

Basic NeuroEndovascular Training Course 2 (BNET Course)

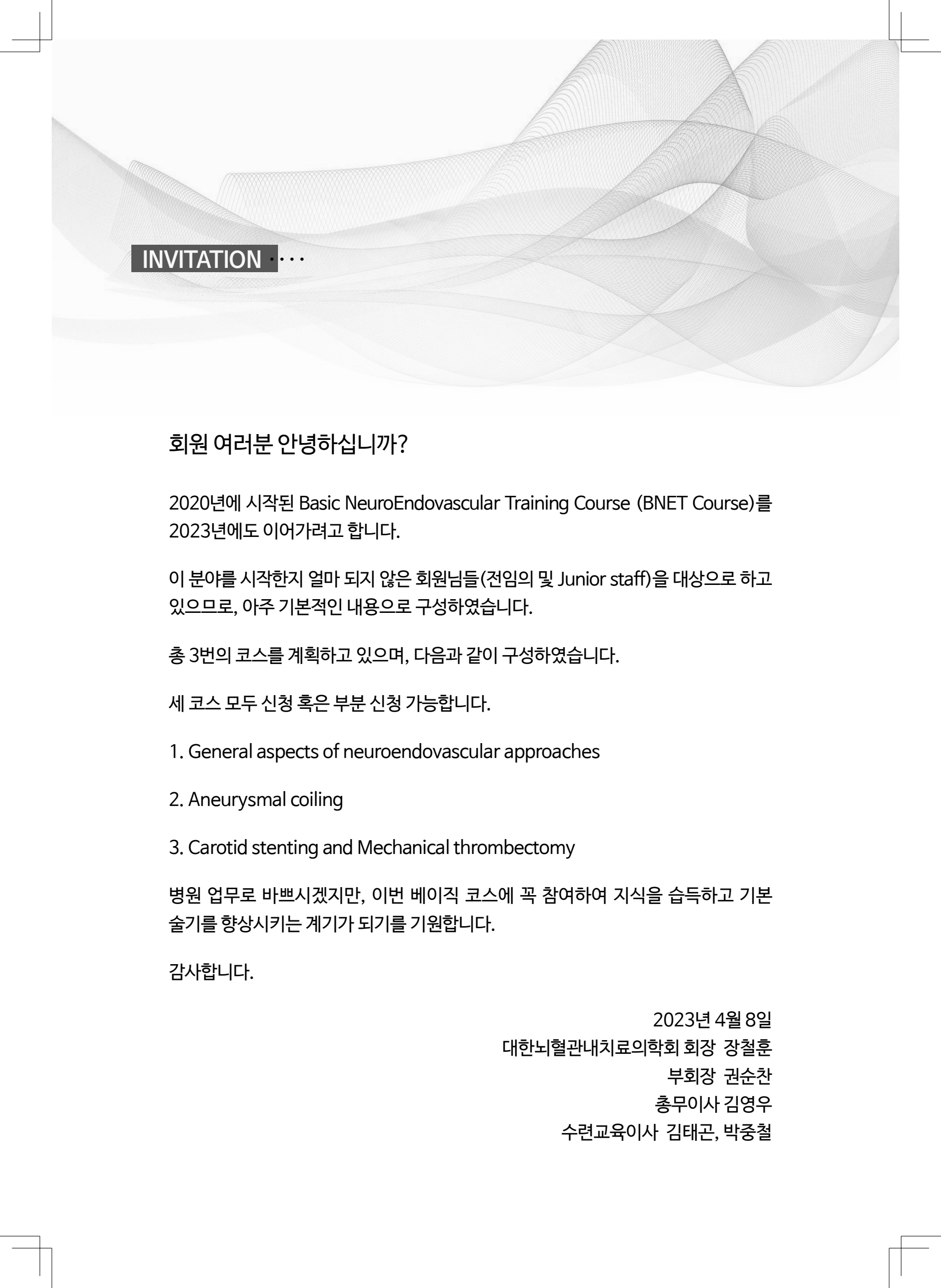
BNET 2nd : Aneurysmal coiling

일시 : 2023년 4월 8일(토)

장소 : 대웅제약본사 별관 베어홀 (지하1층)
(서울 강남구 봉은사로 644)

주최 : 대한뇌혈관내치료의학회

주관 : 대한신경외과학연구재단



INVITATION ···

회원 여러분 안녕하십니까?

2020년에 시작된 Basic NeuroEndovascular Training Course (BNET Course)를 2023년에도 이어가려고 합니다.

이 분야를 시작한지 얼마 되지 않은 회원님들(전임의 및 Junior staff)을 대상으로 하고 있으므로, 아주 기본적인 내용으로 구성하였습니다.

총 3번의 코스를 계획하고 있으며, 다음과 같이 구성하였습니다.

세 코스 모두 신청 혹은 부분 신청 가능합니다.

1. General aspects of neuroendovascular approaches
2. Aneurysmal coiling
3. Carotid stenting and Mechanical thrombectomy

병원 업무로 바쁘시겠지만, 이번 베이직 코스에 꼭 참여하여 지식을 습득하고 기본 술기를 향상시키는 계기가 되기를 기원합니다.

감사합니다.

