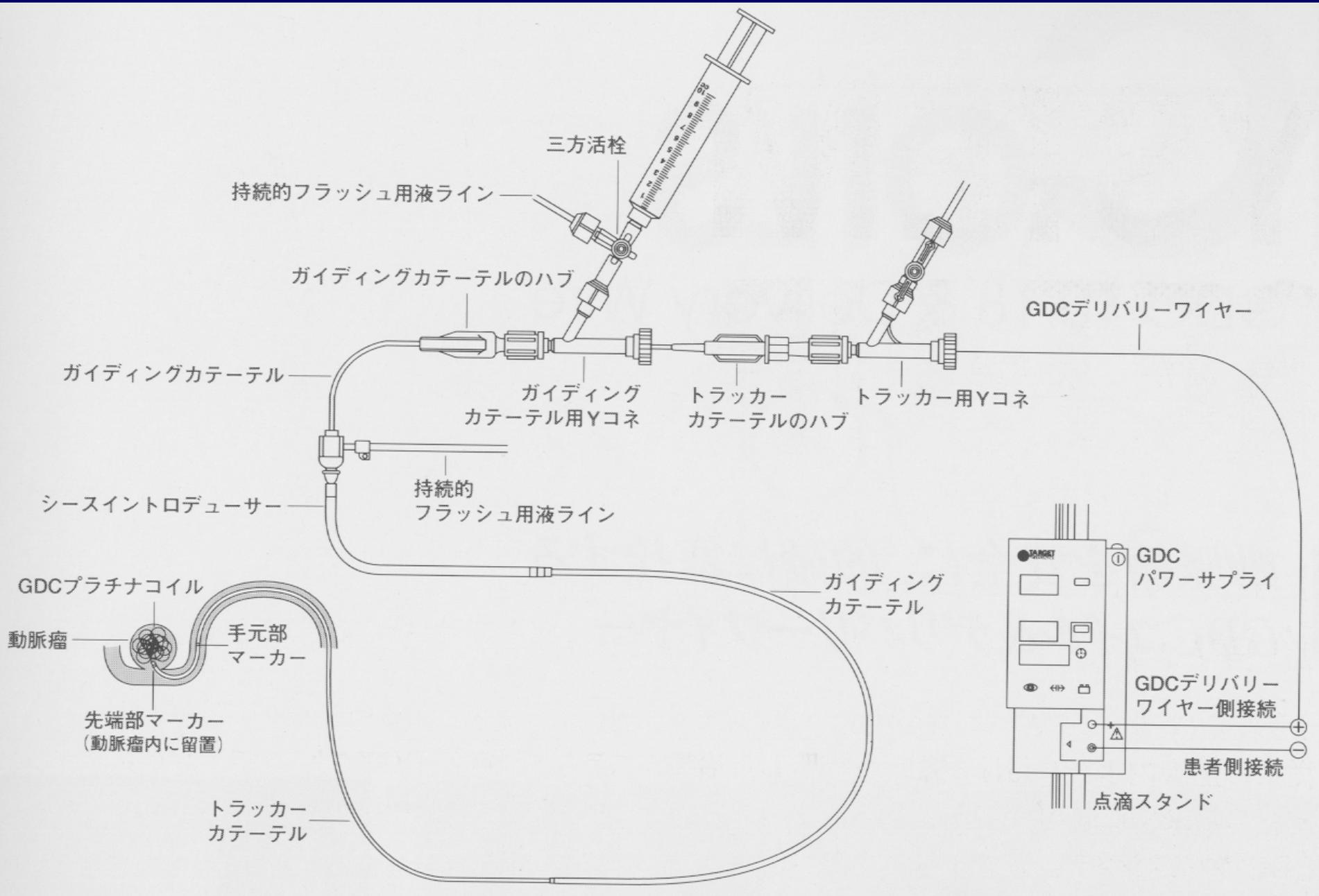


基本的セットアップ

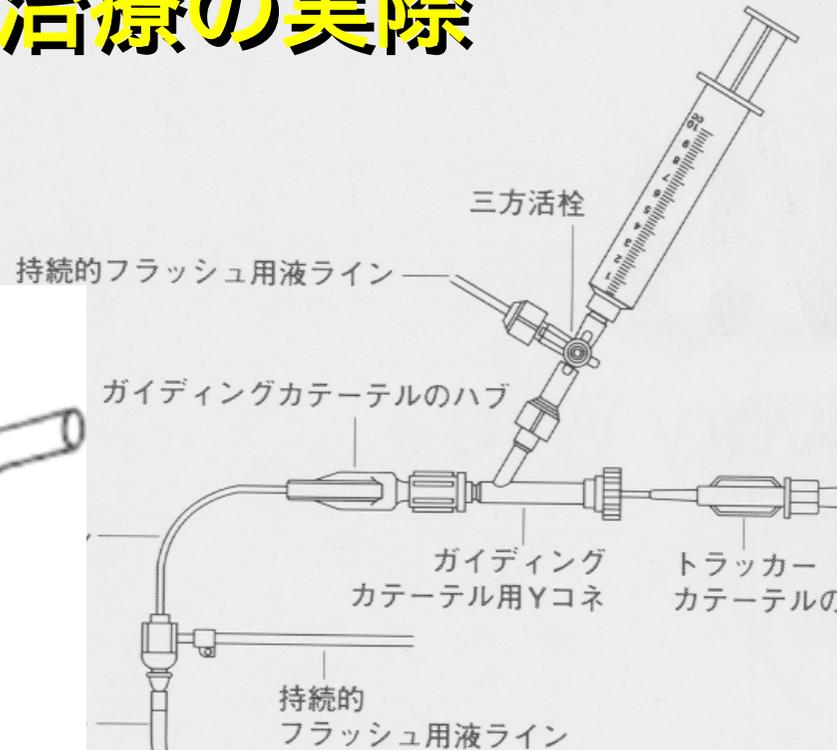
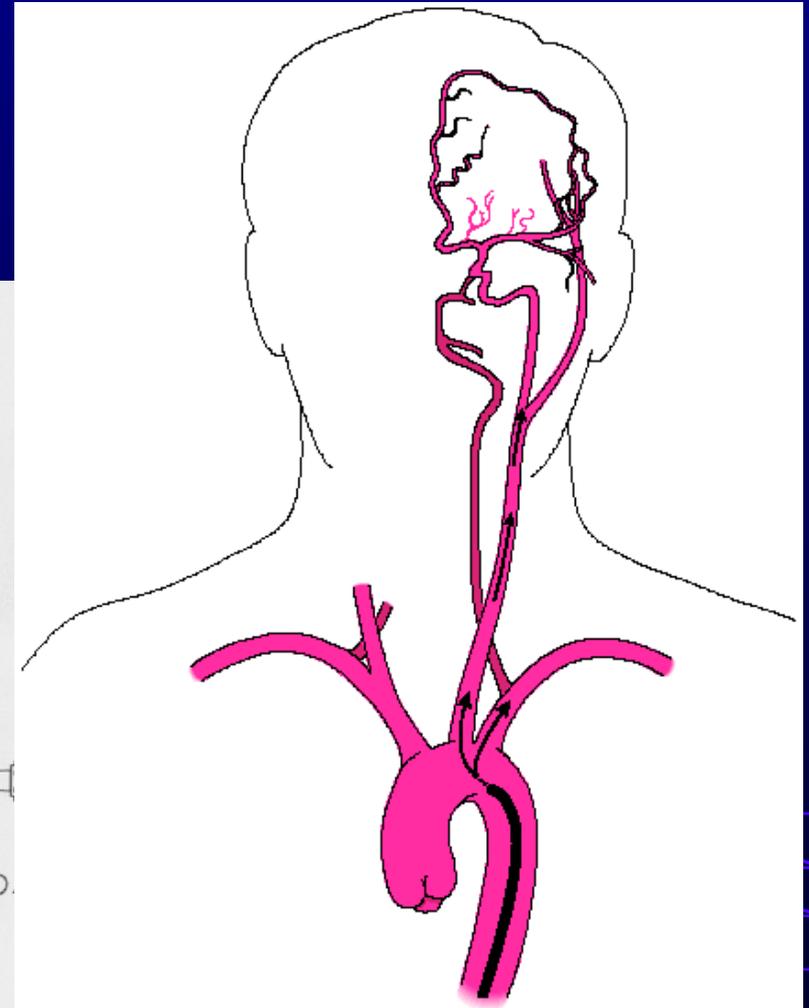
DSA, 透視, Roadmap



基本的セットアップ



血管内治療の実際



GDCプラチナコイル

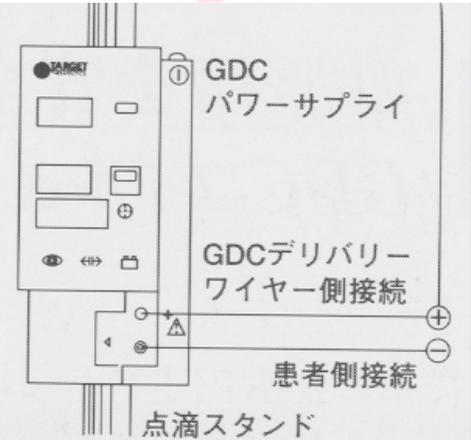
動脈瘤

手元部
マーカー

先端部マーカー
(動脈瘤内に留置)

トラッカー
カテーテル

ガイディング
カテーテル



血管内治療の問題点

カテーテル操作に伴うもの
長期成績

Neck Remnant

In Flow Zone の判定

Wide Neck Aneurysm

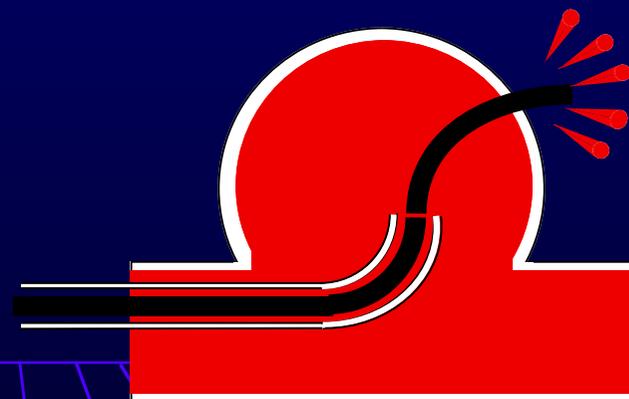
血栓化動脈瘤

母血管閉塞と長期予後

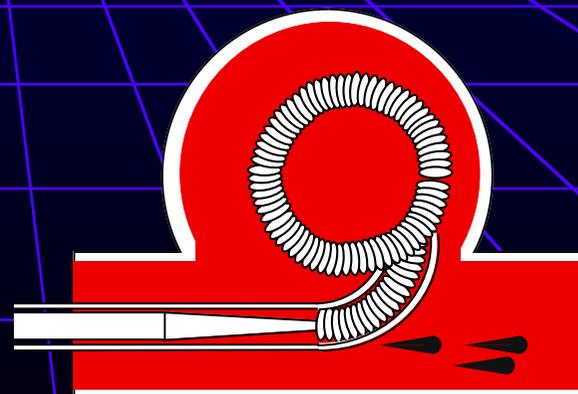
自然経過

カテーテル操作に伴うもの

術中破裂



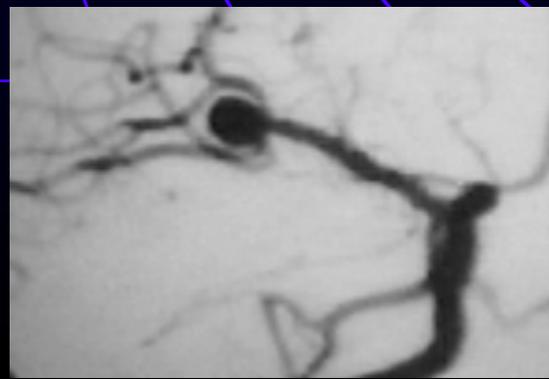
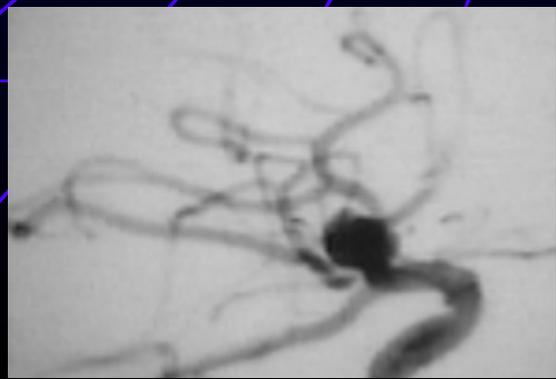
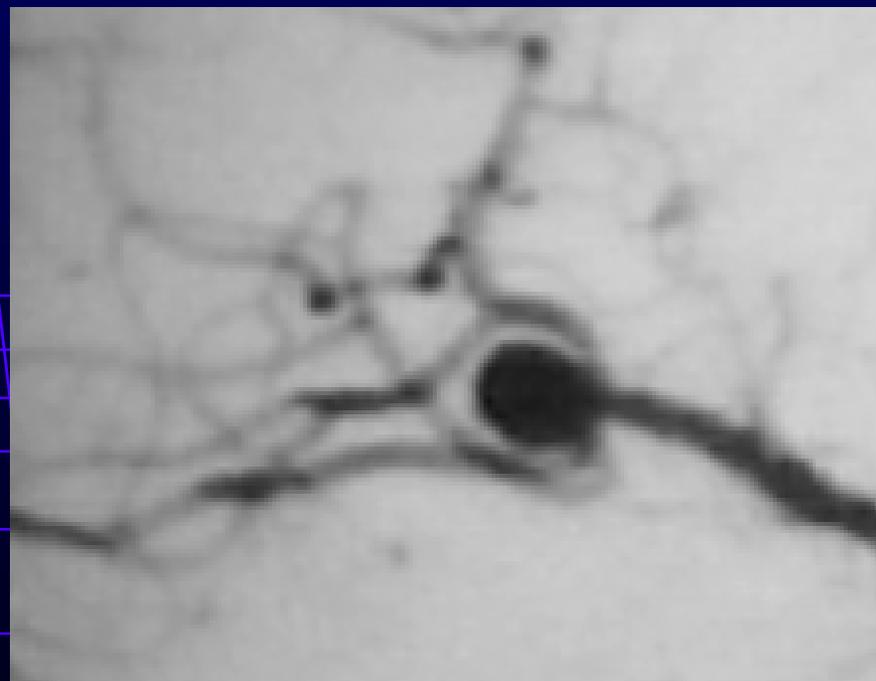
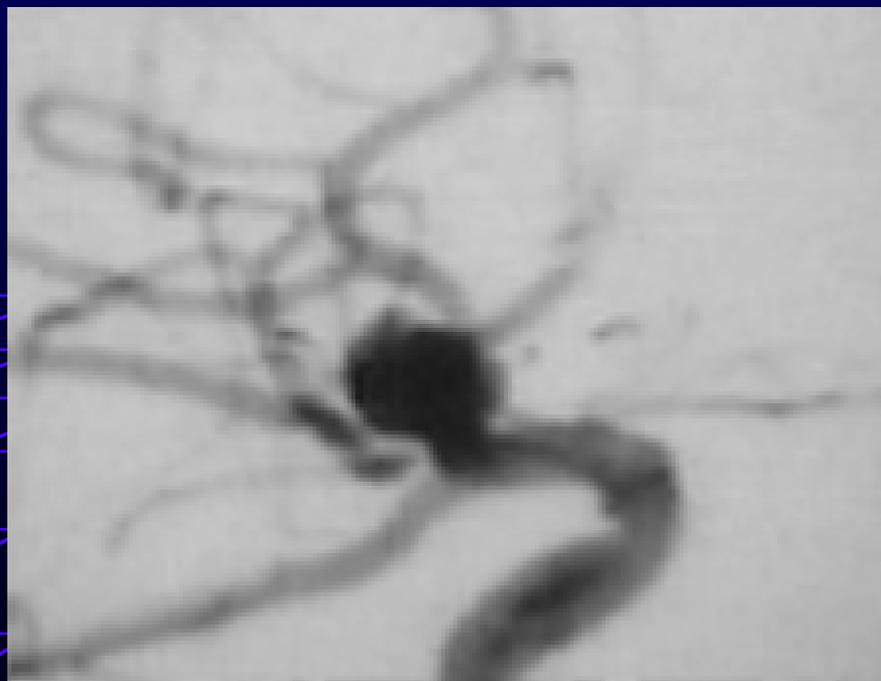
末梢の塞栓



カテーテル操作に伴うもの

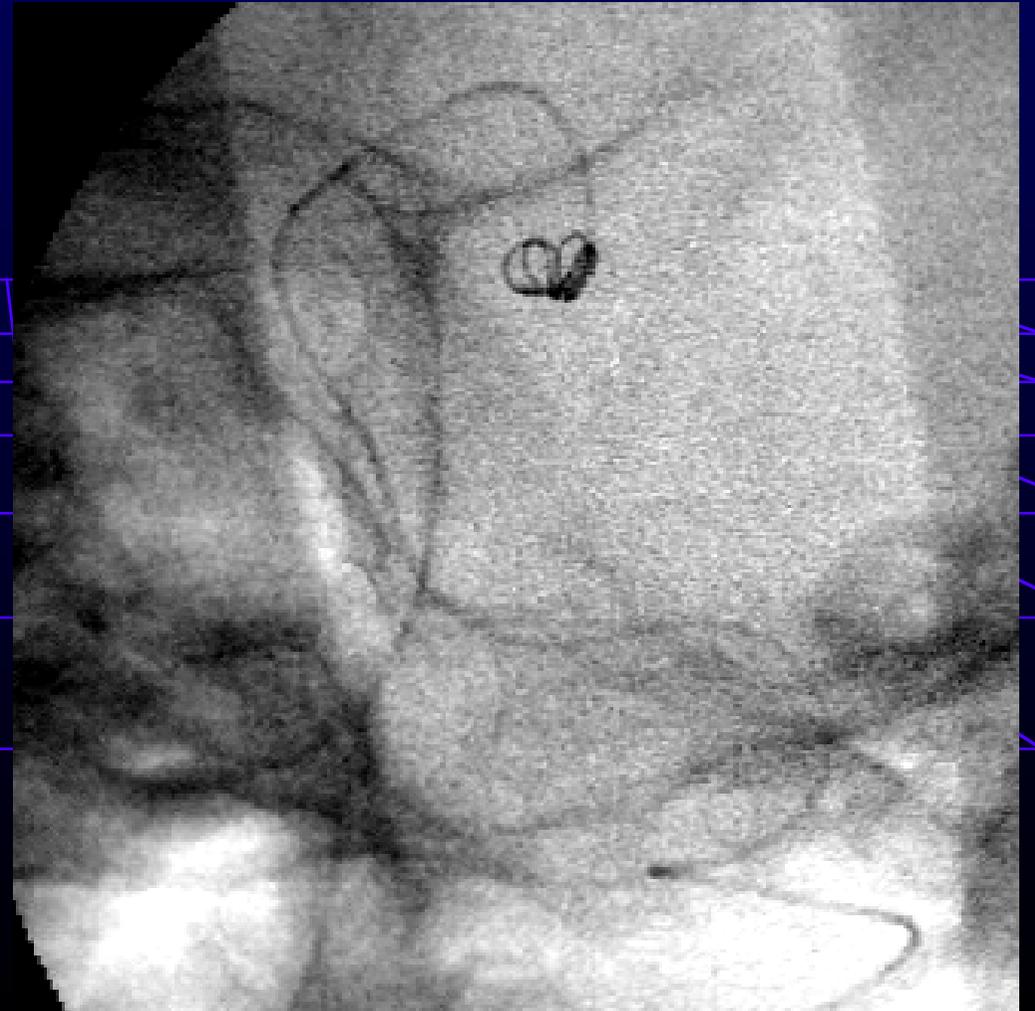
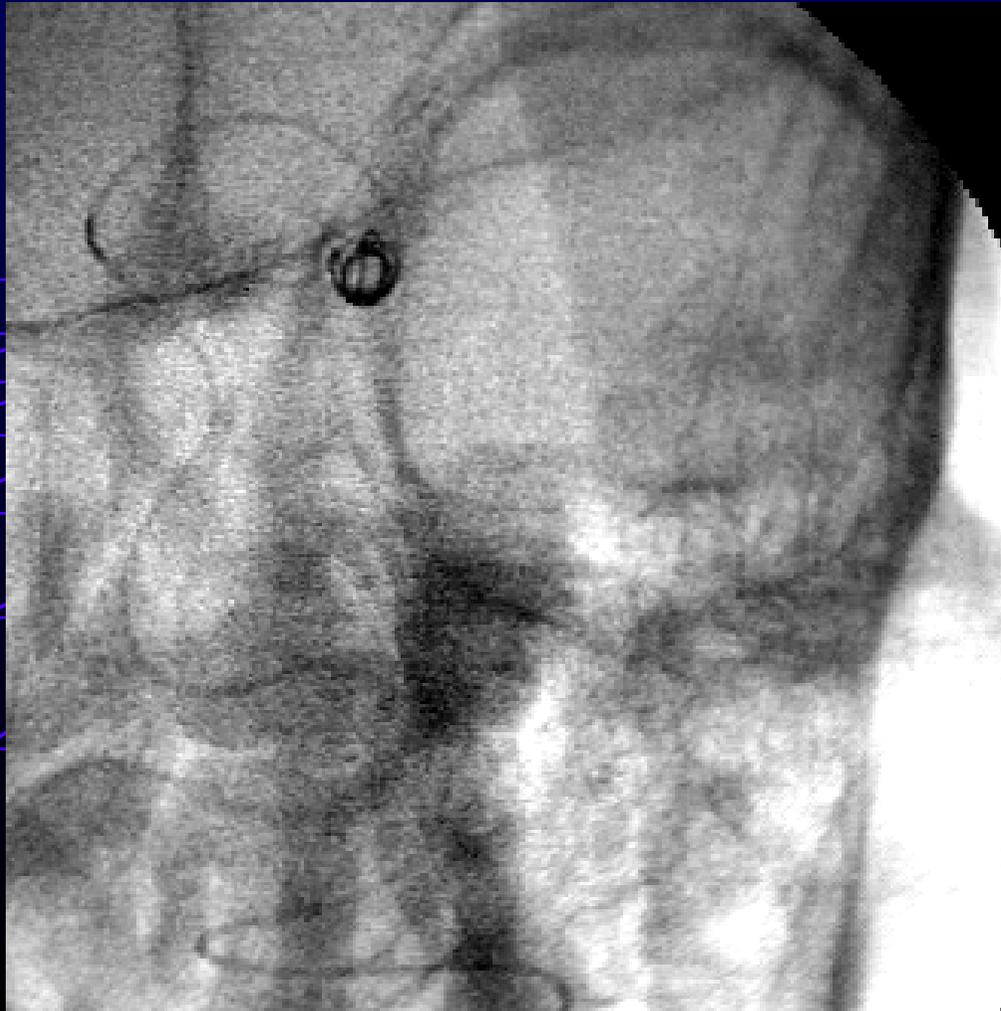
Angle of Attack