2023년 4월 8일
대한뇌혈관내치료의학회 회장 장철훈
부회장 권순찬
총무이사 김영우
수련교육이사 김태곤, 박중철

PROGRAM

일시 : 2023년 4월 8일(토)

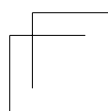
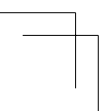
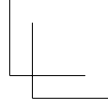
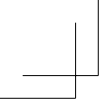
장소 : 대웅제약본사 별관 베어홀

08:30-08:50	Registration			
08:50-09:00	Course Introduction	김태곤	차의과학대 분당차병원	
	Welcome Address	장철훈	KoNES 회장	
09:00-09:30	Coil의 종류와 특성	이종영	한림대 강동성심병원	07
09:30-10:00	Microcatheter-assisted coiling technique - including working angle, shaping, multiple catheter technique	박중철	울산대 서울아산병원	17
10:00-10:30	Balloon-assisted coiling technique - including balloon 종류와 특성	오재상	가톨릭대 의정부성모병원	25
10:30-11:00	Stent-assisted coiling technique - including stent 종류와 특성	박근영	연세대 세브란스병원	43
11:00-11:30	Management of complications - including perioperative rupture, thrombus formation	윤원기	고려대 구로병원	63
11:30-12:00	Lunch			
12:00-13:00	Hands-on (Endovascular coiling using balloon, stent)		All	
	Closing & Photo time	김영우	KoNES 총무이사	

Coil의 종류와 특성

이 종 영

한림대 강동성심병원



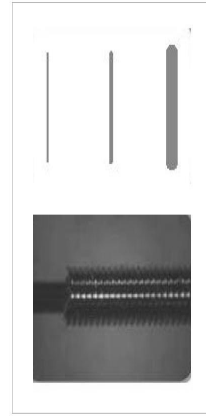
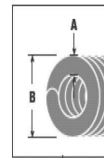
Aneurysm Coils

Jong Yong Lee, MD, PhD.

Hallym University Kangdong Sacred Heart Hospital

Basic Coil Construction

- A coil starts out as a single, platinum primary wire. The thickness of this wire can have a significant effect on the coil's characteristics
- The primary wire (A) is wound around a thin, cylindrical mandrel to create the primary coil (B)



Basic Coil Construction

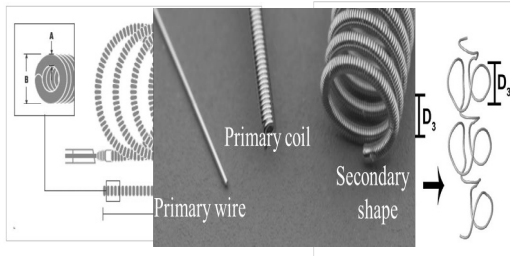
- The primary coil is then wound around a different mandrel and heat-set to create the coil's secondary shape (C).

- Helical coil

- cylindrical mandrel

- Complex coil

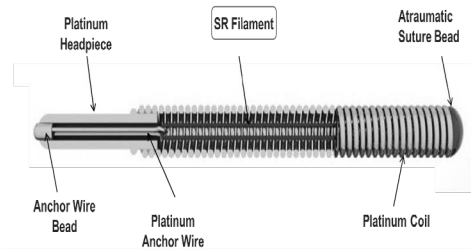
- Multi-dimensional mandrel



Basic Coil Construction

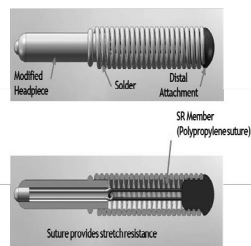
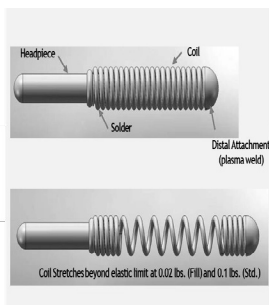
- **Stretch Resistance (SR)**

- usually Polypropylene suture, or hydrocel, PGLA, etc.



Basic Coil Construction

- **Stretch Resistance (SR)**



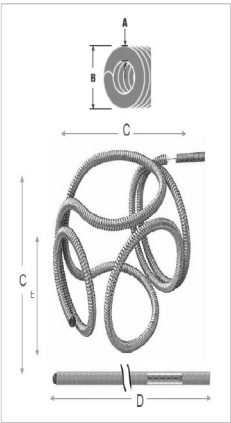
Basic Coil Construction



Basic Coil Construction

• **Coil Dimensions**

- A. Primary Wire Diameter (in)
- B. Primary Coil diameter (in)
- C. Secondary Coil diameter (mm)
- D. Coil Length (c m)
- E. Diameter of 2D loop (mm) 75% of secondary coil diameter



Basic Coil Construction

• **Coil Dimensions**

A. Primary Wire	B. Primary Coil
Platinum alloy (90% platinum, 10% tungsten)	Measured by outside diameter (OD) in inch
Measured by outside diameter (OD) in inch	Determines the coil OD size
Various size (0.0015, 0.0017, 0.002 etc.)	0.010 - 10 system coil
	0.012 - 12 system coil
	0.014 - 14 system coil
	0.015 - 18 system coil

Basic Coil Construction

• **Coil Dimensions**

C. Secondary shape

Determine the coil loop size and shape

helical 2mm, Complex 6mm, 3D 5mm

Various different secondary shape. Some are industry standard and some are manufacturer specific

Helical – standard

3D, 360° – target specific, Complex – Optima specific, Complex 1D – Microvention specific

Coil Types

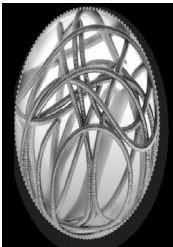
- Three different types based on the coil primary coil, secondary shape, and the coil size
- **Frame** : used to form a basket or frame into the aneurysm in order to deposit additional coils
- **Filling** : used to fill in the frame or basket coil and provide a dense packing
- **Finishing** : very soft and small coils, used to finish, generally the last coils placed at the neck

Coil Types

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Coil Types

- **Framing coil**
 - 3D, 360°, Complex, Frame etc.
 - Designed to give the initial stability and protection to the aneurysm.
 - Creates neck bridge
 - Covers the neck with several coil loops
 - Allow subsequent coils placed to remain inside the aneurysm.