安全な操作ができる透視の角度は？



カテーテル操作に伴うもの

Angle of Attack



カテーテル操作に伴うもの

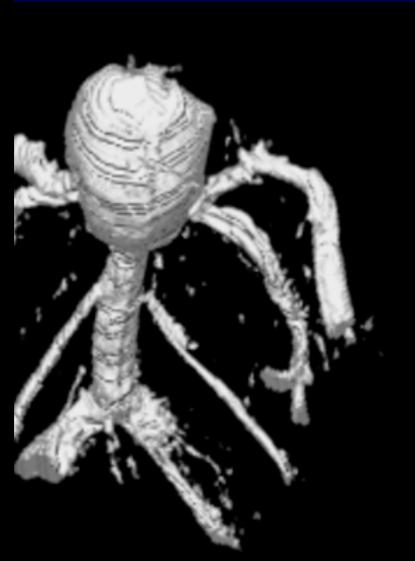
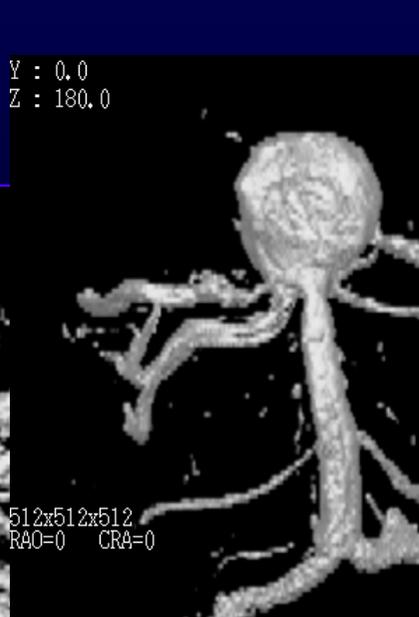
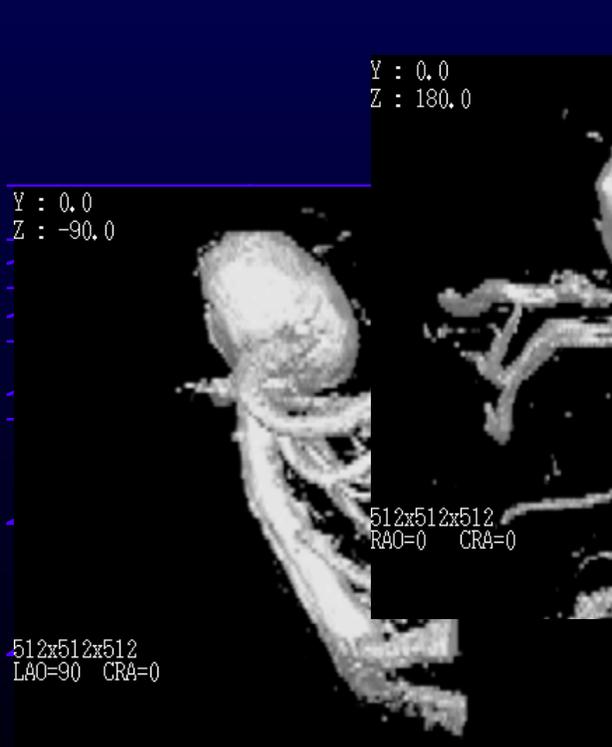
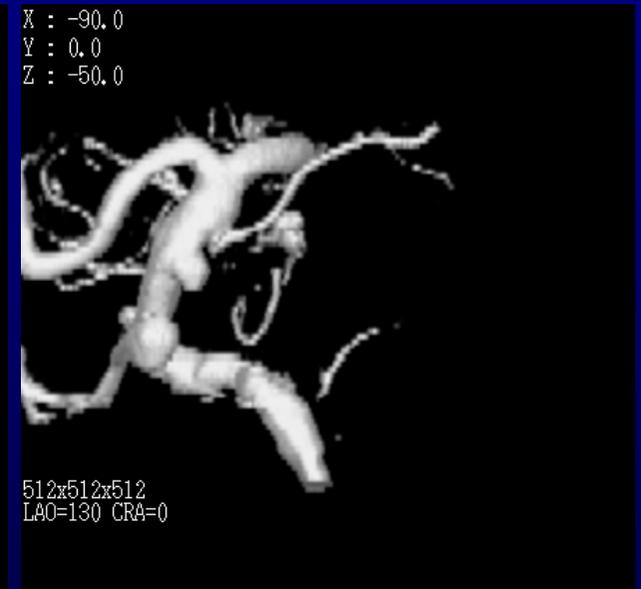
Angle of Attack - Rotation DSA



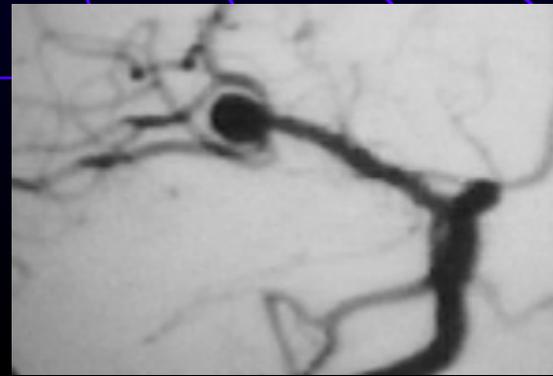
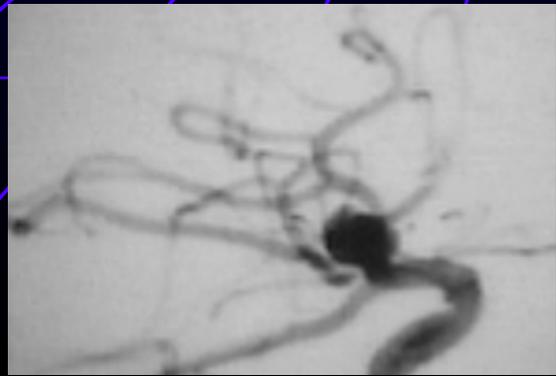
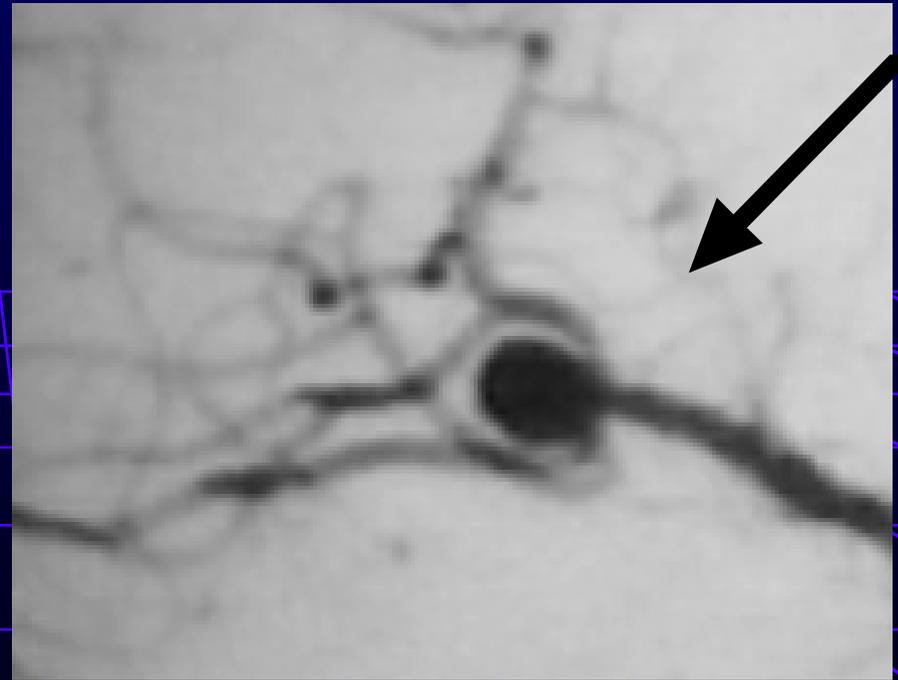
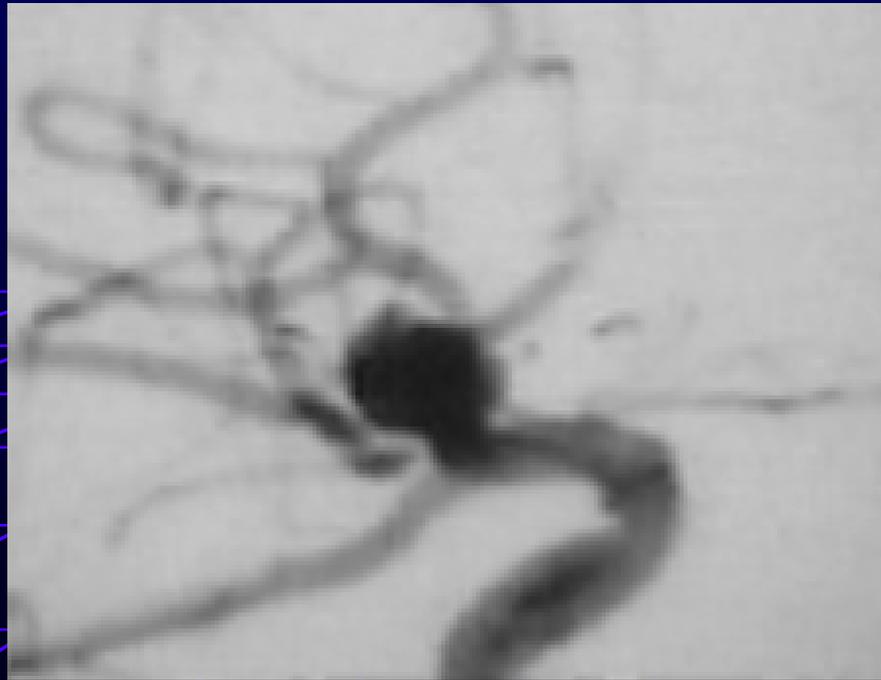
Angle of Attack



Angle of Attack



Angle of Attack



カテーテル操作に伴うもの

Manipulator

100 Base T Hub



Master



Slave



カテーテル操作に伴うもの

Manipulator



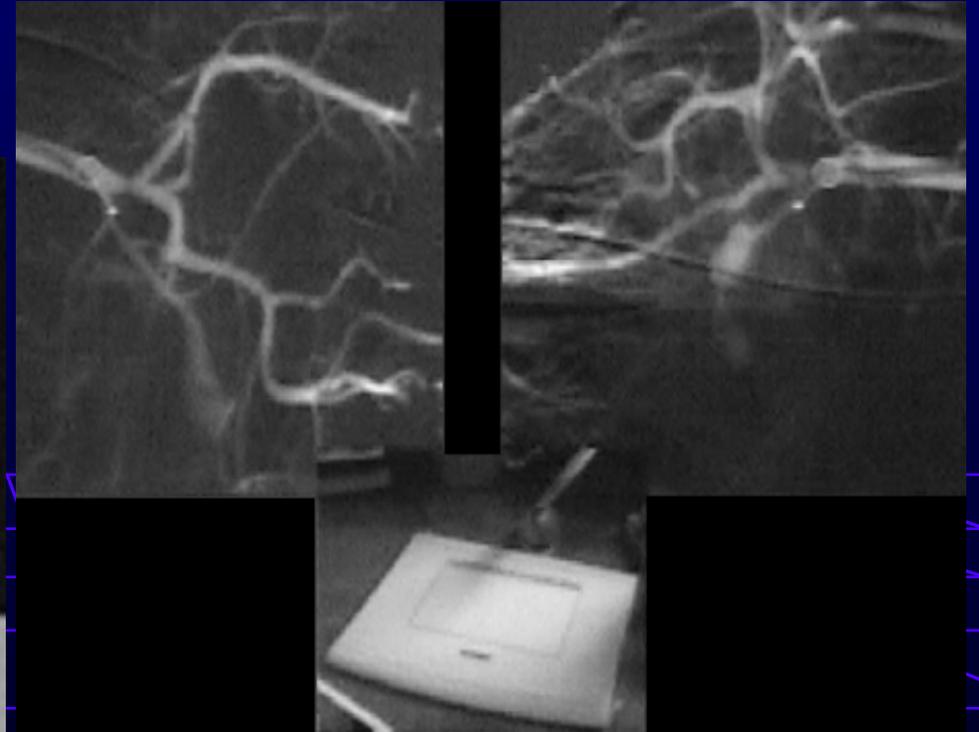
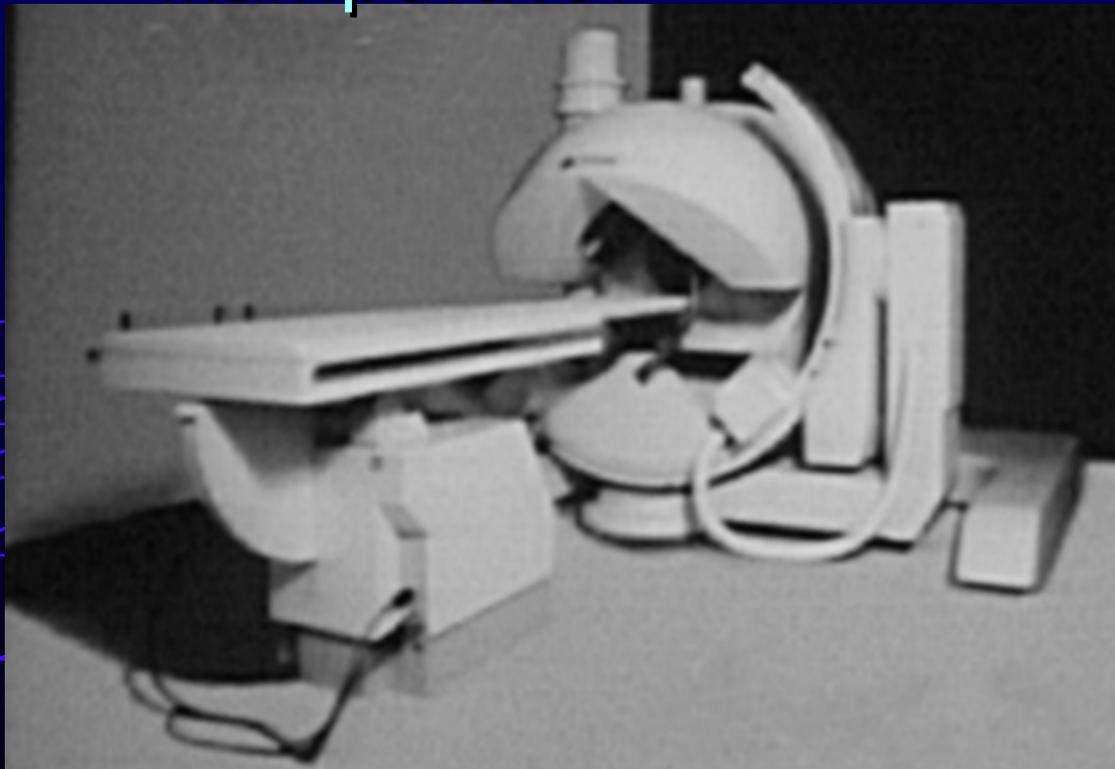
カテーテル操作に伴うもの

Manipulator



カテーテル操作に伴うもの

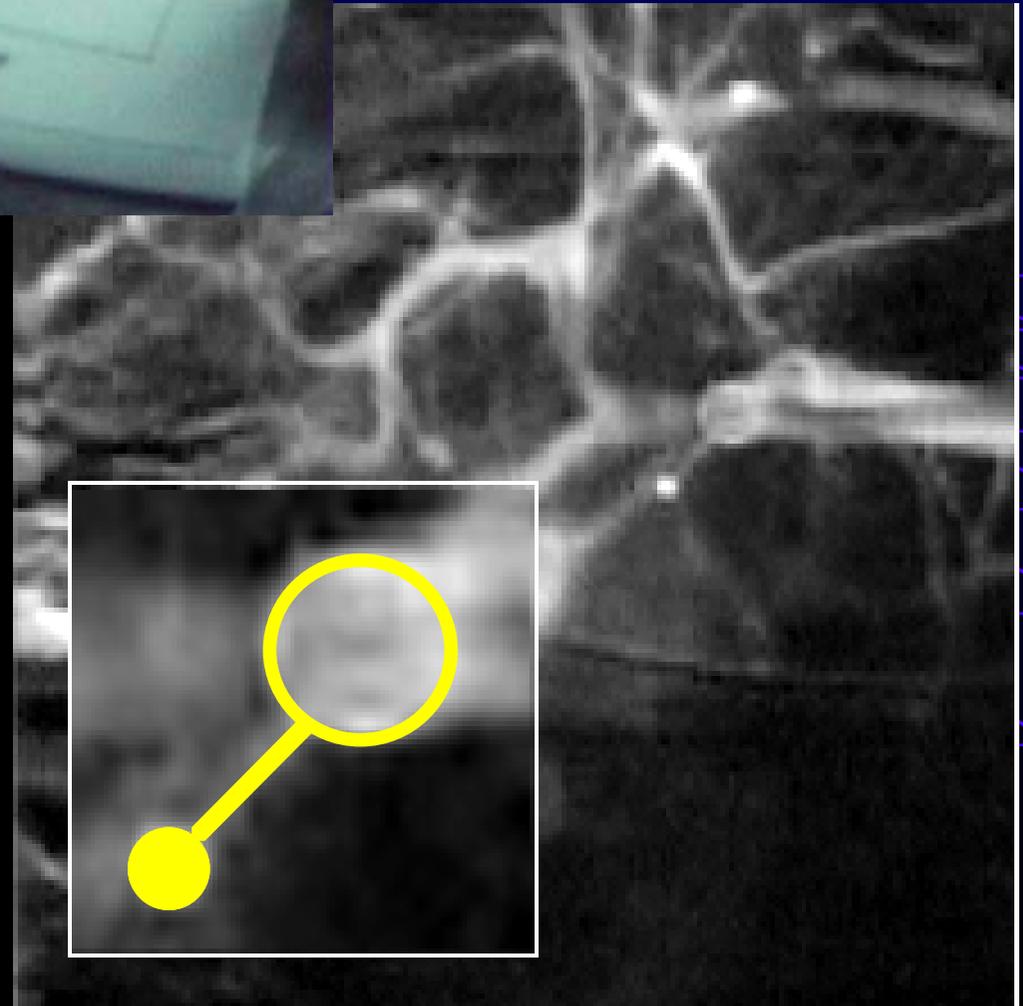
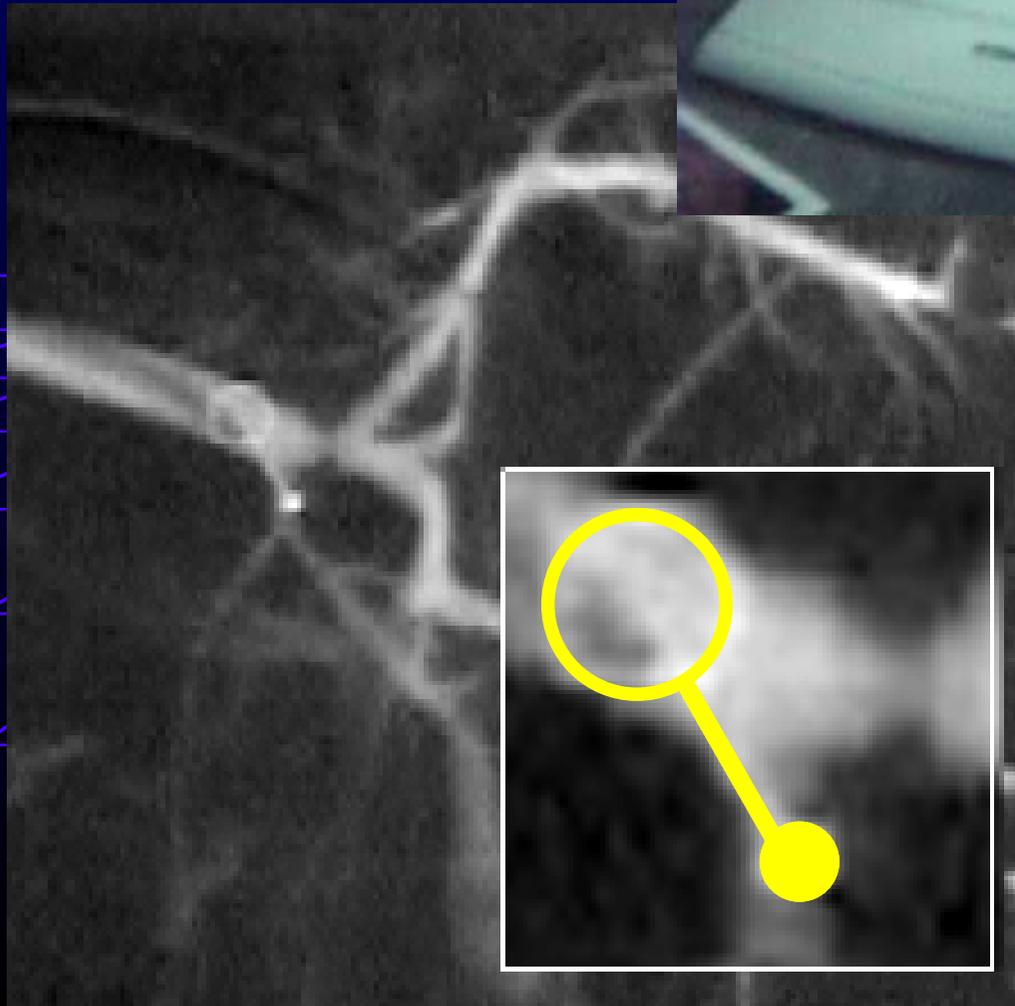
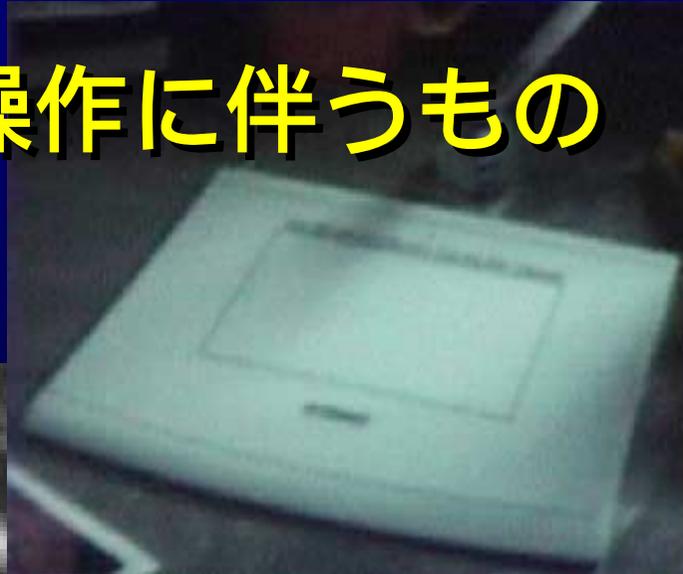
Manipulator



John Perl II,
Departments of Neuroradiology
Barrow Neurological Institute

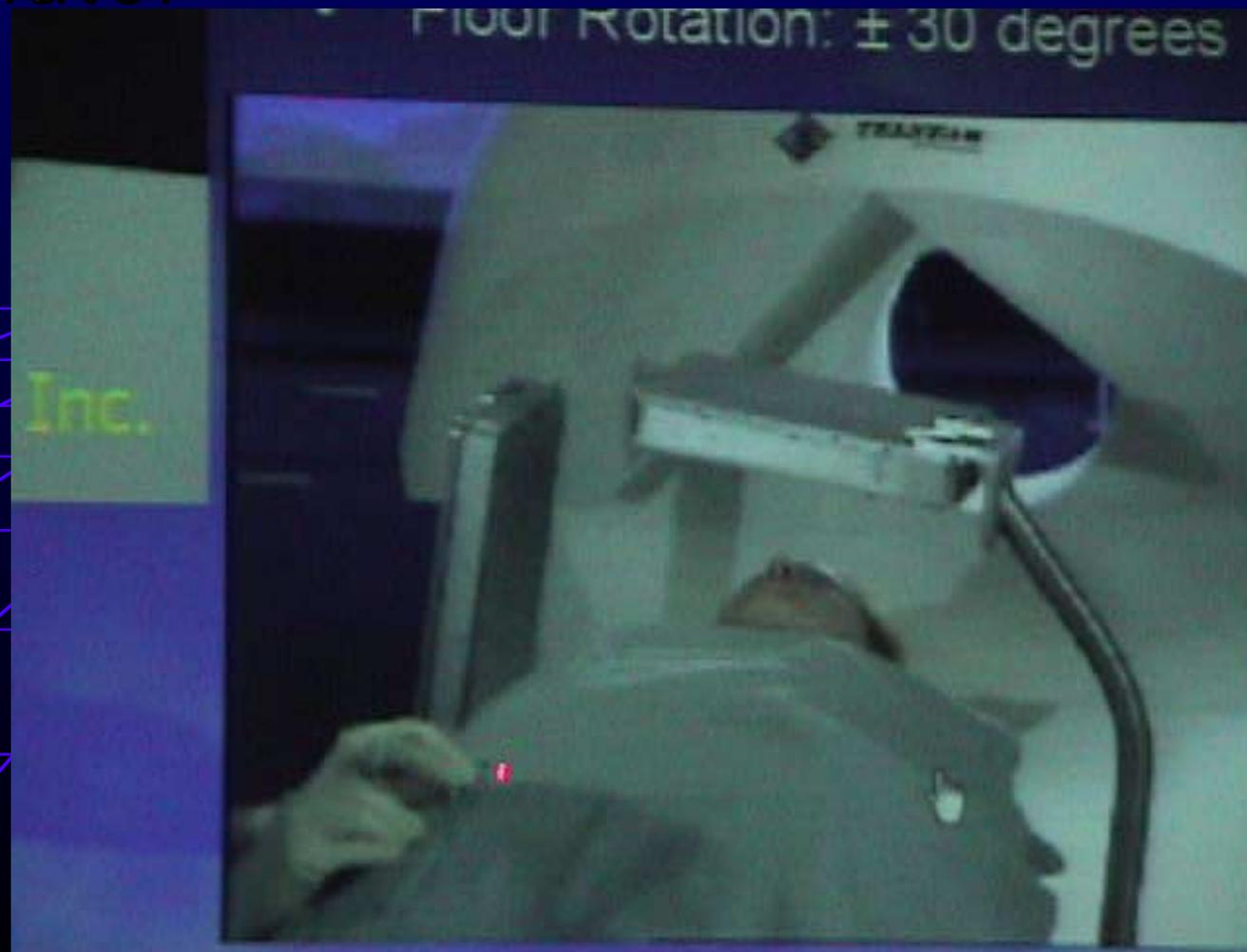
カテーテル操作に伴うもの

Manipulator



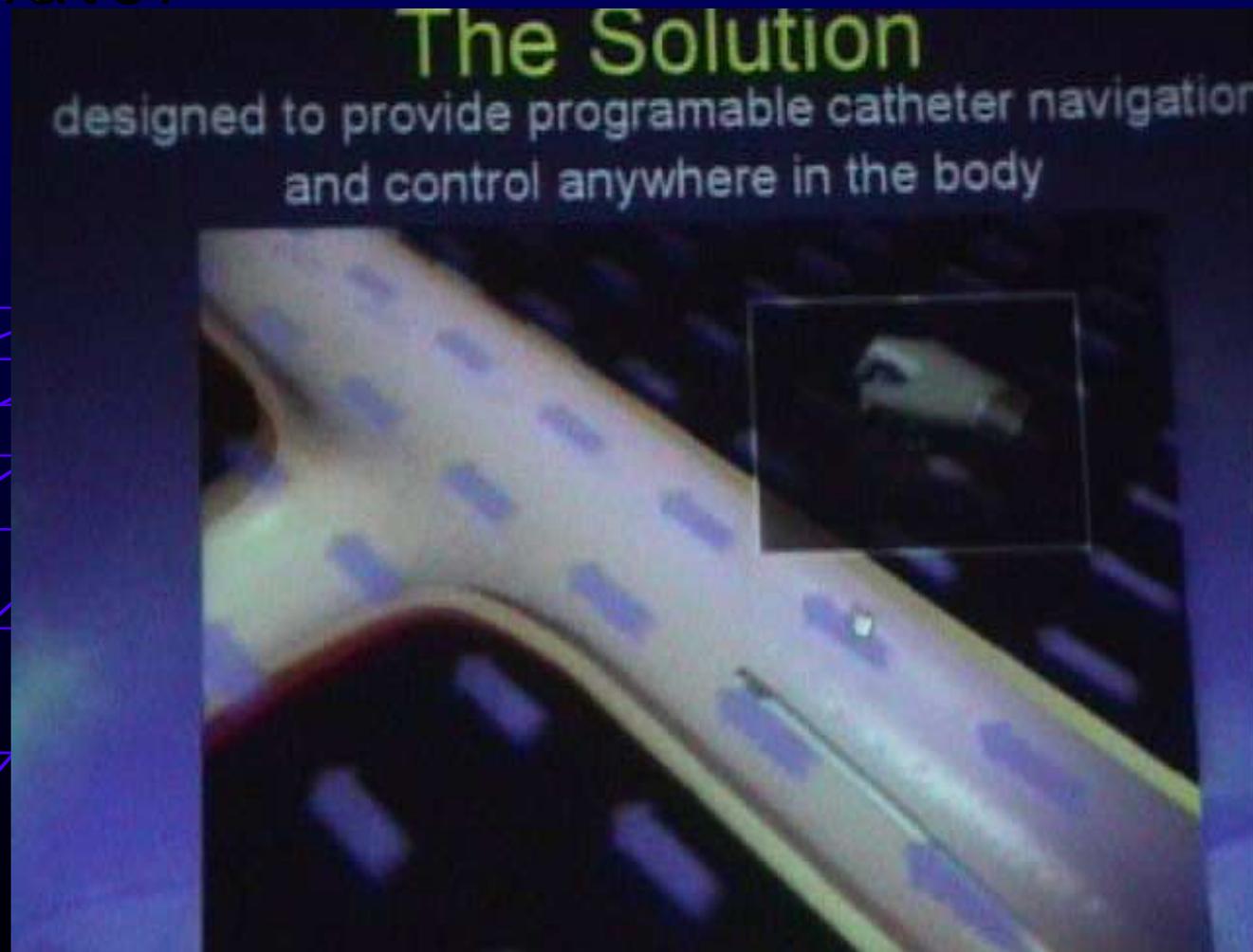
カテーテル操作に伴うもの

Manipulator



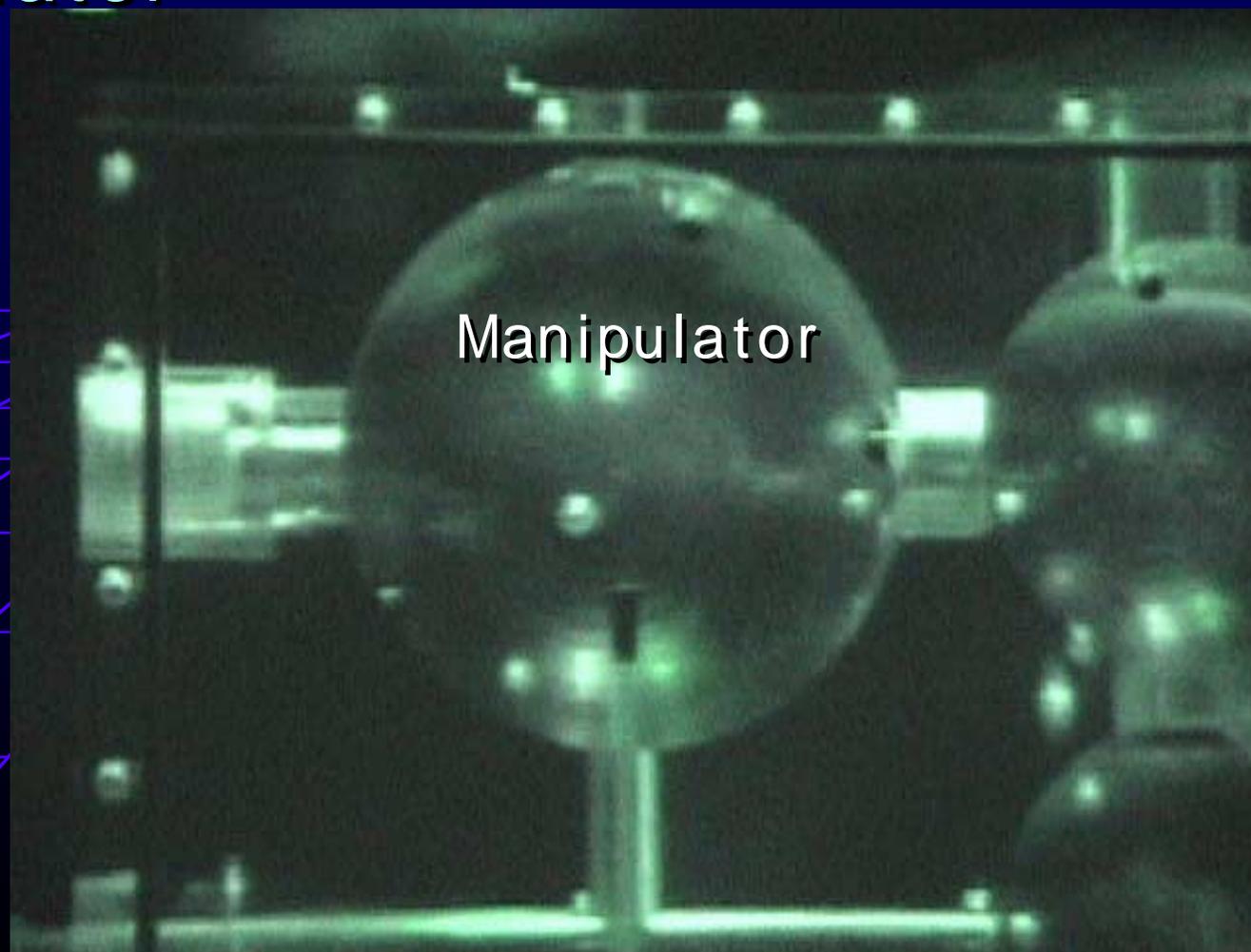
カテーテル操作に伴うもの

Manipulator



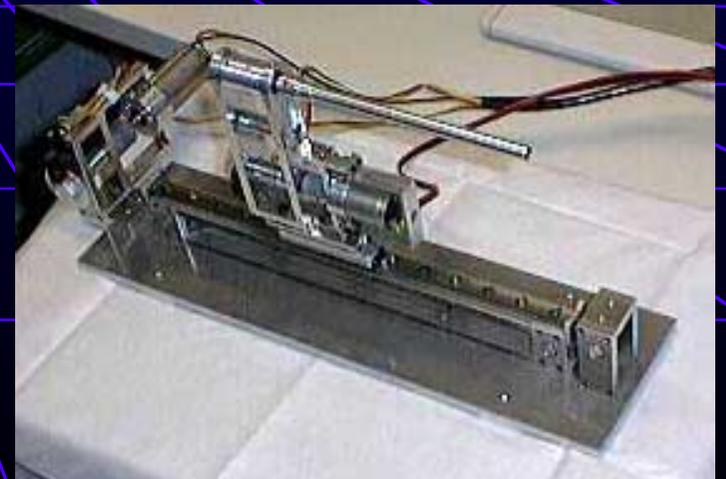
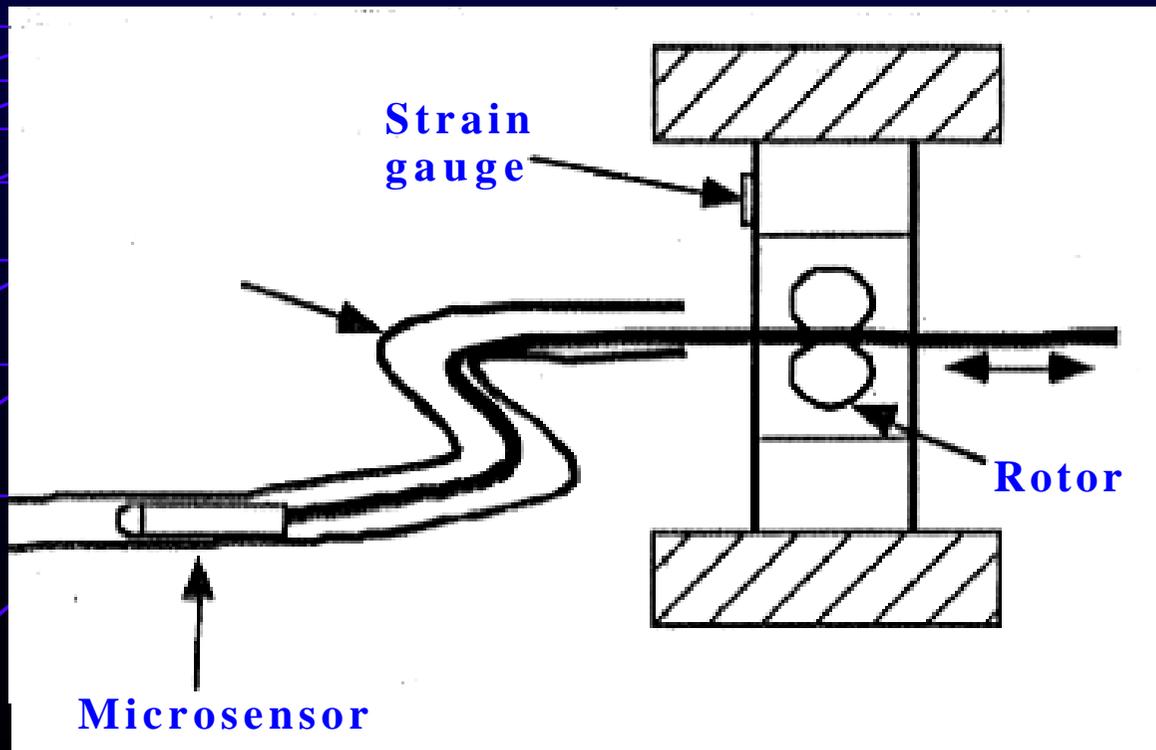
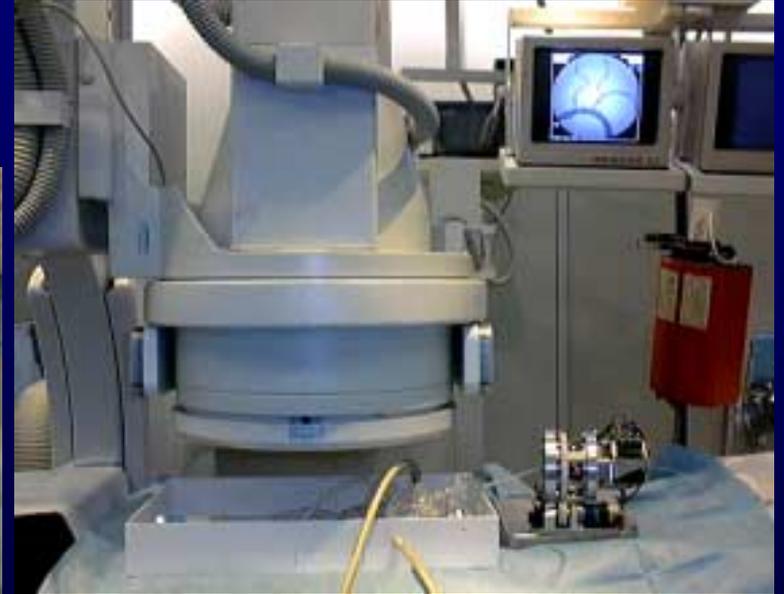
カテーテル操作に伴うもの