Coil Types

• Filling coil

- Used to fill in the frame coil and provide a dense packing
- Generally helical, or complex type
- Available in many diameters and lengths to accommodate the needs of the aneurysm



Coil Types

• Finishing coil

- Very soft and small coils, used to finish at the neck.
- Ultrasoft, hypersoft, mini etc...
- Very little space left for a coil to fit into towards the end of the cases
- Generally helical, but could also be complex type



Delivery wire

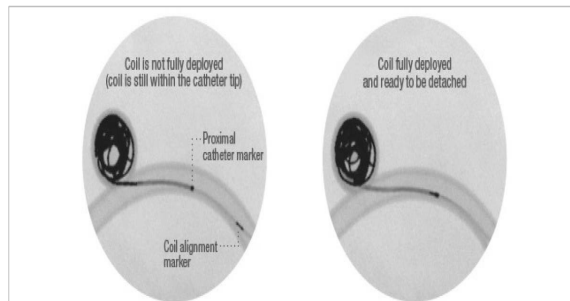
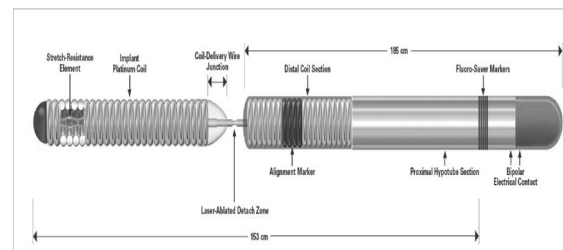
• Impact on coil performance

- Push the coil through tortuous anatomy into the aneurysm
- Translate manipulation of the proximal end to predictable coil movement at the distal end
- Translate coil movement at the distal end to tactile sensation at the proximal end
- Deliver current to detach the coil

Delivery wire

• **Hybrid design:** Hypotube + Flexible coil construction

- Usually bipolar pathway, mechanical also.
- Radiopaque alignment marker, Fluorosaver Marker



• Radiopaque Alignment Marker

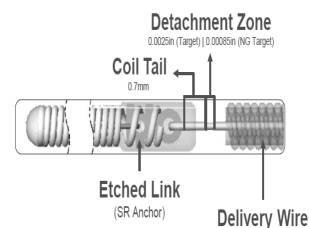
- Intended to facilitate accurate alignment for coil detachment



Detachment zone

• Junction (Detachment Zone)

- Transition point between the delivery wire and main coil that serves as the site for coil detachment



Detachment zone

- Electrolytic detachment (Target)
 - Transition point between the delivery wire and main coil that s detachment

The diagram illustrates the Target Detachable Coils system. It shows a cross-section of the coil with labels for the 'Distal Delivery Wire Coil', 'Detachment Zone', 'Tapered Dymax Adhesive', 'New SR Anchor (Inside Wires)', and 'Main Coil'. A 'Target Coil Junction' is indicated, which is '~50% Shorter than GDC Coil Junction'. An inset shows a 'Cathode' and 'Insulated Anode' for electrolytic detachment. Another inset shows the 'Target Coil Detachment Zone' with 'Polyimide Wire Insulation' and 'Polyimide Removed by Laser Ablation'.

Detachment zone

This diagram shows various detachable coil systems. It includes labels for 'Coupler', 'PET Cover', 'Support Coil', 'Electrical Lead', 'Heater', 'Heater Coil Pitch', 'Heater Coil', 'Outer PET Layer', 'Inner PET Layer', 'Implant', 'Coupler', 'Implant', 'Adhesive', 'Severed Polymer Tether', 'Critical Leads', and 'Polyimide Insulation'. It illustrates the detachment zone and the components involved in the process.

Detachment zone

- Mechanical detach (Axiom)
- Hydraulic detach (Orbit Galaxy)

The diagram shows the 'Axiom Prime Detachment System' with a mechanical detachment mechanism. It also shows a 'Hydraulic detach (Orbit Galaxy)' coil with a 'Laser Detachment' mechanism. The diagram illustrates the detachment zone and the components involved in the process.

Basic Coil Construction

- Coil Softness
 - Primary wire diameter, primary coil OD, secondary OD, pitch, delivery wire flexibility

The diagram illustrates the basic coil construction. It shows a 2x2 matrix of coil softness based on 'Wire Diameter' (increasing upwards) and 'Coil Diameter' (increasing rightwards). The quadrants are labeled 'Stiffest', 'Stiff', 'Soft', and 'Softest'. To the right, it shows 'Open Pitch' and 'Closed Pitch' coils. A list of factors affecting coil softness is provided: 'Primary wire diameter, primary coil OD, secondary OD, pitch, delivery wire flexibility'.

Stryker

InZone® Detachment System

The image shows the 'Stryker InZone® Detachment System' and a box of 'Target® Detachable Coils'. The box is labeled 'Technology Overview' and 'Target® Detachable Coils'. The system includes a 'Stryker Neurovascular' device and a 'Target® Detachable Coils' box.

Conformability

The 360 coil employs an open loop configuration for conformability. The below illustrates how open loop designs differ from close loop designs.

The diagram illustrates the conformability of the 360 coil. It shows a 'Competitor Coil' (closed loop) and '360 Coils' (open loop). The competitor coil is shown 'Contacts a wall or coil mass' and 'Tend to keep their shape - they compress, or distribute their force around the loop.' The 360 coils are shown 'Contacts a wall or coil mass' and 'Tend to adapt their shape - they conform to objects, opening up their shape and seeking the path of least resistance.' A list of factors affecting conformability is provided: 'Primary wire diameter, primary coil OD, secondary OD, pitch, delivery wire flexibility'.