Manipulator



カテーテル操作に伴うもの

Pressure
Sensor



カテーテル操作に伴うもの

Angle of Attack

Robotics

PHANToM

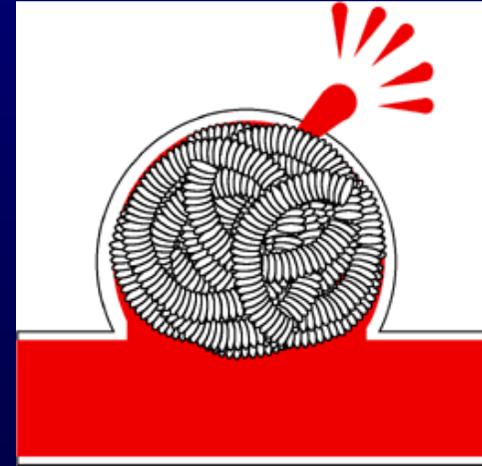
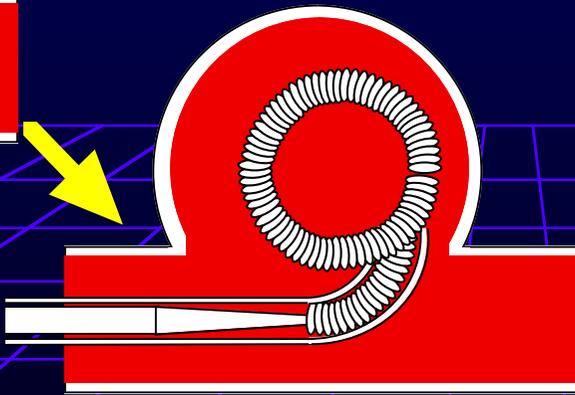
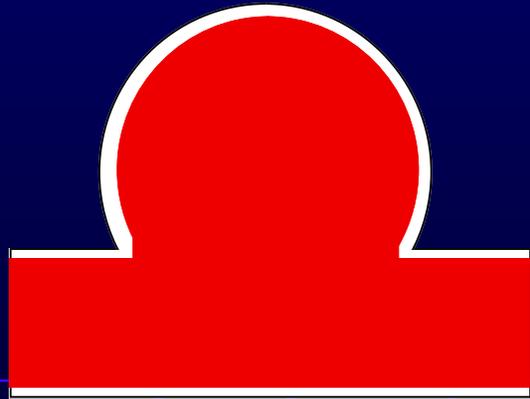
Magnet guide

Slip Ring & Motor

Catheter Tip Press Sensor

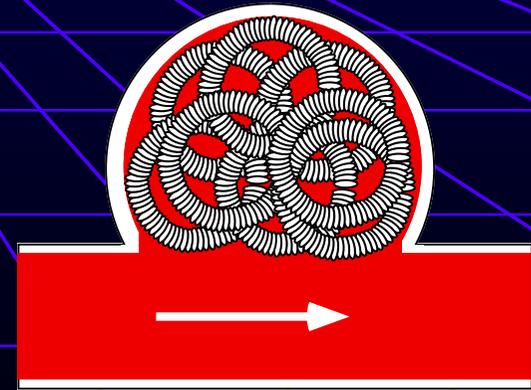
Active Wire

Flow Guided Catheter?



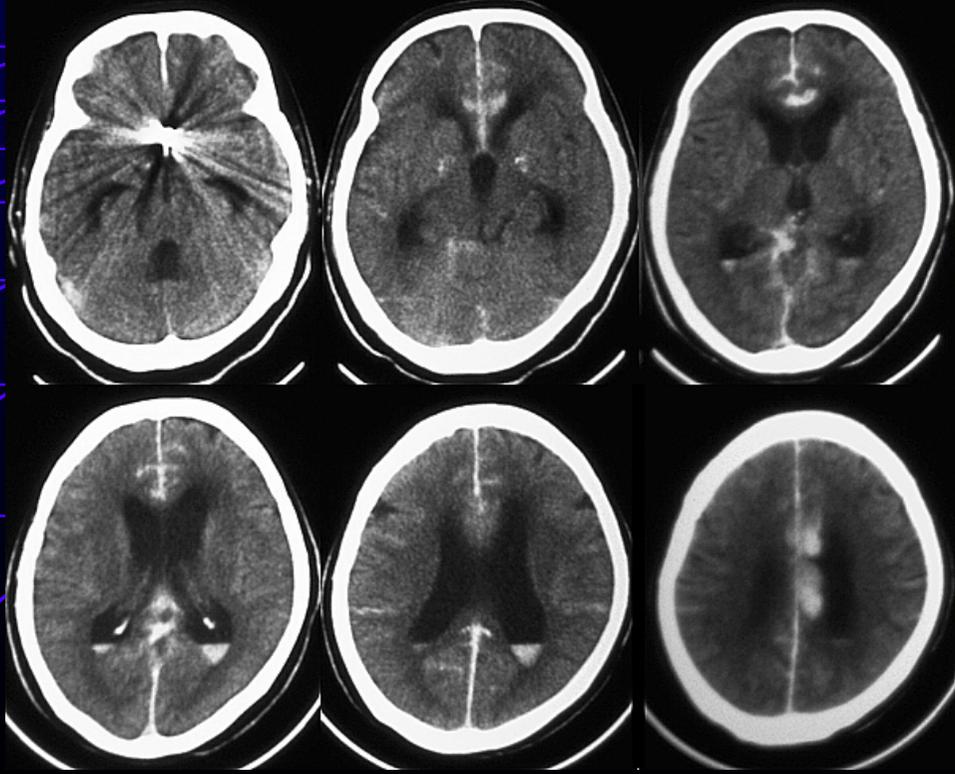
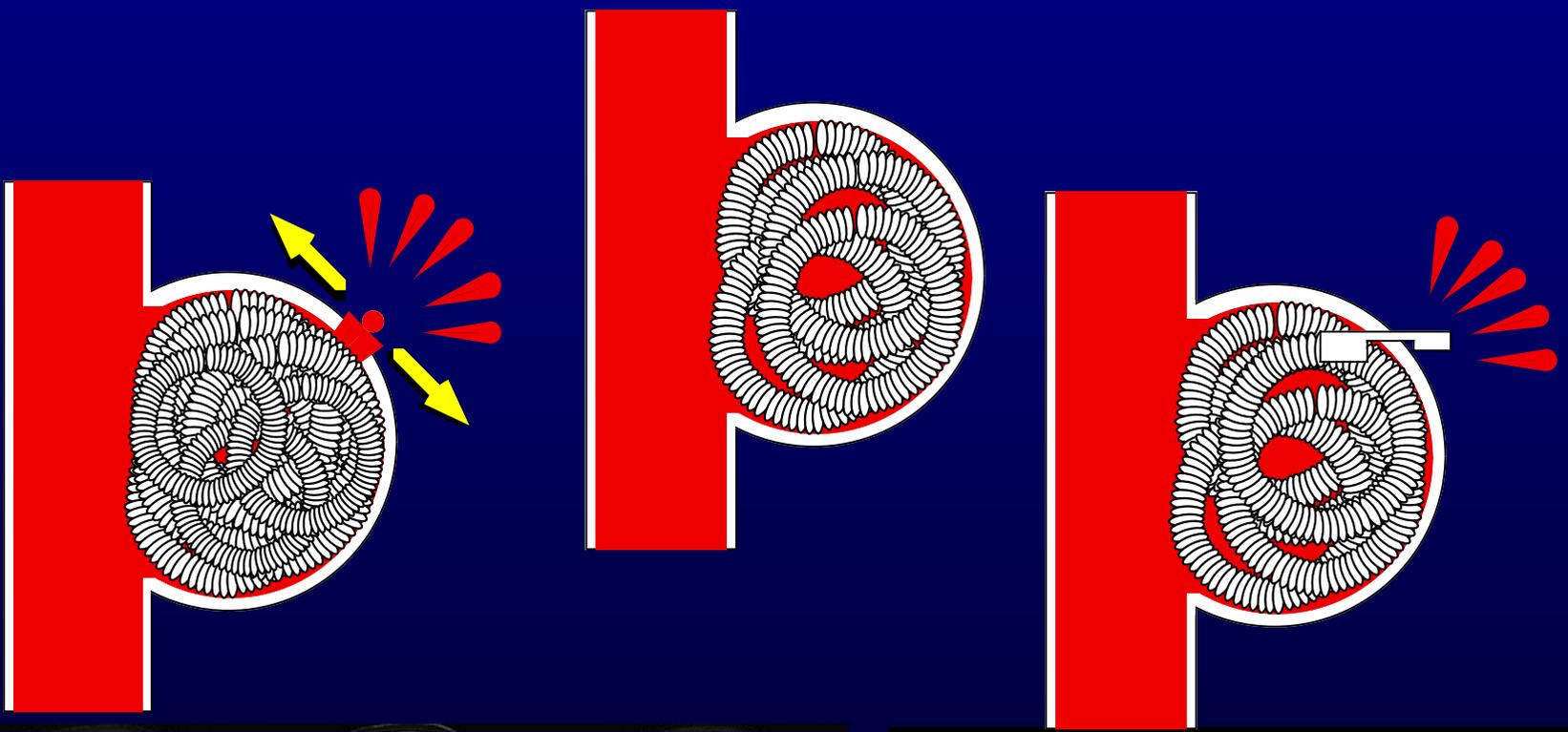
Over
Packing

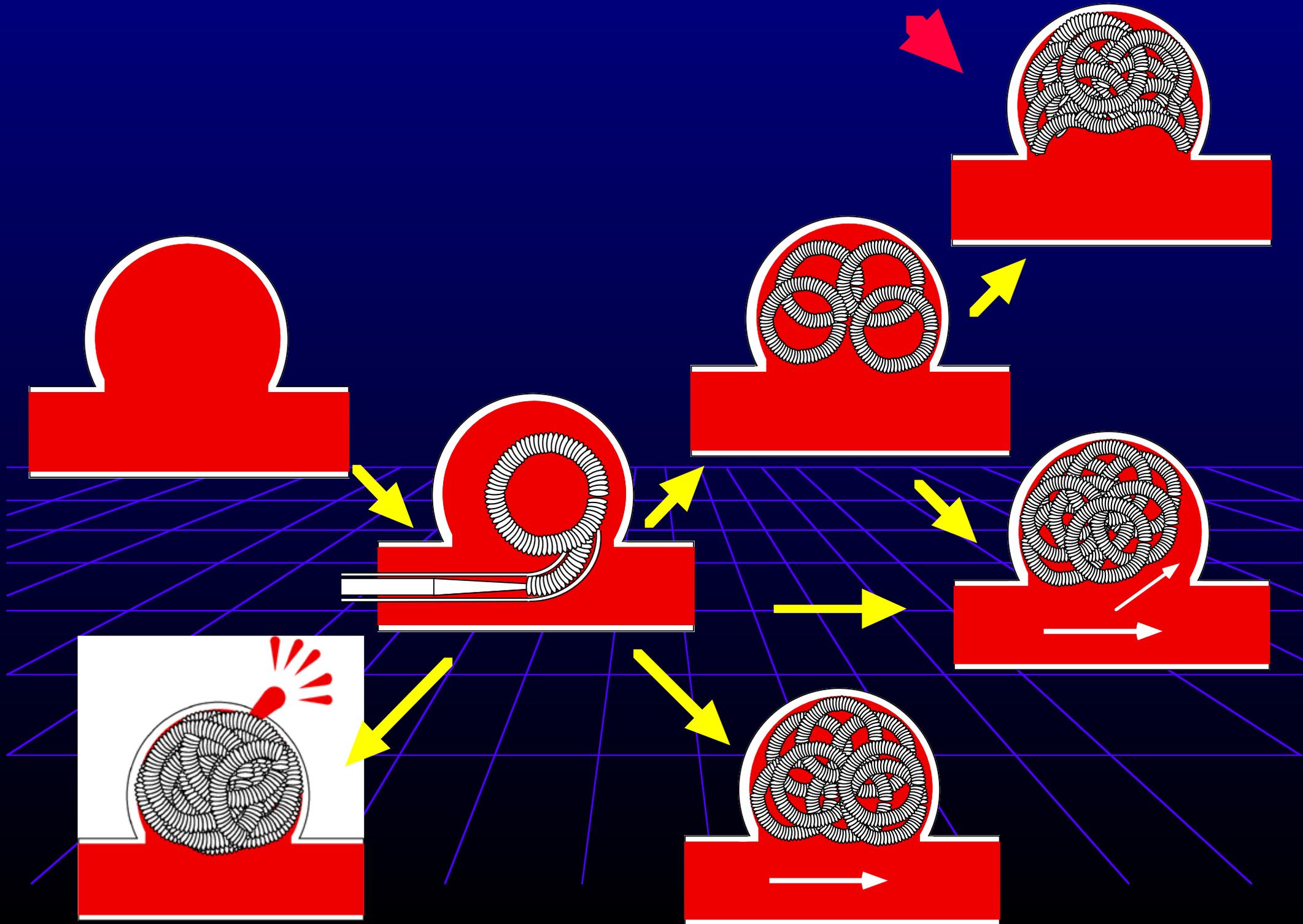
-> 出血



VER (Volume Embolization Ratio)
30 % ?

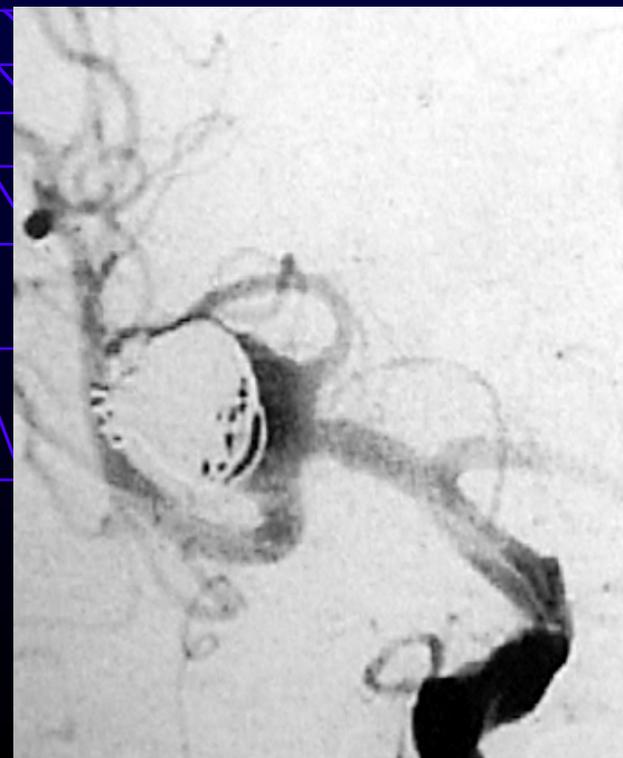
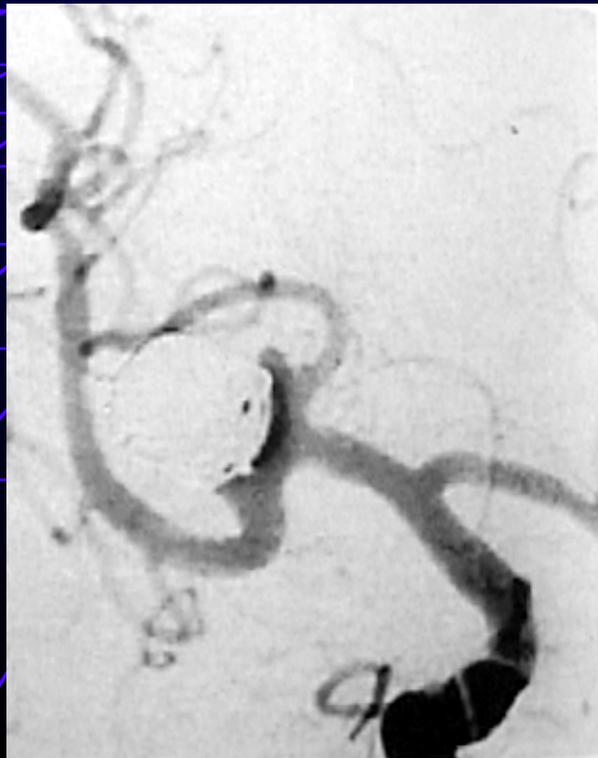
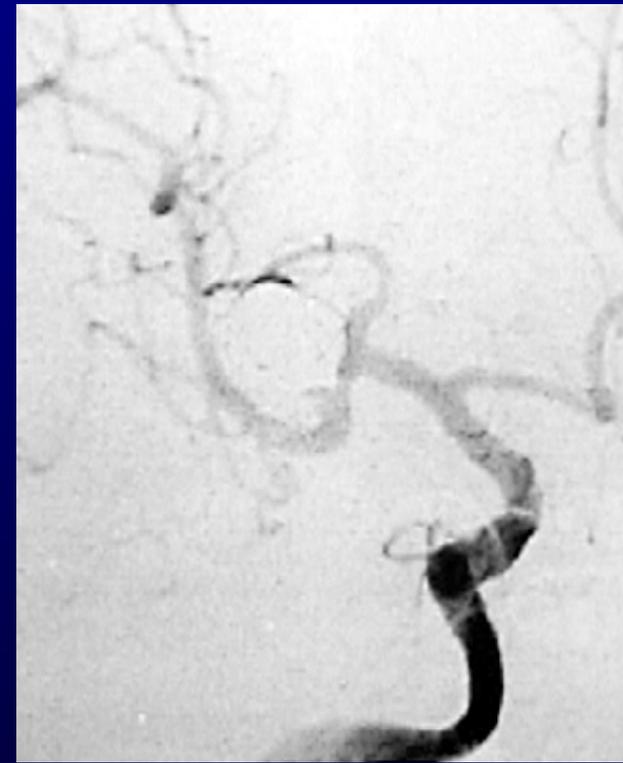
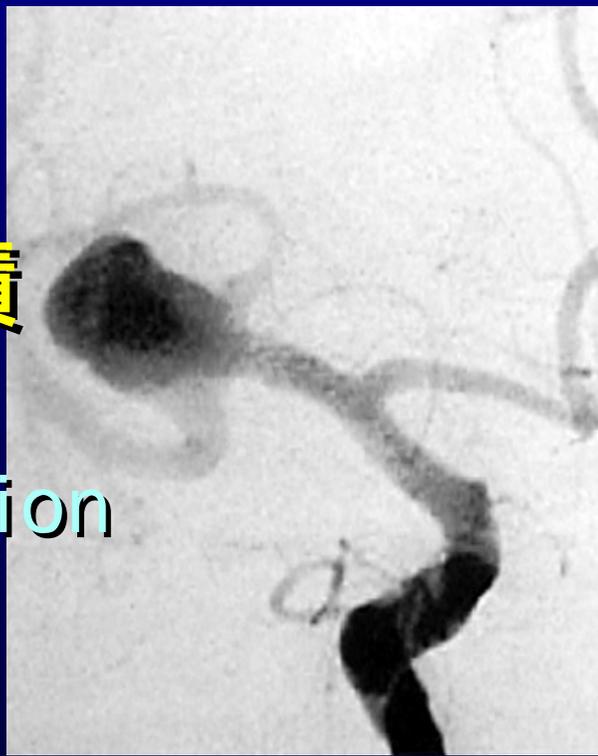


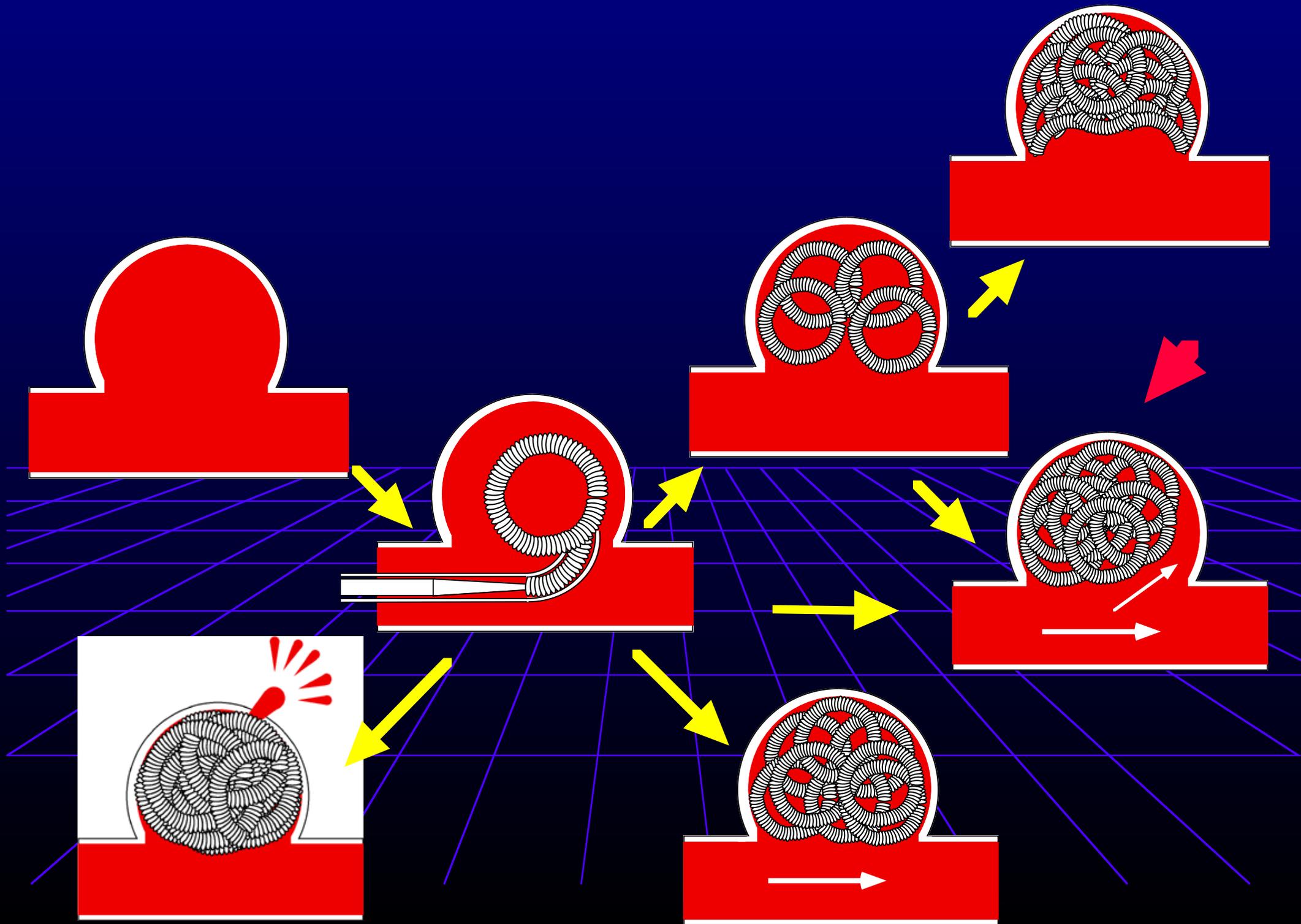




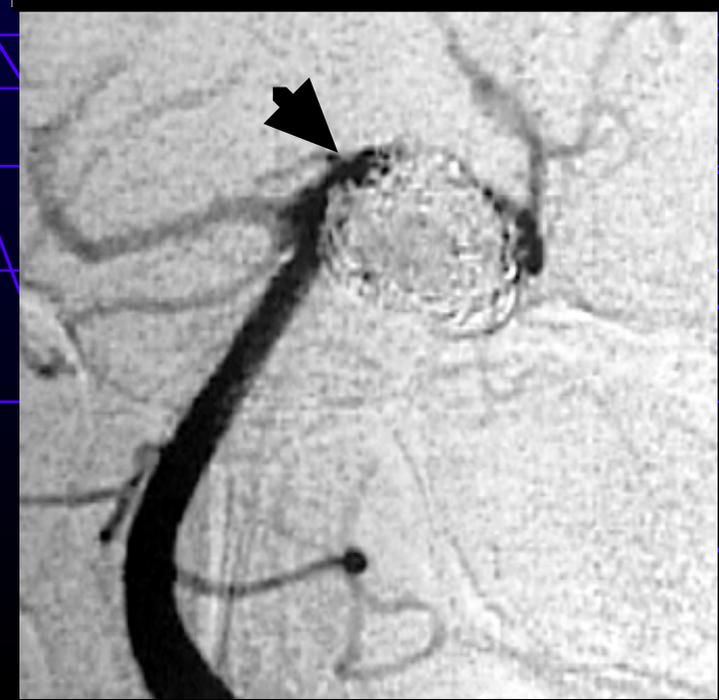
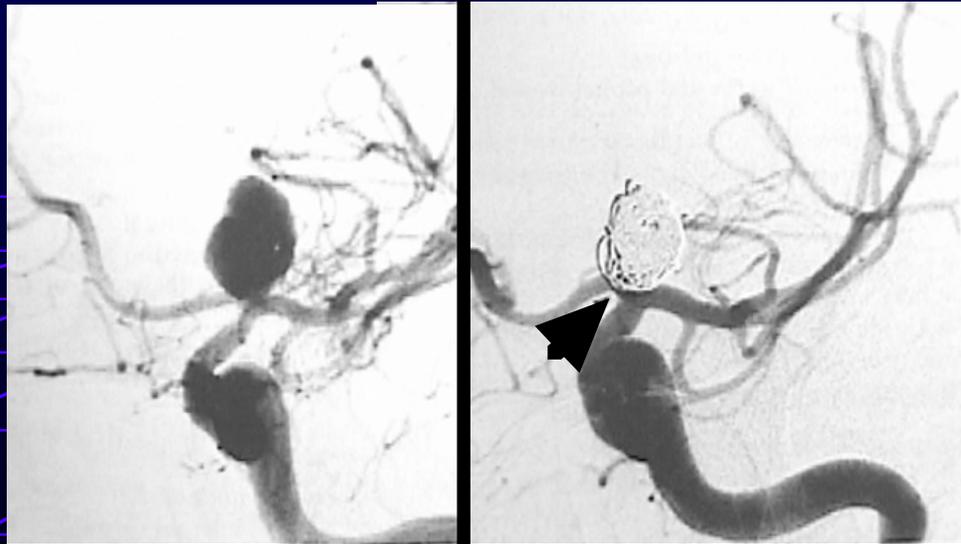
長期成績

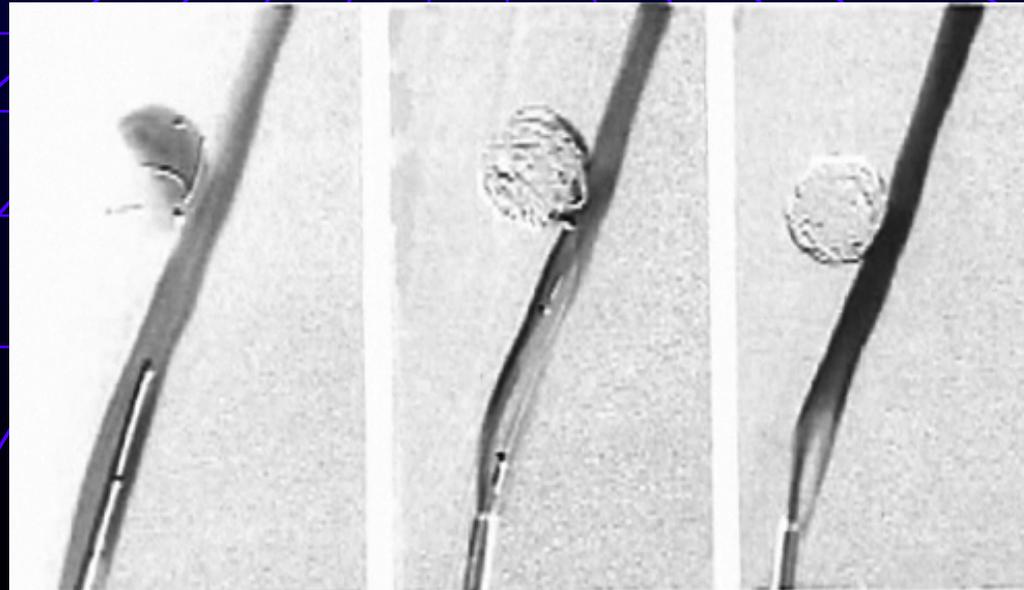
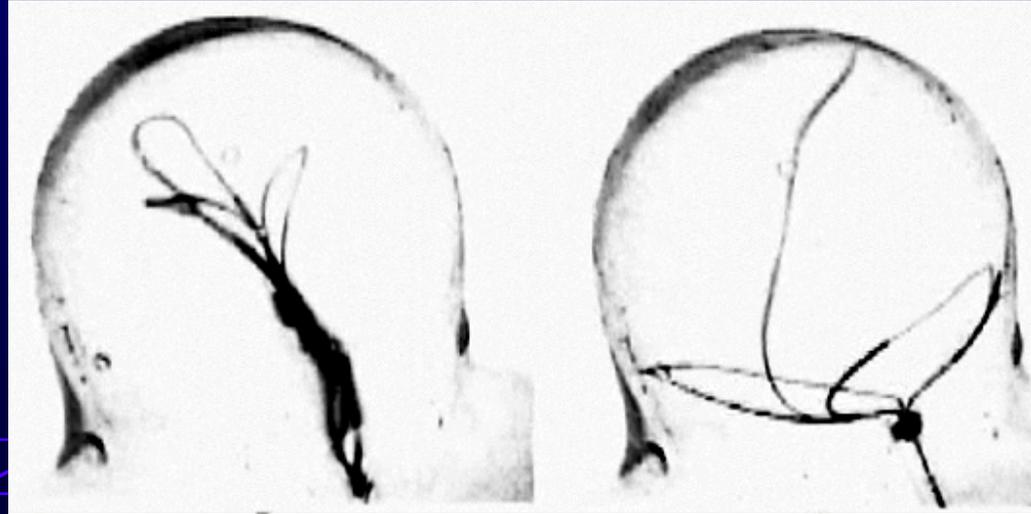
Coil
Compaction

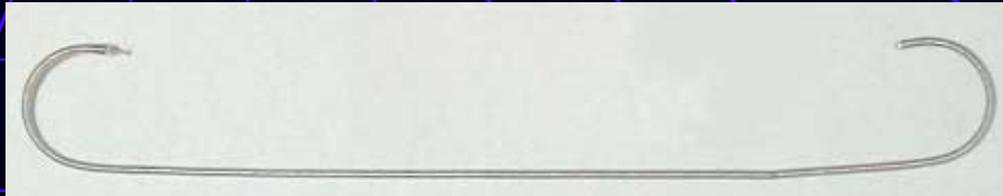
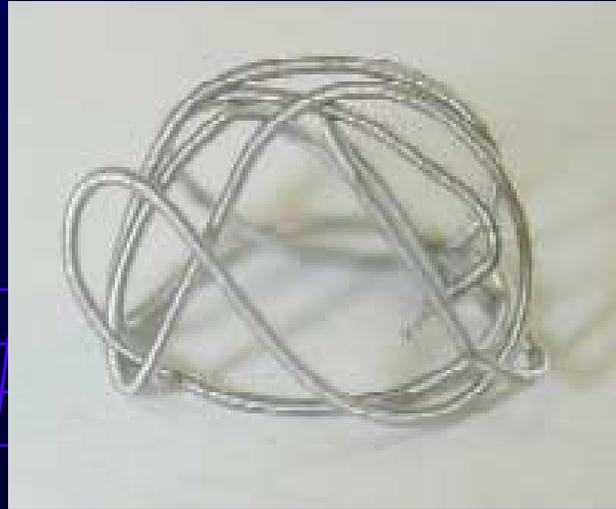




Neck Remnant







長期成績

43例46塞栓術

治療直後

complete(CP) - 24 / 46 (52%)

neck remnant(NR) - 8 / 46 (18%)

partial(PA) - 14 / 46 (30%)

6M Follow up

改善11例

(PA - CP; 8, NR - CP; 1, PA - NR; 2)

悪化9例(CP - NR; 5, CP - PA; 1, PA - PA; 3)

長期成績

47例 (破裂23例、未破裂24例)

complete occlusion 10
neck remnant 7
body filling 18
neck remnant + body filling 12

1) 術直後にcomplete occlusion 10 全て不変

2) neck remnant 7
不変 2
neck remnant 拡大 5

3) body filling 18
不変 4
body filling 拡大 4
coil compactionのためneck側にfillingが出現 4
neck remnant + body filling 2
aneurysmal regrowth 1
complete occlusion 3

4) neck remnant + body filling 12
不変 2
body filling 拡大 5
neck remnant, body fillingともに拡大 2
aneurysmal regrowth 3例

Neck Remnant, Compaction

VER?

任意長で離脱可能なコイル？



Soft Coil?

Bioactive Coil

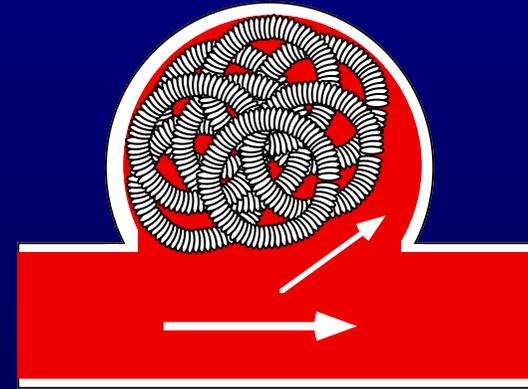
New Device?

Trispan

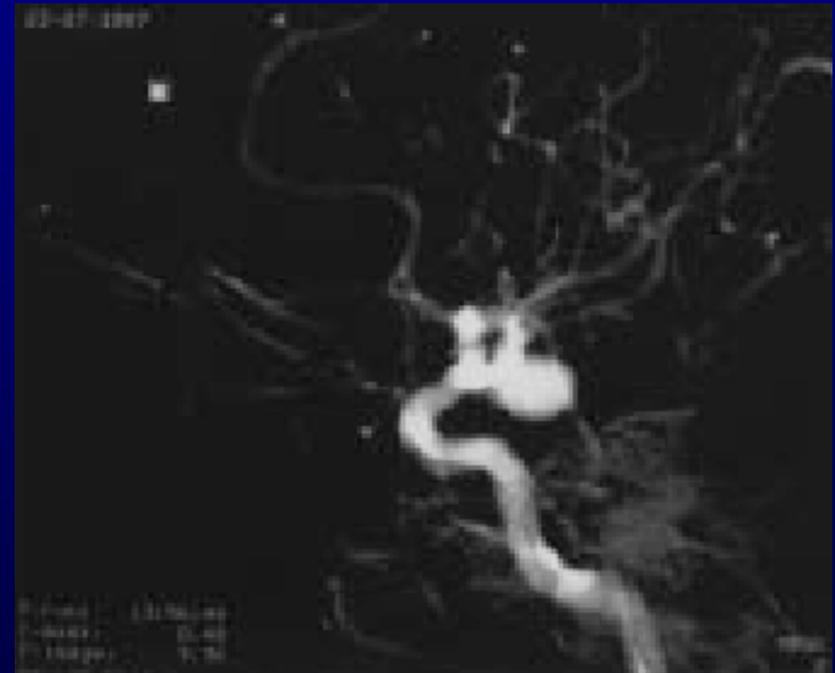
Stent

Liquid Embolus?

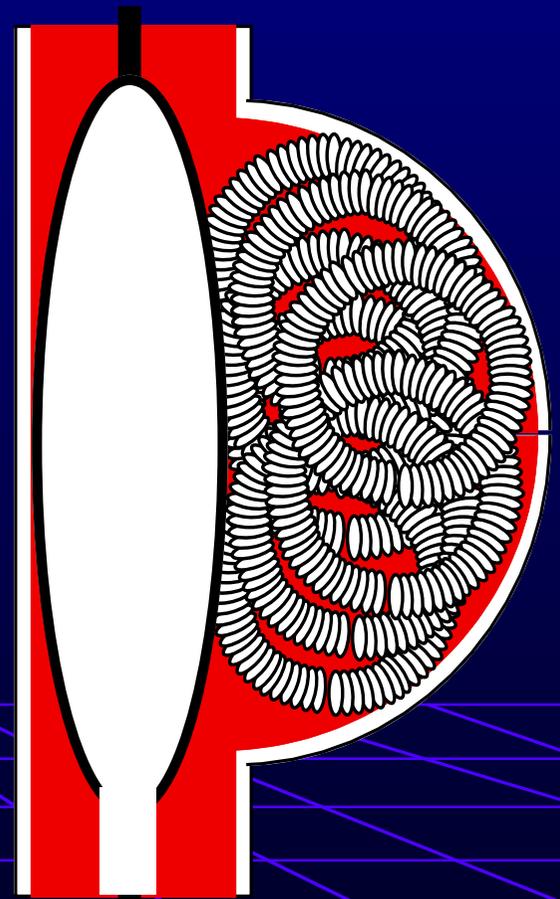
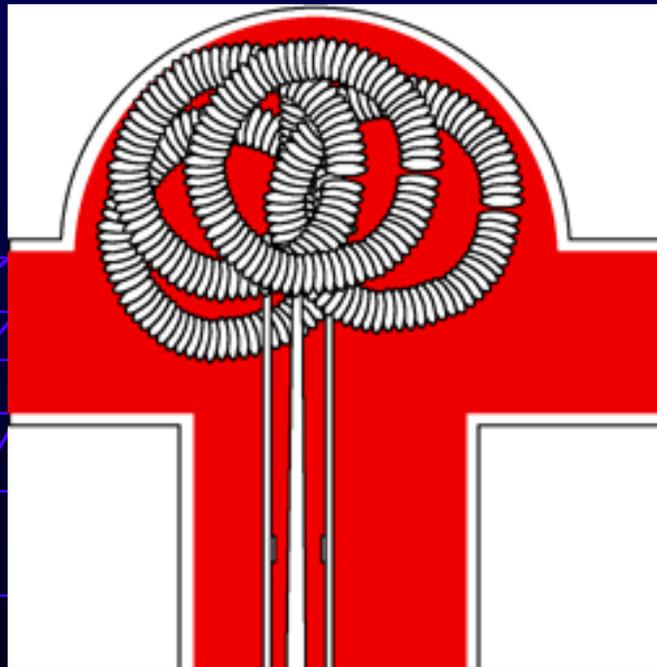
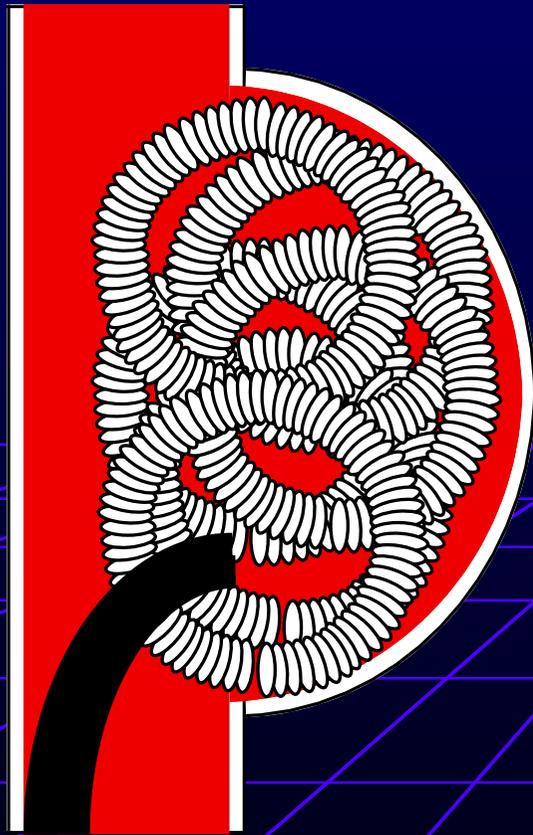
Inflow Zone?