Balt			
Coil Name	Coil D	Filar D	Primary D
OPTIMA COMPLEX SUPER SOFT 10	1 ~ 2.5 mm	0.00125"	0.010"
	3 ~ 5 mm	0.00150"	0.011"
OPTIMA COMPLEX SOFT 10	2 ~ 2.5 mm	0.00150"	0.011"
	3 ~ 5mm	0.00175"	0.010"
OPTIMA COMPLEX STANDARD 10	6 ~ 8mm	0.00175"	0.011"
	3 ~ 5(9) mm	0.00175"	0.011"
OPTIMA COMPLEX 18	5(17) ~ 10 mm	0.002"	0.012"
	5 ~ 10 mm	0.00225"	0.013"
OPTIMA COMPLEX 18	11 ~ 15 mm	0.003"	0.014"
	16 ~ 24 mm	0.0035"	0.014"
OPTIMA HELICAL SUPER SOFT	1 ~ 5 mm	0.00125"	0.010"
OPTIMA HELICAL SOFT	3 ~ 6 mm	0.00150"	0.011"
OPTIMA HELICAL STANDARD	6 ~ 10 mm	0.002"	0.012"

Balt

Complex Coil Shape

Loops 1 & 2
The 1st loop is always 1.5 revolutions and 70% nominal diameter (>2mm coils). This allows the coil to stay inside aneurysm. The 2nd loop is 1% revolution. This is called open loop design and allows the coil to open and conform to aneurysm neck and aneurysm wall in order to anchor and stabilize the coil basket. The 2nd and all subsequent loops are nominal in diameter.

Loops 3 & 4
Similar to loop 2, loops 3 and 4 are open loop design. All loops are deployed in 90 degree orientation from the previous loop. The 90 degree orientation design allows the coil to change direction in the aneurysm. This design reduces compartmentalization during deployment.

Loops 5 & 6
Loop 5 is an open loop design similar to loop 3 and 4. Loop 6 is the last loop and is 2.75 revolution. The last loop in every coil will be closed loop design between 1.5 and 4 revolutions. The last loop is closed to prevent the coil herniation into the parent vessel.

Microvention

COSMOS: an evolution in framing aneurysms

Microvention

Configuration Size

Refractive and #16

4mm, 5mm

7mm and

Cosmos™ Loop Chart

4mm

Coil Size	Loop #	Dia. (mm)
1	2	
2	3	
3	4	
4	5	
5	6	
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		Pre Gel Expansion Outer Diameter	Post Gel Expansion Outer Diameter	% Increase of Outer Diameter	Working Time Microcatheter Size		
					0.0165"	0.021"	
Lea:		HYDROFRAME 10	0.012" – 0.0135"	0.0125" – 0.014"	4%	30 min	30 min
0.0		HYDROSOFT	0.012"	0.013"	8%	30 min	30 min
		HYDROFRAME 18	0.015" – 0.016"	0.015" – 0.016"	8%	30 min	30 min
		HYDROFILL	2-4 mm: 0.013" 5-10 mm: 0.015"	2-4 mm: 0.016" 5-10 mm: 0.018"	2-4 mm: 23% 5-10 mm: 20%	30 min	30 min

The Hydrogel Endovascular Aneurysm Treatment Trial (HEAT): A Randomized Controlled Trial of the Second-Generation Hydrogel Coil

TABLE 3. Primary and Secondary Outcomes

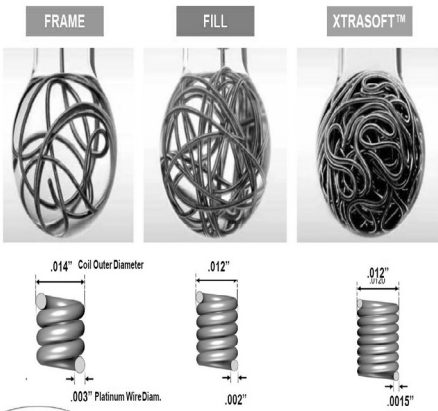
	HydroCoil Embolic System	Bare platinum coils	P value
Recurrence: any progression on the RR scale	4.4%	15.4%	.002
Occlusion stability: any increase on the Meyers scale	13%	27%	<.001
Minor recurrence: progression on the RR scale from 1 to 2	2 (1.0%)	14 (5.0%)	.004
Major recurrence: progression on the RR scale to 3, or a 3 with an increase in the Meyers scale	32 (12.8%)	55 (20.7%)	.016
Packing density	32.5% ± 14.8%	24.7% ± 10.2%	<.001
Initial occlusion	50 (17.8%)	82 (28.3%)	.003
Occlusion stability			<.001
3-12 mo	64.9%	49.0%	
18-24 mo	68.6%	51.5%	