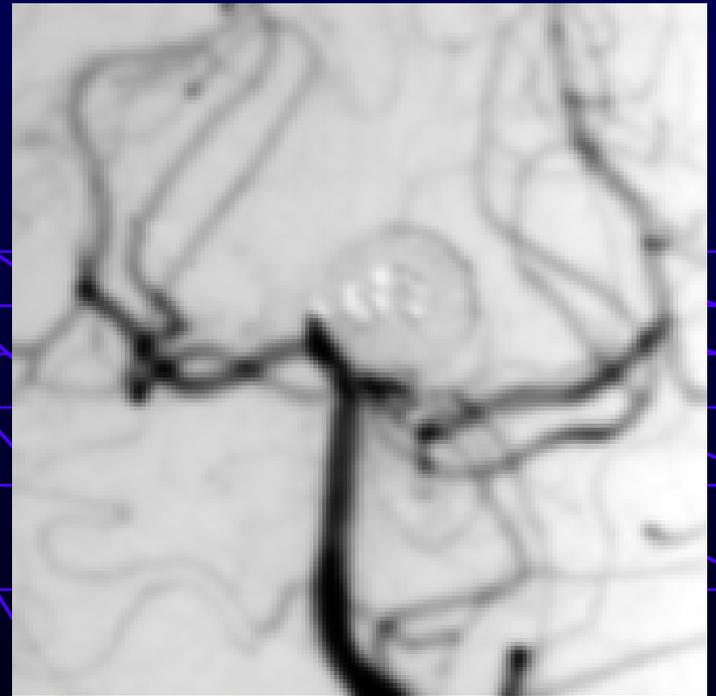
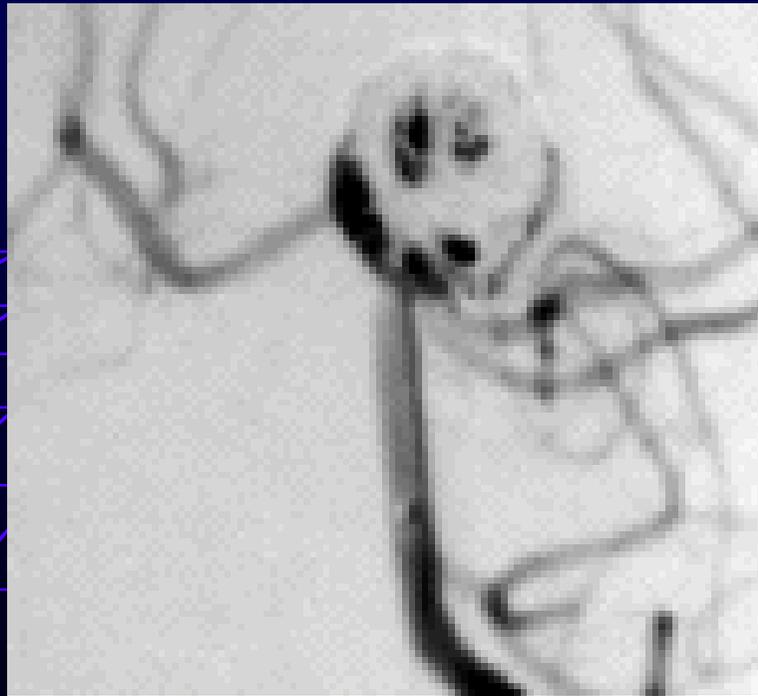
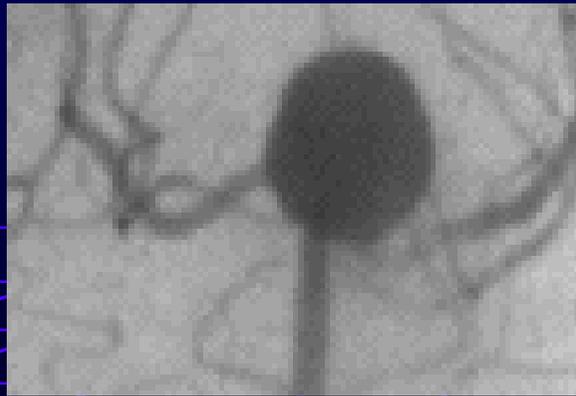
Inflow Zone



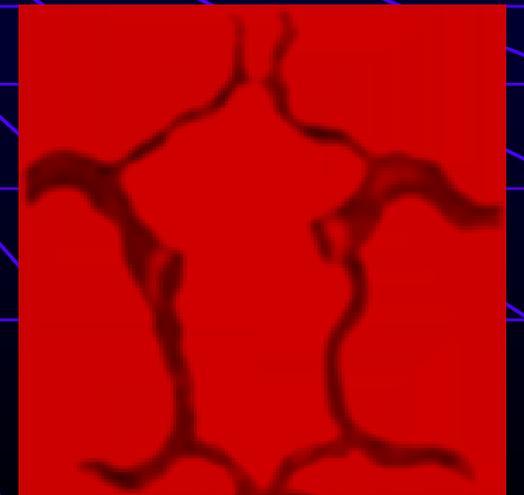
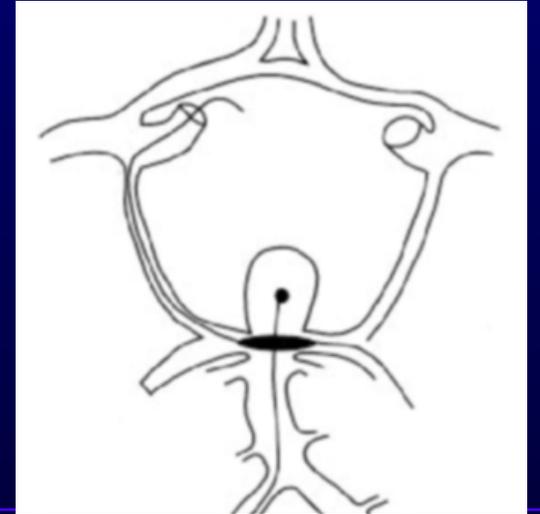
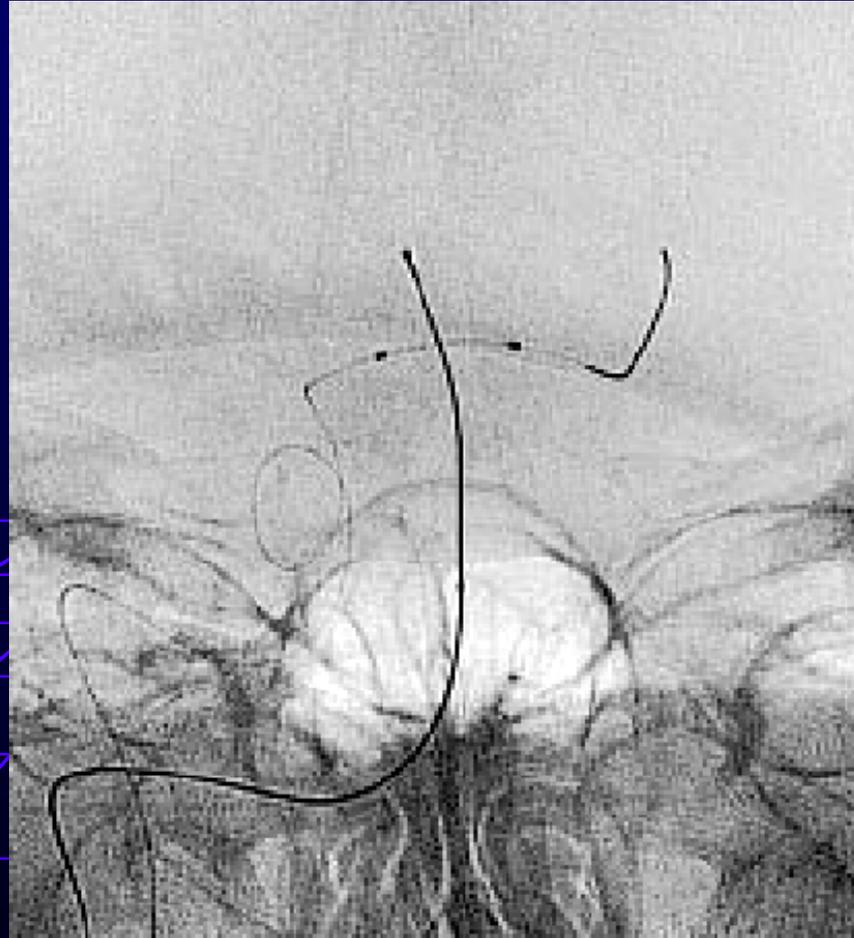
Wide Neck な動脈瘤



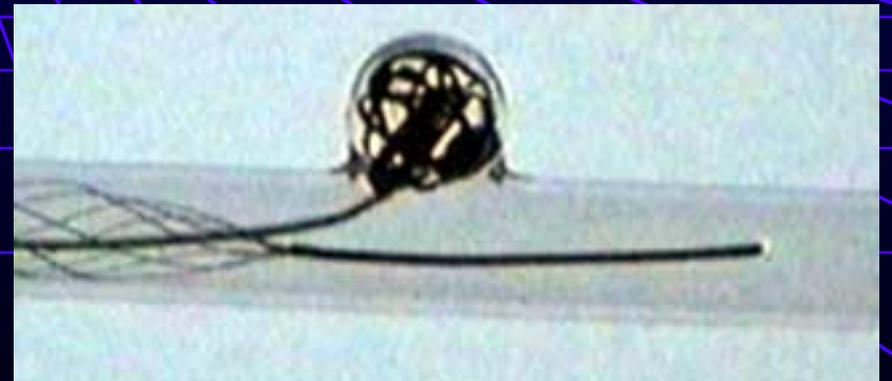
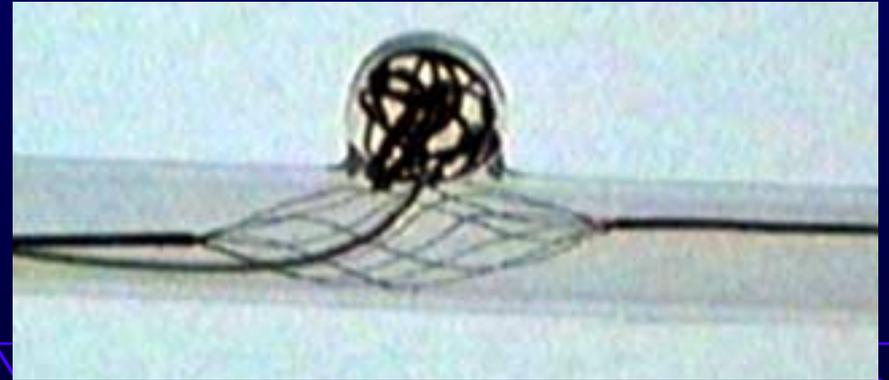
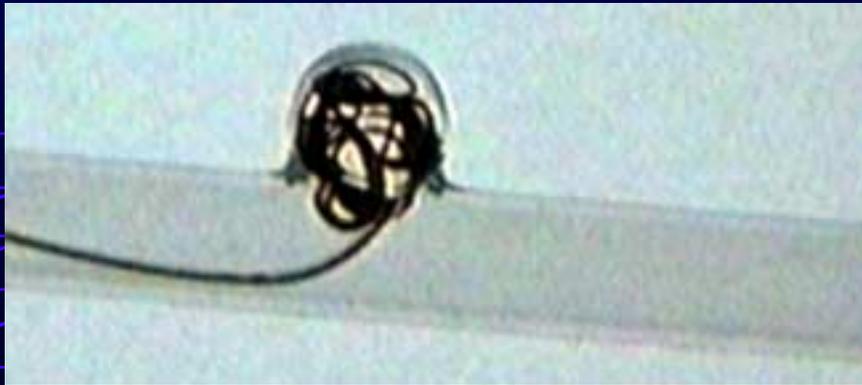
Wide Neck な動脈瘤



Wide Neck な動脈瘤



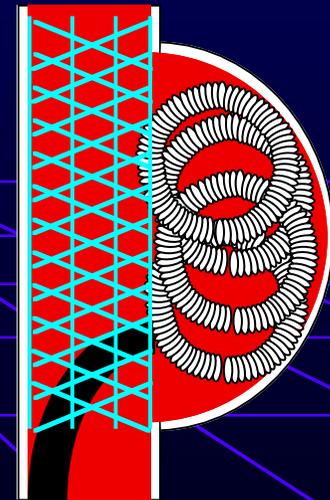
Wide Neck な動脈瘤



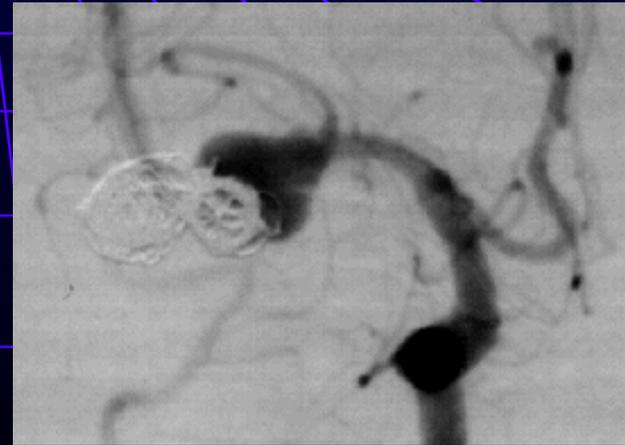
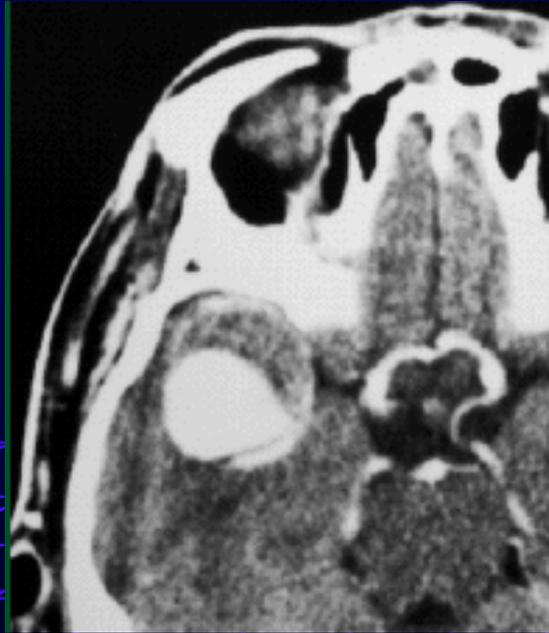
Wide Neck な動脈瘤

Remodeling
Technique?

New Device
Stent



部分血栓化動脈瘤



部分血栓化動脈瘤

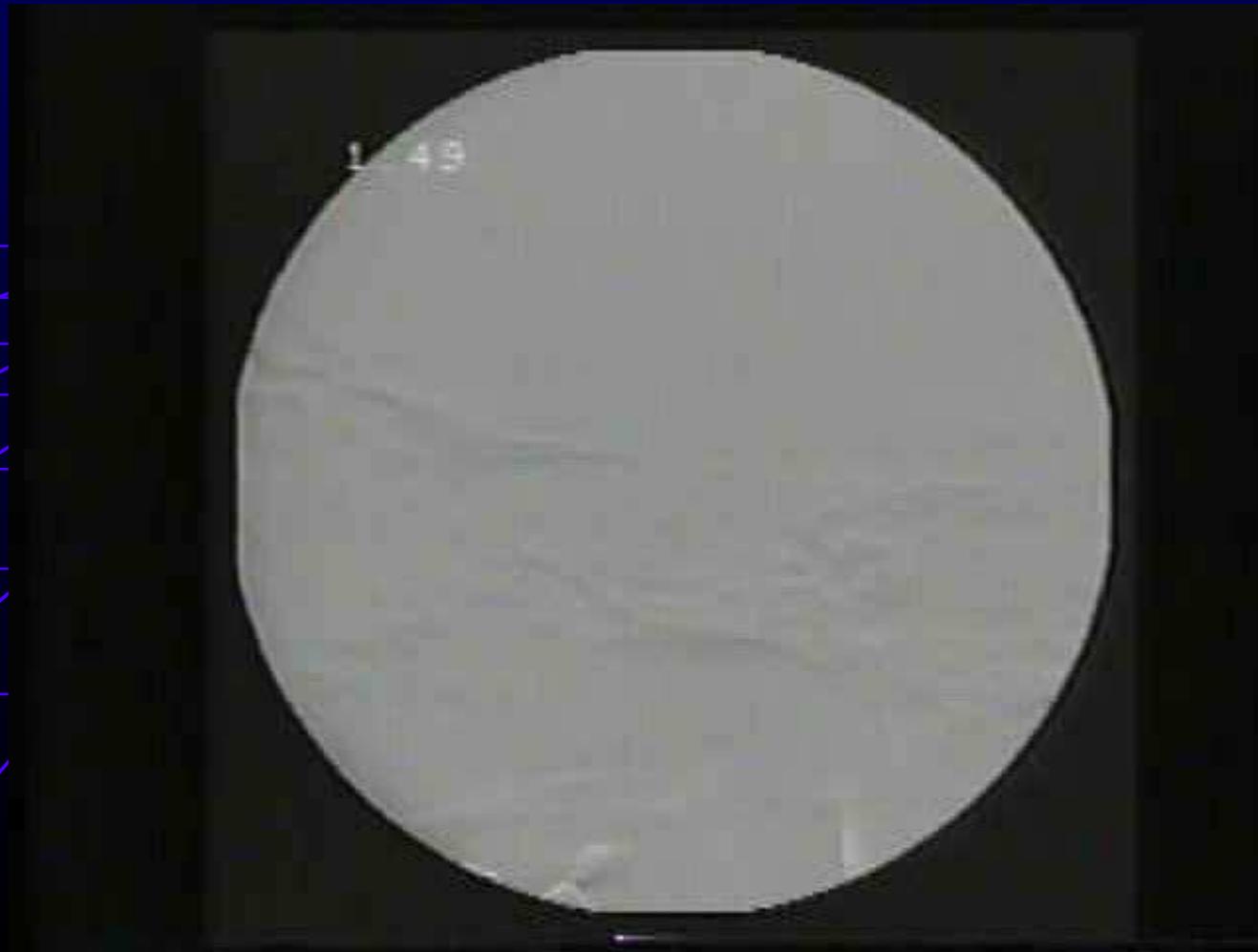
Bioactive Coil?

Liquid Embolus?

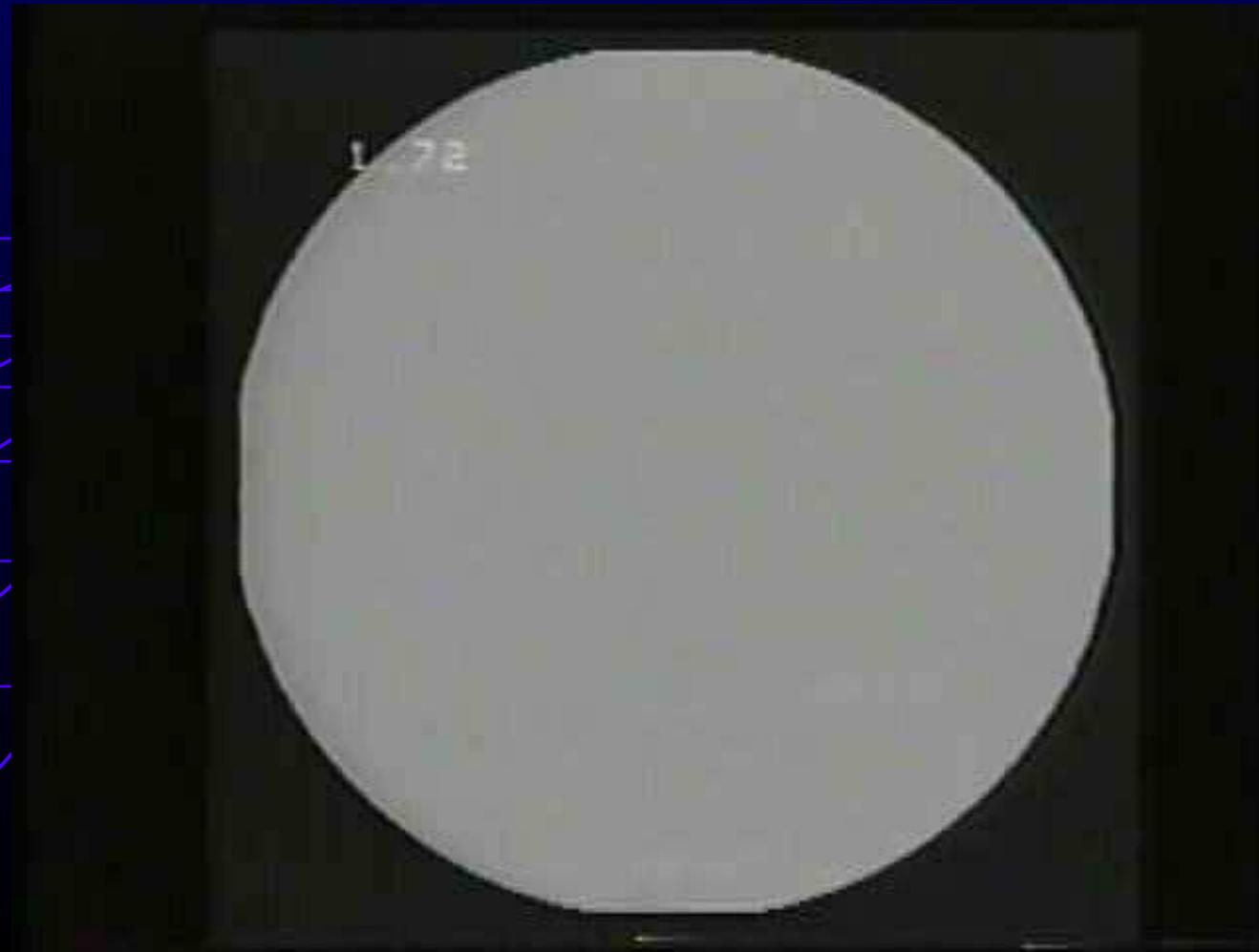
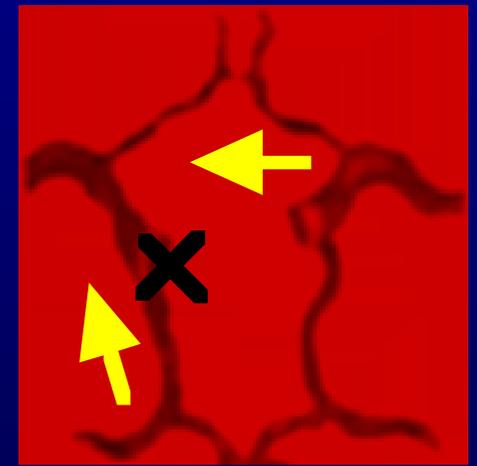
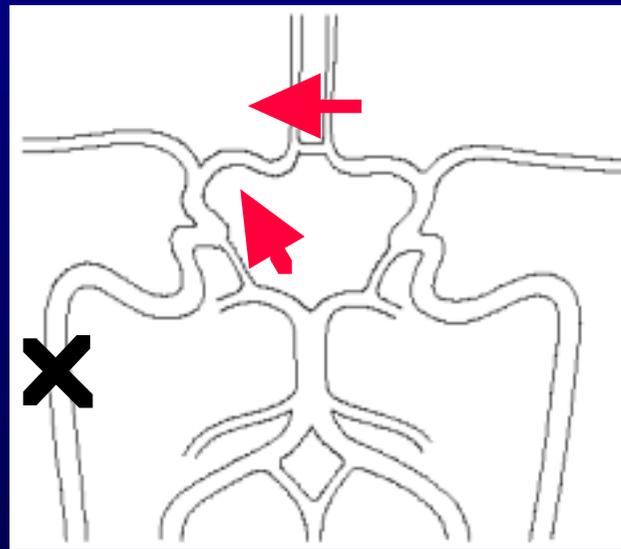
Parent Artery
Occlusion?

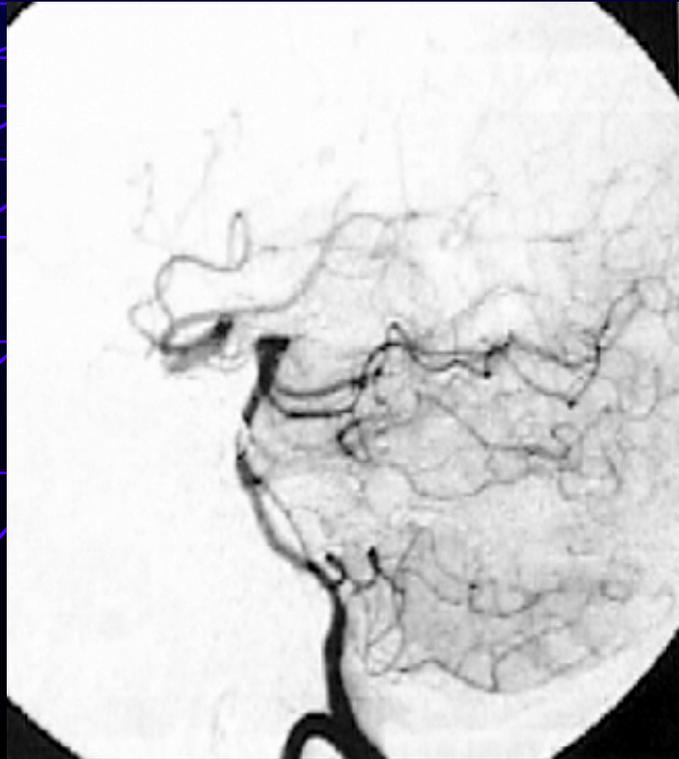
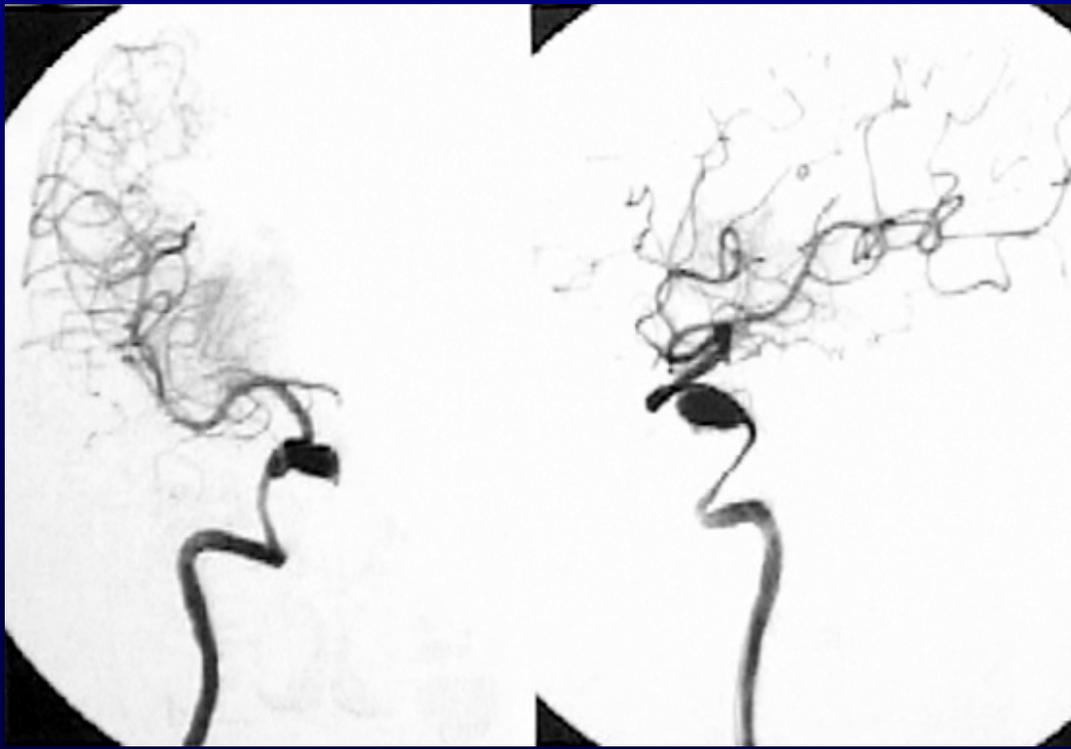
Other New Materials?