Neurosurgery 86:615-624, 2020

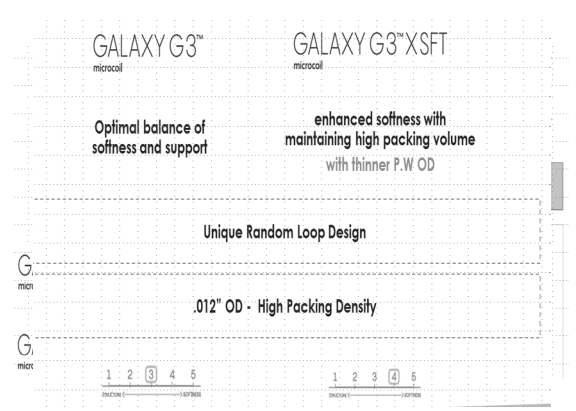
Cerenovus



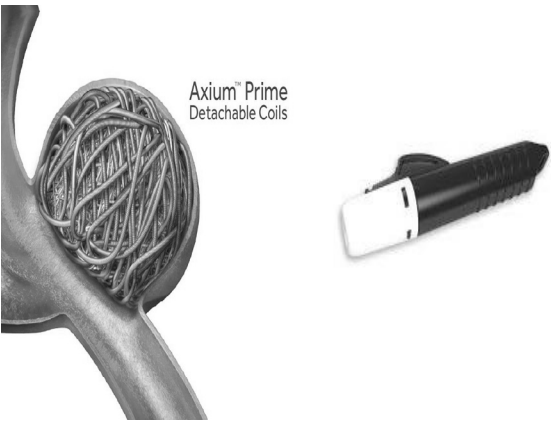
Cerenovus



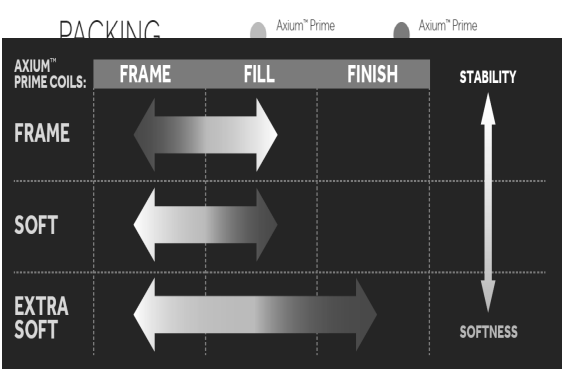
Cerenovus



Medtronic



Medtronic

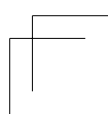
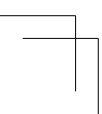
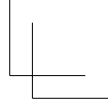
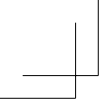


MEMO //////////////////////////////////////

Microcatheter-assisted coiling technique - including working angle, shaping, multiple catheter technique

박 중 철

울산대 서울아산병원



Microcatheter-assisted coiling technique: including working angle, shaping, multiple catheter technique

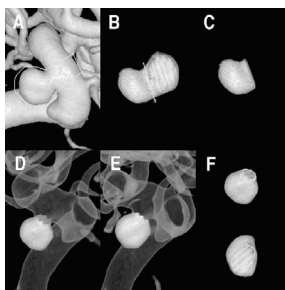
Jung Cheol Park

Department of Neurosurgery,
Asan Medical Center
University of Ulsan College of Medicine, Seoul, Korea

Working angle

- ✓ 3-Dimensional aneurysm → 2-D specific X-ray image
- ✓ working projection, working view
- ✓ should be optimal for
 - measuring the aneurysm sac diameter
 - inserting the first coil, feasibility for coiling
 - checking coil overhang into the surrounding vessels
 - accessible for device
 - not fixed, but changeable