親血管閉塞



親血管閉塞





親血管閉塞

血栓化するか？

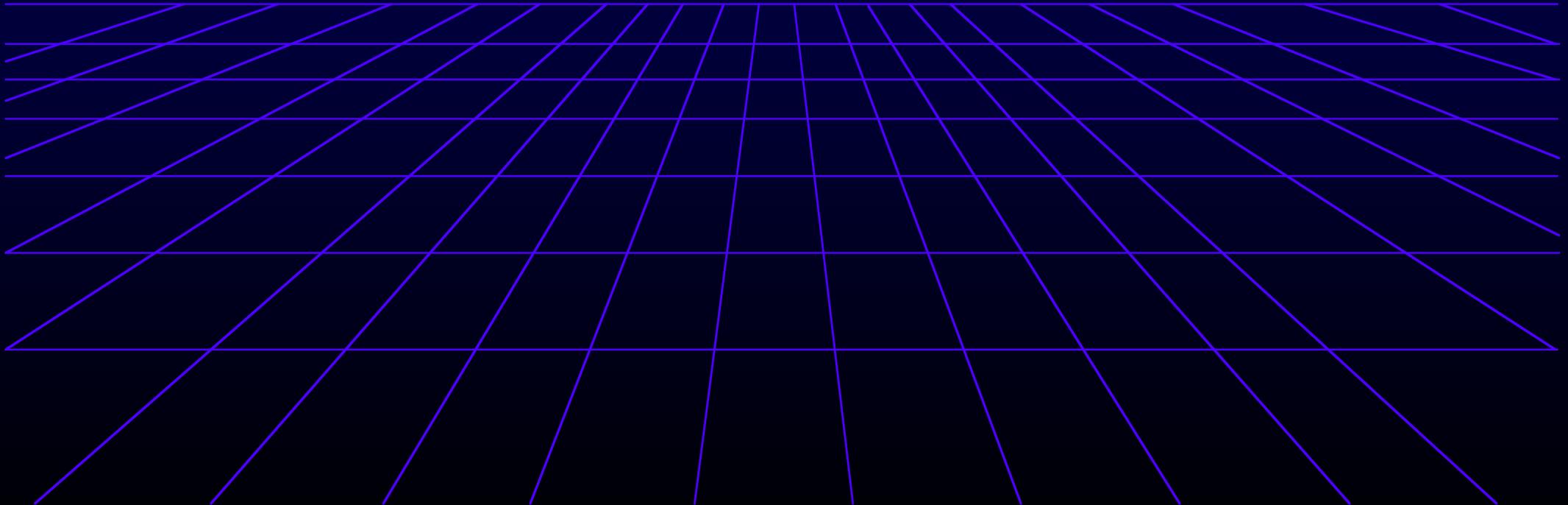
側副血行路は十分か？

近位血管の修飾で処理できないか？

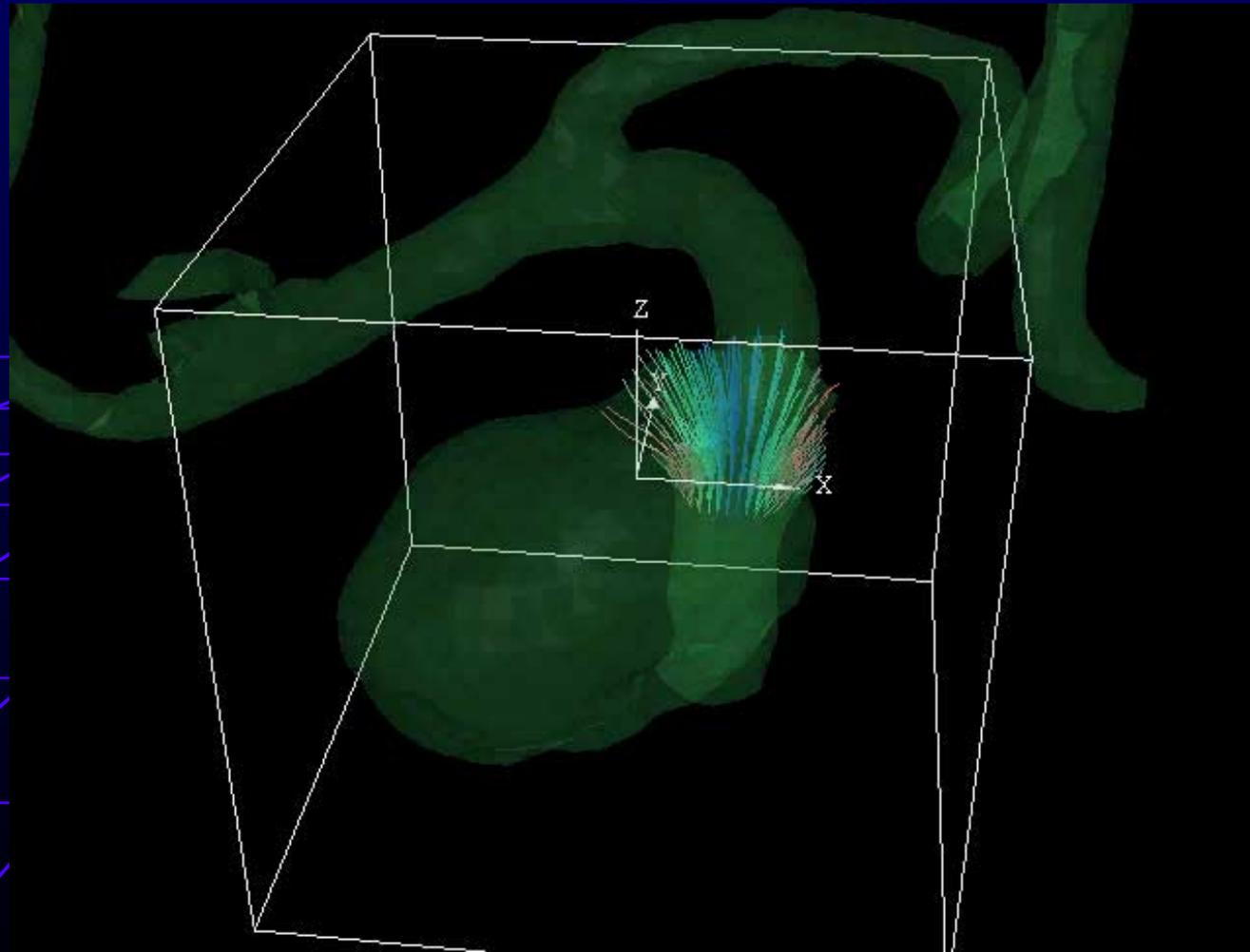


自然経過

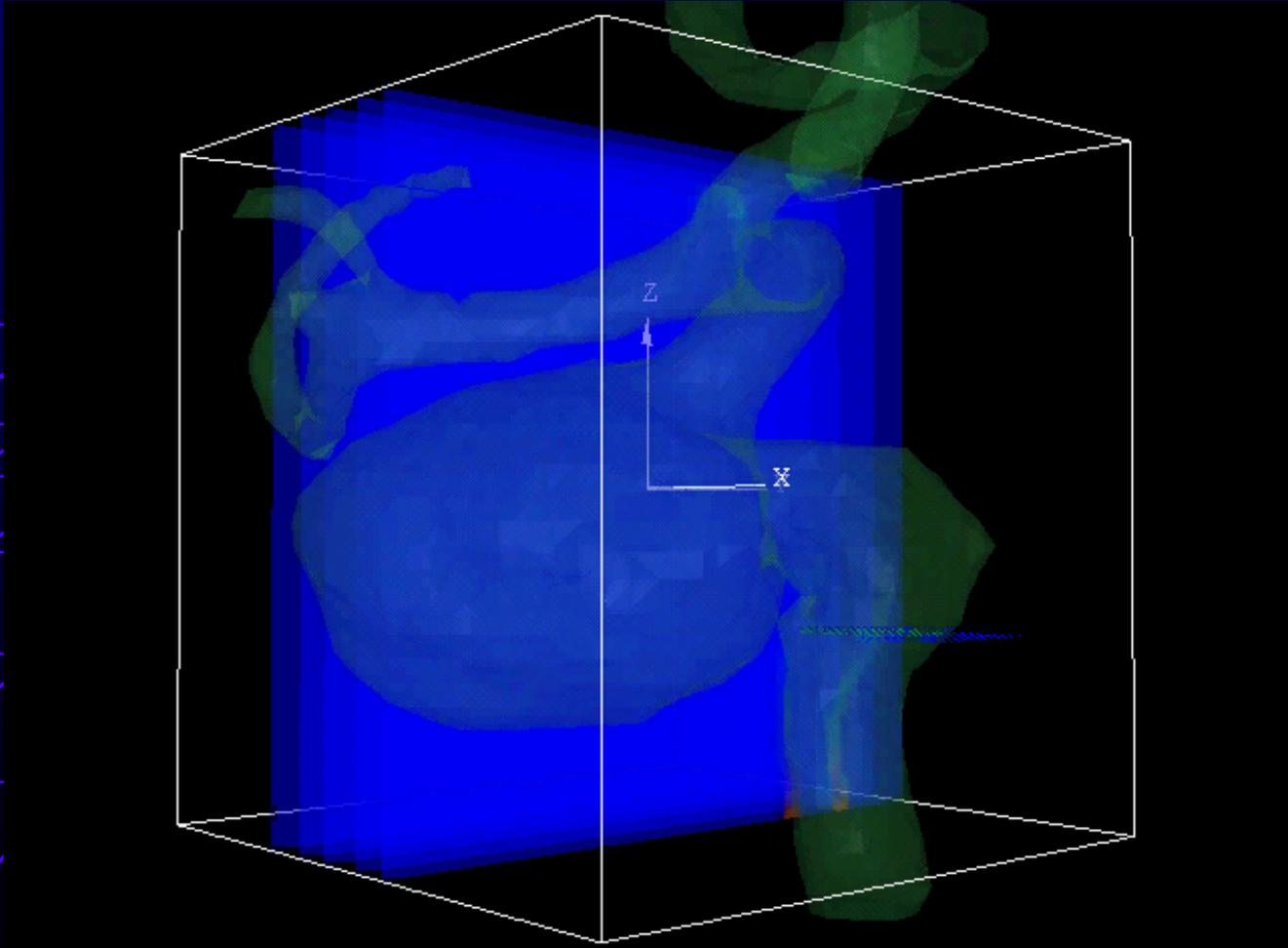
そもそも、全ての動脈瘤に治療の必要があるのか？

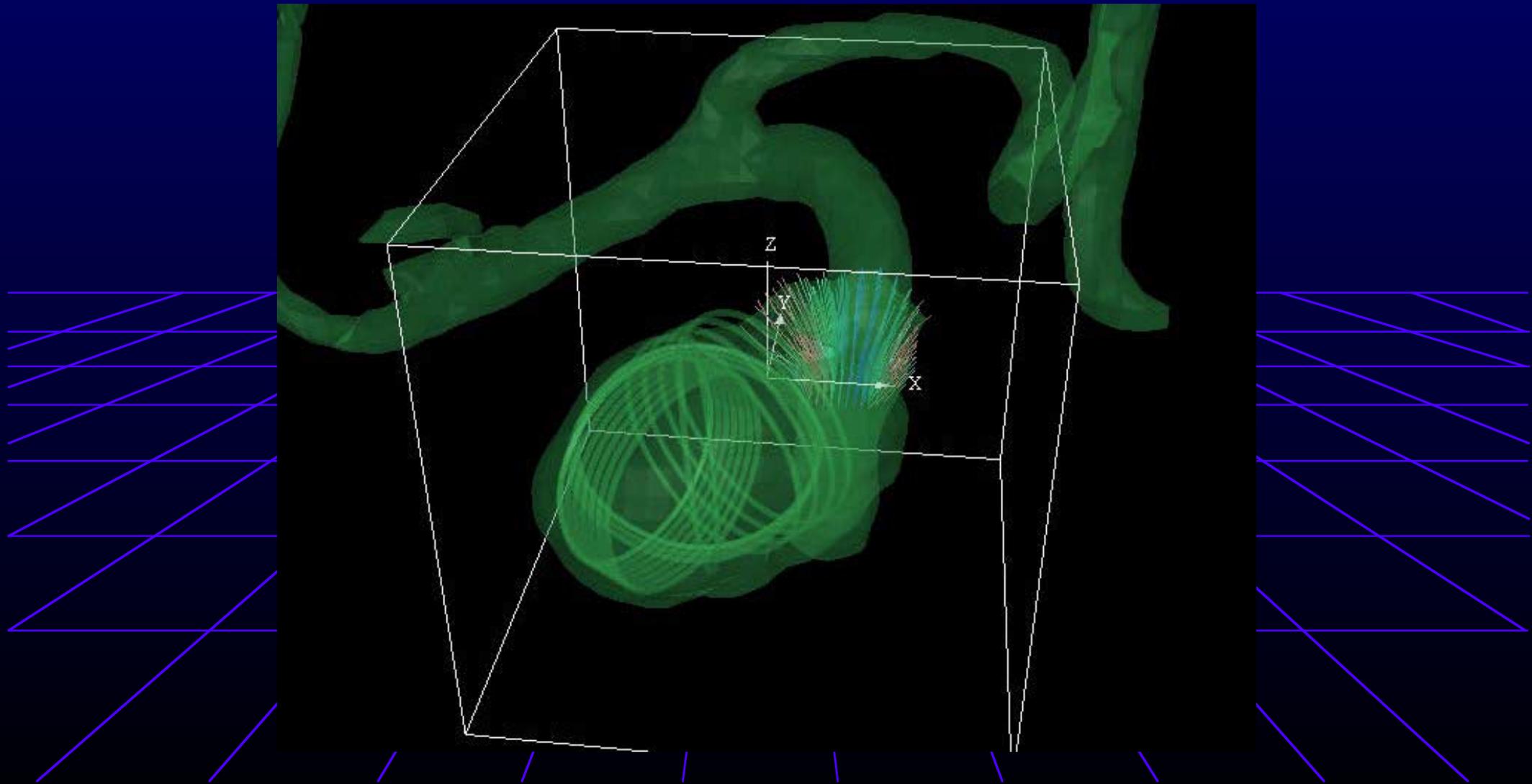


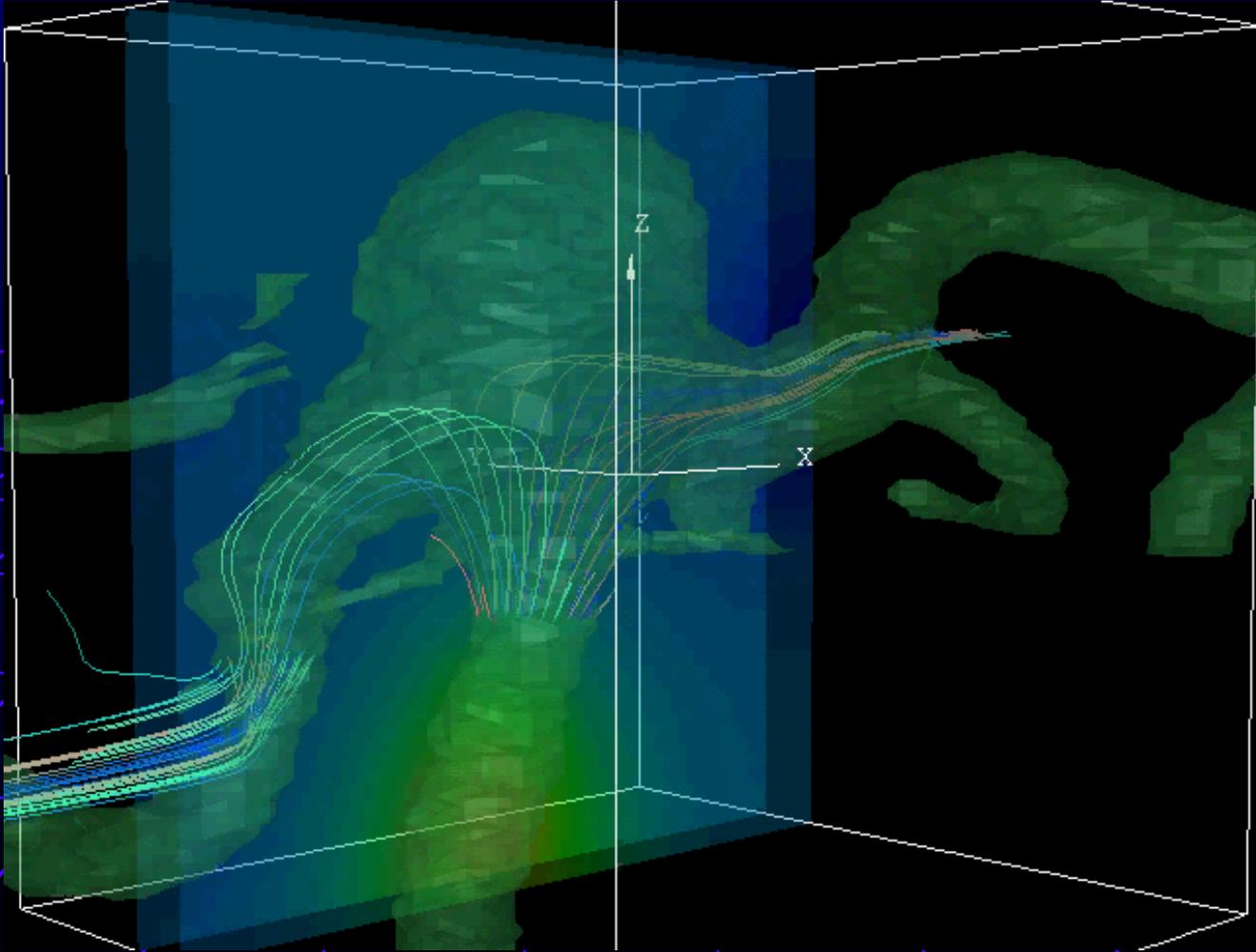
CFD for Aneurysms

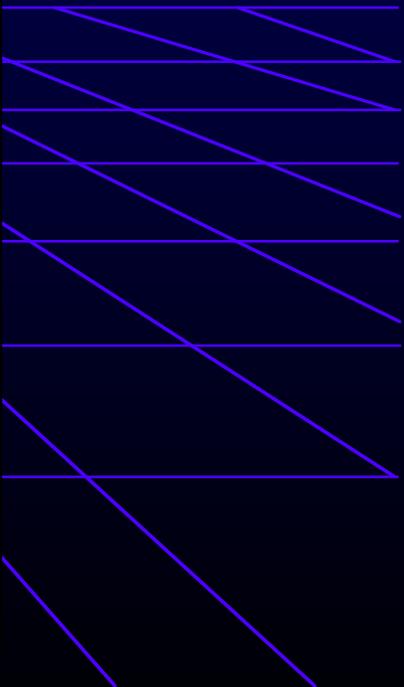
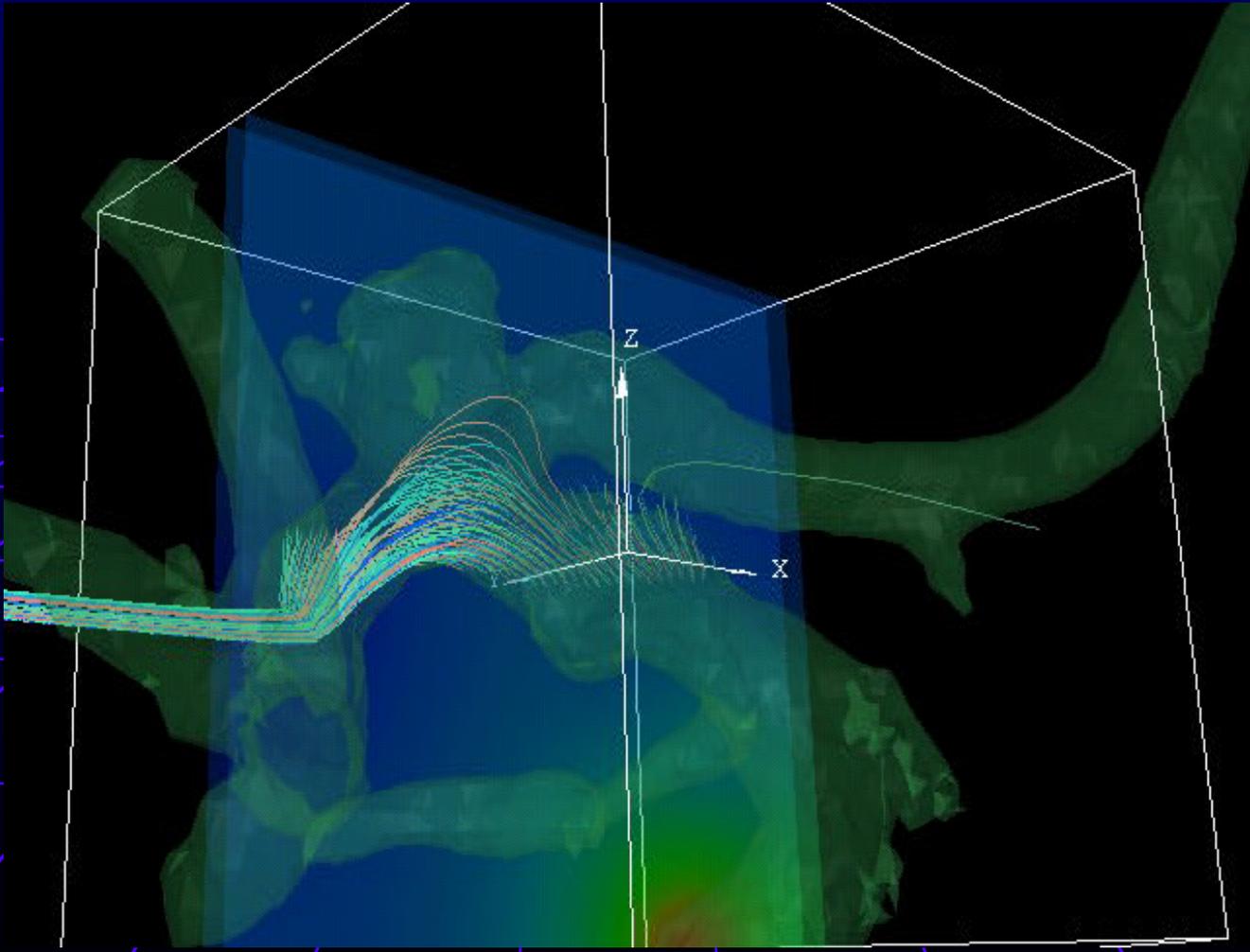


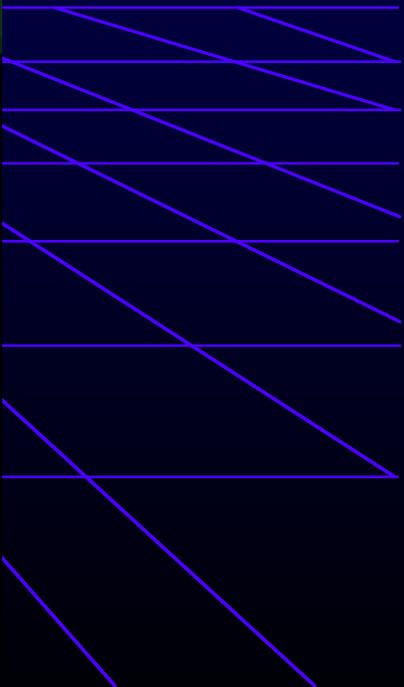
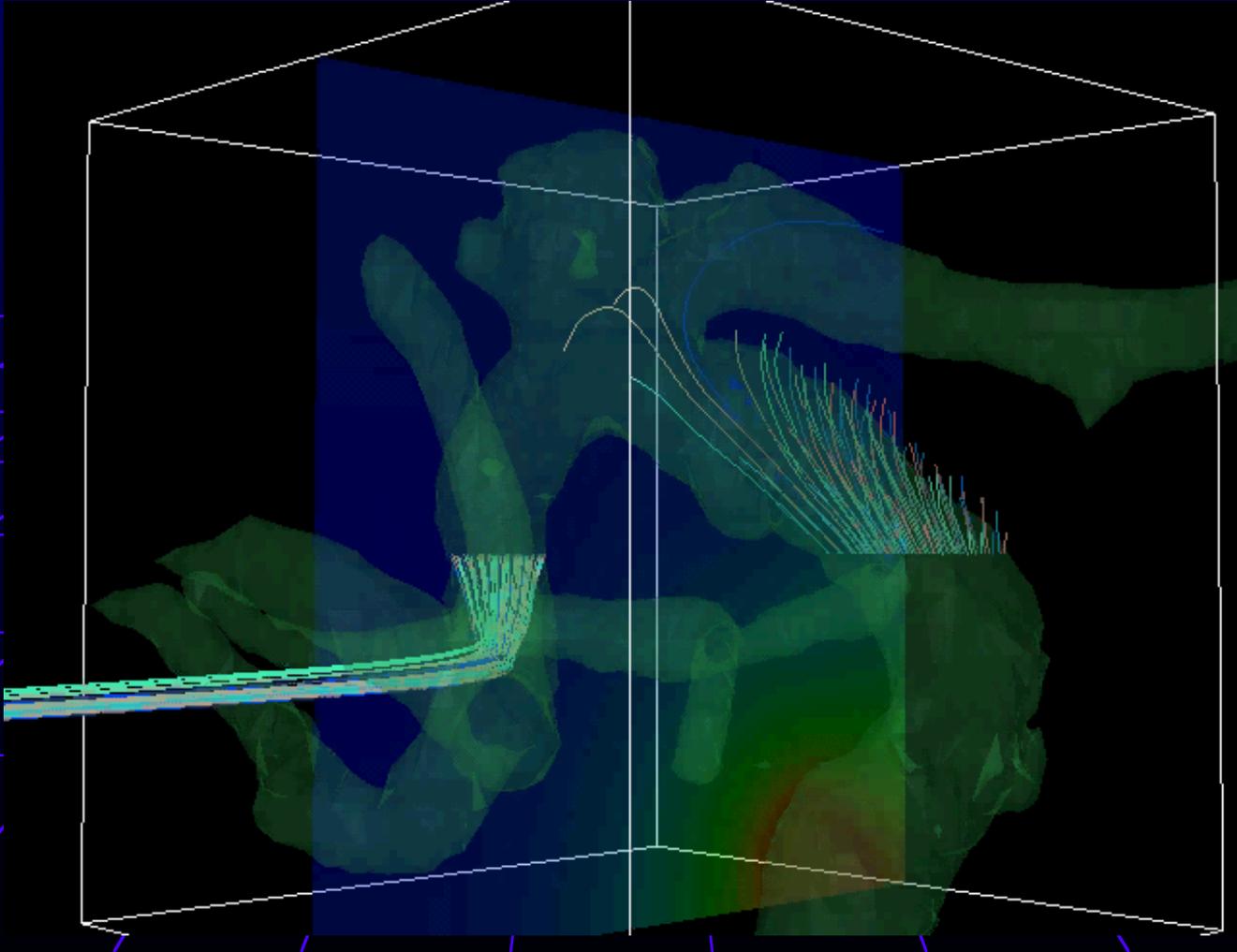
FLDesigner, 流体物理研究所



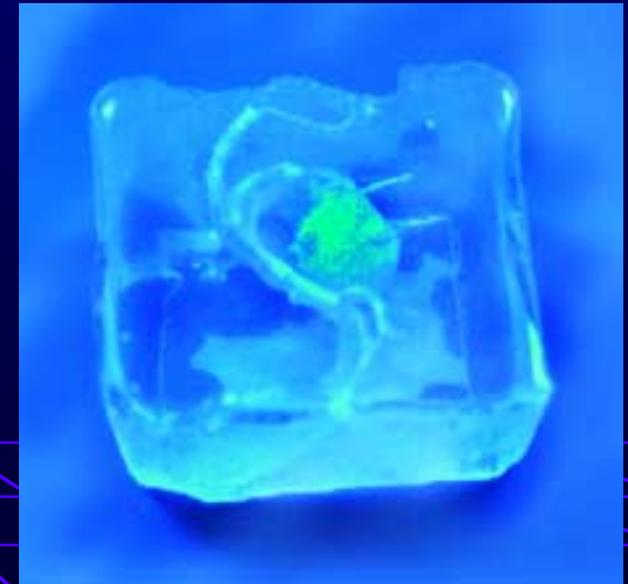
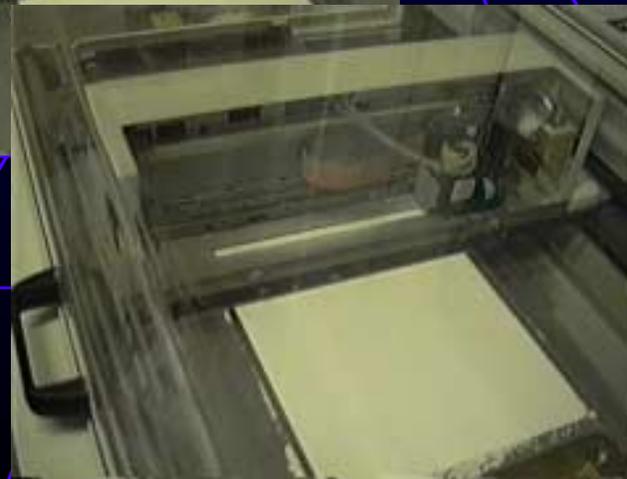
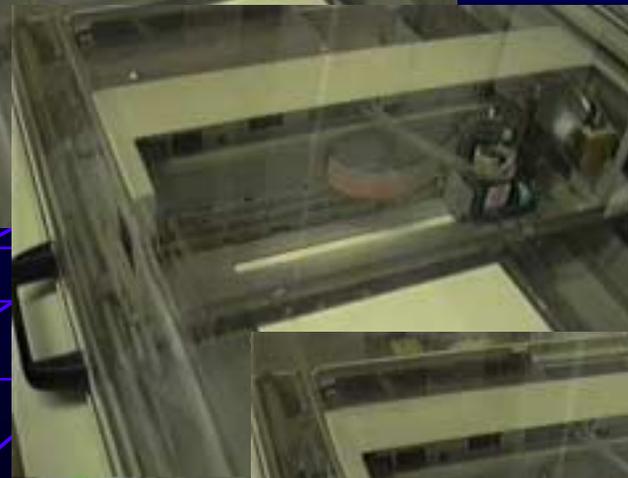








Model for CFD



問題点と対策

治療の必要性？

どんな動脈瘤が危ないのか？

瘤にはどんな力がかかっているのか？

親動脈閉塞

可能なのか？

それ以外の方法（近位での修飾）はないのか？

確かに血栓化するのか？

血栓化動脈瘤

治療方法の確立（血管内）

問題点と対策

術中破裂 (Ovar Packing)

「十分な量」のコイルとは？

コンパクション

「十分な量」のコイルとは？

生体反応の修飾？

液体塞栓物質？

Neck Remnant

「十分な量」のコイルとは？

操作に伴うもの

流れの利用

ロボットやセンサー、磁気の利用

まとめ

脳動脈瘤の臨床上的の問題点

血管内治療の現状と問題点

数値流体解析への大いなる期待

どこまで Coil をおけば良いのか？

術中出血を避け、再発させない

どこにおけば良いのか？

Inflow をどう押さえれば良いか？

直達術以外の治療法の開発