Working angle

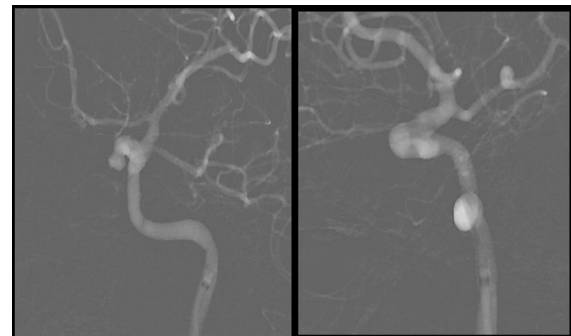


Kitazawa K et al. J Neurointerv Surg, 2013

- Visualization of aneurysm neck and sack

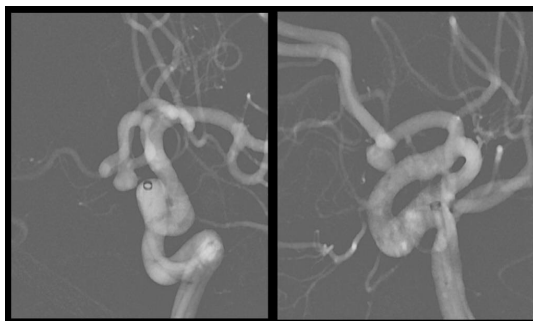
Working angle

- ✓ Side wall type



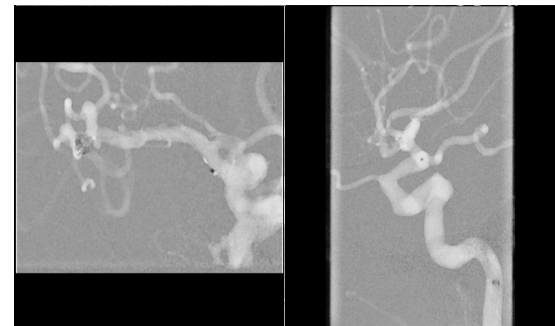
Working angle

- ✓ Terminal type



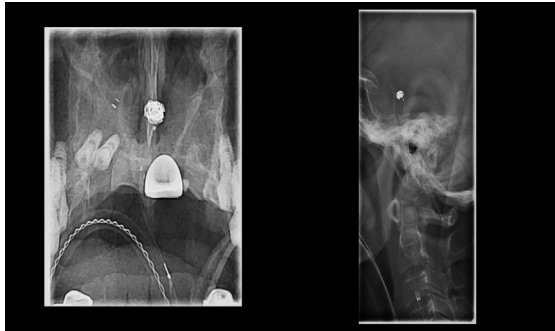
Working angle

- ✓ Terminal type



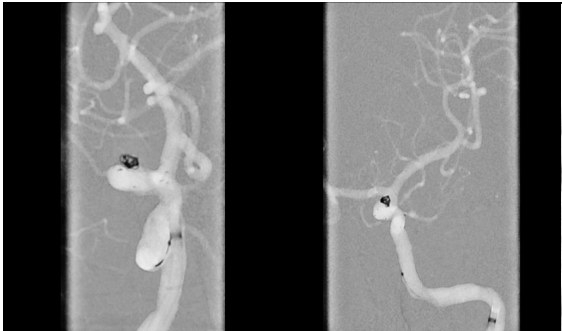
Working angle

F/60, basilar tip aneurysm



Working angle

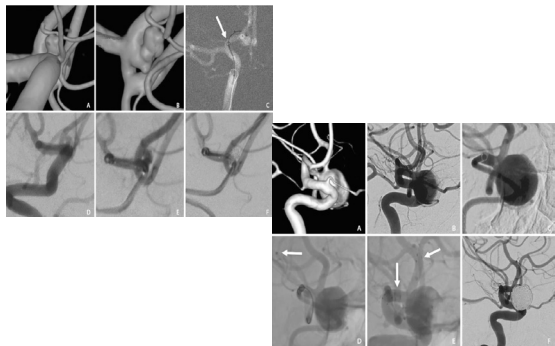
F/48, Lt paraclinoid ICA aneurysm



Working angle

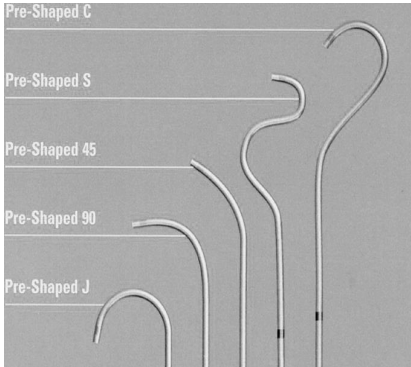
Distal Intermediate Catheter for Better Working View

Mahmoud E et al. Neurointervention, 2021



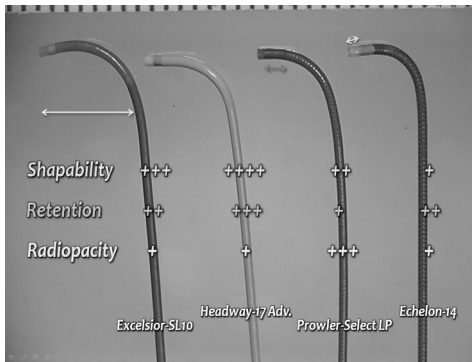
Microcatheter shaping

✓ pre-shaped



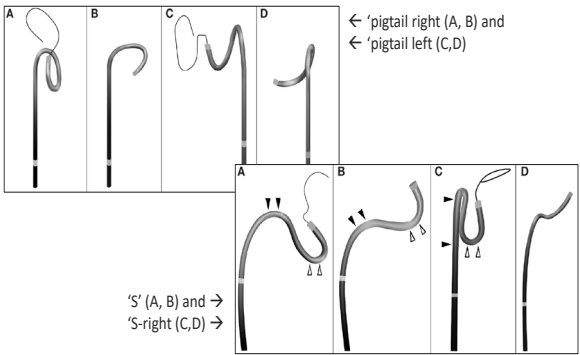
Microcatheter shaping

✓ pre-shaped



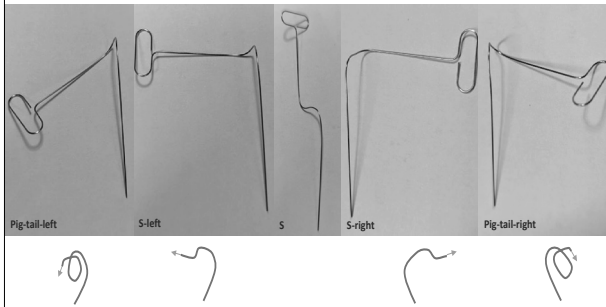
Microcatheter shaping

Kwon BJ et al. Shaping and Navigation Methods of Microcatheters for Endovascular Treatment of Paraclinoid Aneurysms. Neurosurgery 67(1):34-40, 2010



Microcatheter shaping

- ✓ steam shaping
 - pig-tail/reverse 'S'

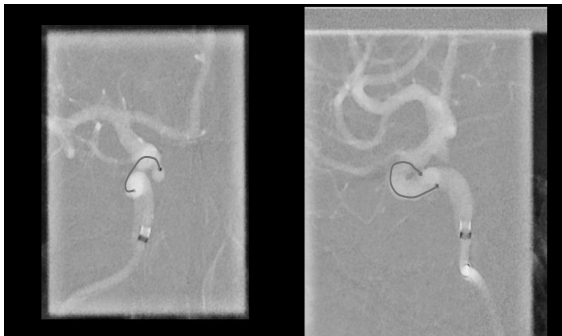


Aneurysm selection

- ✓ Microcatheter directed
- ✓ Wire steering
- ✓ Wire directed (guided) X
- ✓ Wire looping
- ✓ Coil guided

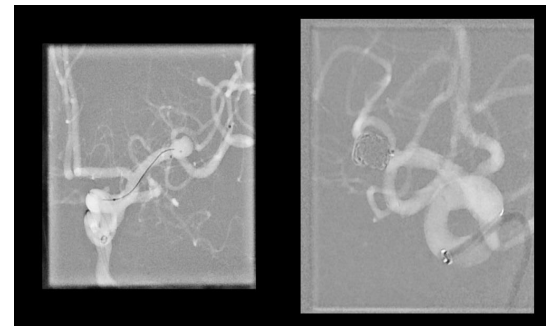
Microcatheter shaping

F/53, Rt paraclinoid ICA aneurysm



Microcatheter shaping

F/50, Lt MCA bifurcation aneurysm

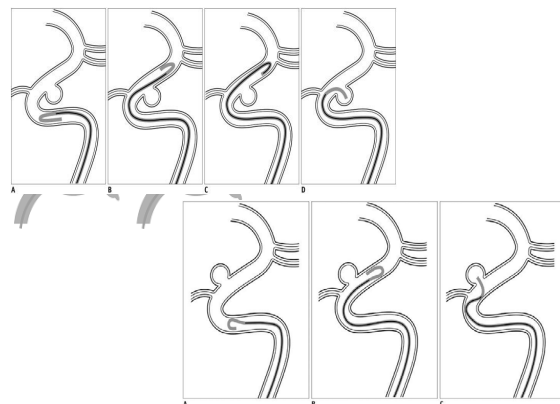


Microcatheter shaping

F/54, Lt ophthalmic artery aneurysm

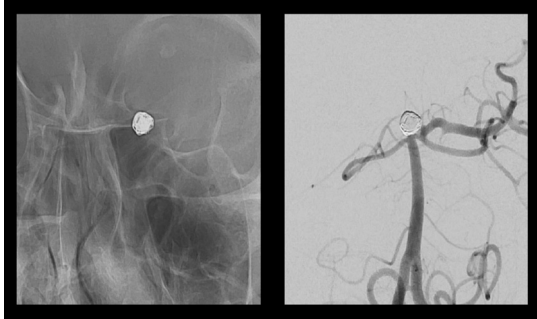


Microcatheter shaping



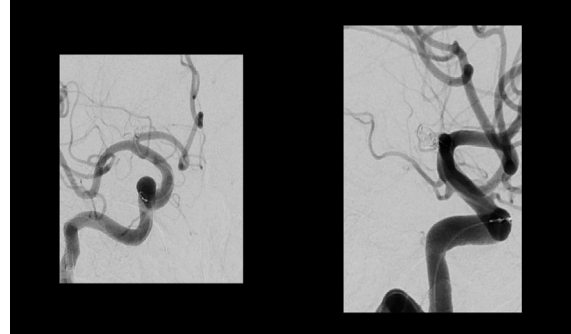
Microcatheter shaping

F/41, basilar tip aneurysm



Microcatheter shaping

F/58, Right proximal A1 aneurysm



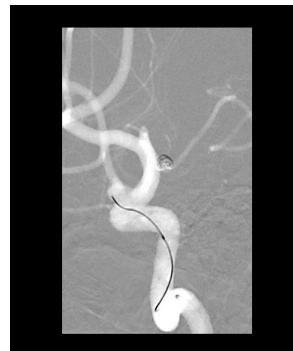
Microcatheter shaping

F/60, Right proximal A1 aneurysm



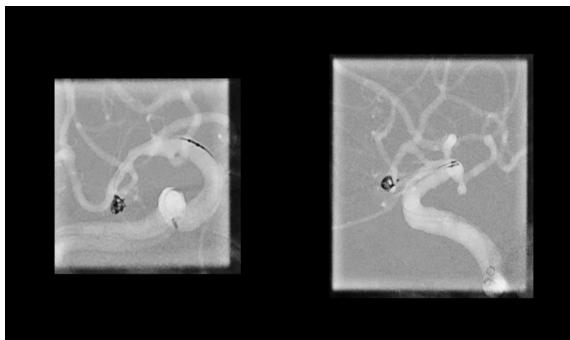
Microcatheter shaping

F/63, Left parophthalmic ICA aneurysm



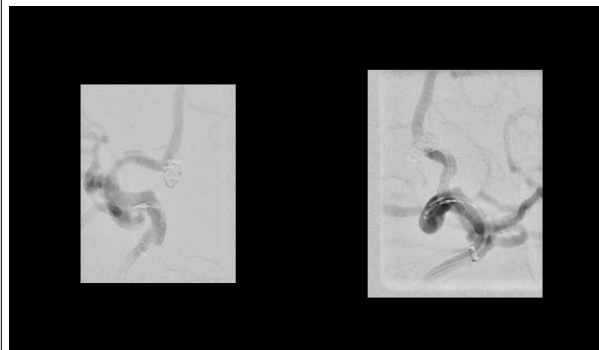
Microcatheter-assisted

1) Double microcatheter: frame instability



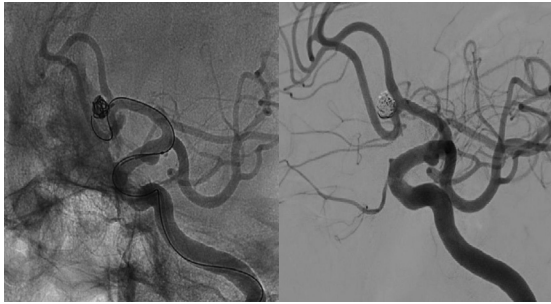
Microcatheter-assisted

2) Double microcatheter: different location



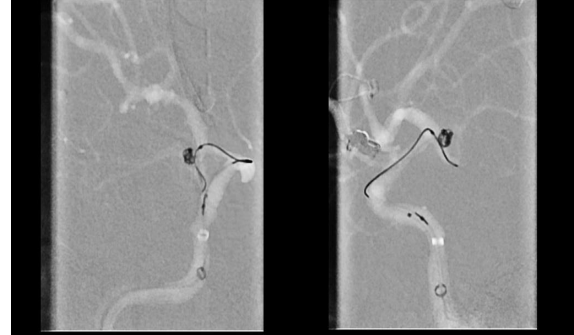
Microcatheter-assisted

3) Microcatheter protection



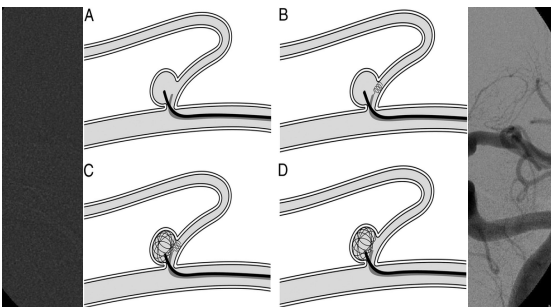
Microcatheter-assisted

4) Microwire/coil protection

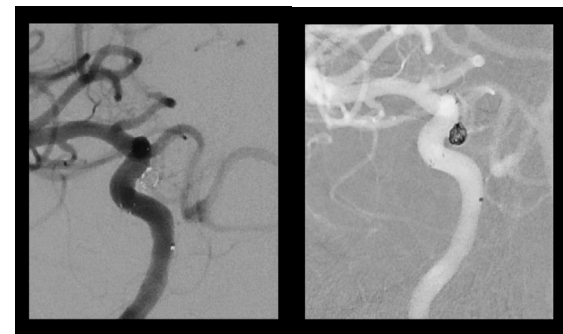


Microcatheter-assisted

4) Microwire/coil protection



Limitation

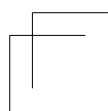
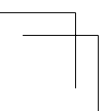
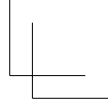
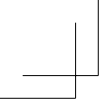


MEMO //////////////////////////////////////

Balloon-assisted coiling technique - including balloon 종류와 특성

오재상

가톨릭대 의정부성모병원



Balloon assisted Coiling 풍선 보조하 코일 색전술

오재상
가톨릭대학교
의정부 성모병원

Wide neck aneurysm

Balloon assisted coiling

- 경부가 넓은 뇌동맥류(wide-necked aneurysm, neck size ≥ 4 mm 혹은 dome-to-neck ratio 2.0)
- 어려운 점
 - 코일의 이동 (migration)
 - 완전 폐색의 어려움
- 1997 Moret 처음 소개
- BAC 의 순서
 - Inflation , Coiling, deflation, Coil detachment
 - Packing density 높이기

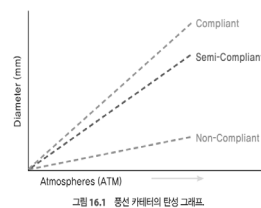
풍선 Balloon

- 1974년 Gruentzig & Hopff : polyvinyl chloride (PVC) 이용
- Walter Schlumpf: 최초의 PVC 소재의 풍선 카테터
- 1977년 Gruentzig가 첫 번째 경피경관 관상동맥성형술 (percutaneous transluminal coronary angioplasty, PTCA)을 시행
- 1977년 Mathias 경동맥 풍선 성형술 성공

풍선의 소재와 탄성

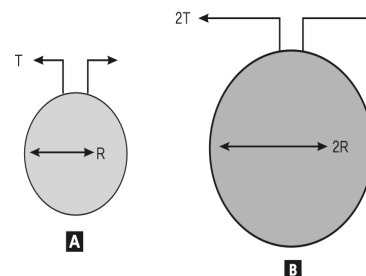
- Polyvinyl chloride (PVC)
 - 고탄성 - 압력에 쉽게 반응하고 직경을 증가
- PE, polyethylene terephthalate (PET), nylon, polyurethane
 - 저탄성 - PTA 적합
- 탄성 한계점에 이를때까지 풍선 직경의 변화가 없음

탄성과 풍선



- Highly compliant balloon** : 파열압력 도달시 표준압력에서의 직경보다 10% 이상 팽창, Balloon test occlusion
- Compliant balloon** : 1기압 이하의 저압력에서 조영제 용량에 따른 변화, BAC
- Non-compliant balloon & Semi-compliant balloon** : 표준압력에서 직경 10% 미만, ICAS 로 인한 PTAS

탄성과 풍선



R = Radius of circle A
 T = Outward force of balloon A

그림 16.2 Laplace 공식($T = P \times R$), 그림에서 A와 B는 동일한 팽창 압력을 갖는다.

풍선의 팽창과 수축

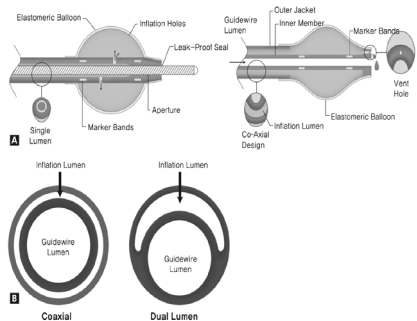


그림 16.3 A. 단일 내강(single lumen)과 풍속 이중 내강(coaxial dual lumen) 풍선 카테터의 구조도. B. 이중 내강 풍선 카테터의 구조적 도식도.

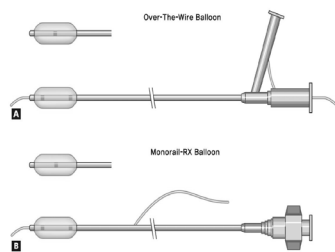


그림 16.4 A. Over-The-Wire 타입의 풍선 카테터 구조도. B. Monorail (Rapid exchange, RX) 타입의 풍선 카테터 구조도.

- 풍선 카테터의 팽창
시할때 회색된 조영
제 (50~70%)
- Over the wire
 - Gateway balloon
 - Sceptor balloon
 - Avitor
- Monorail
 - Sterling
 - Coronary balloon

표 16.1 두개강내에 사용하는 풍선 카테터들의 종류와 특성

제조사	제품명	탄성	내강 구조	적용증	유도형사	풍선 직경	풍선 길이
Acandis	Neurospeed	반 탄성	동축 이중내강	풍선 혈관성형술	≤0.014"	1.5~4.0 mm	8 mm
Stryker	Gateway	반 탄성	동축 이중내강	풍선 혈관성형술	≤0.014"	1.5~4.0 mm	9/15/20 mm
	Transform	고 탄성 초 고탄성	단일 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.014"	3~5 mm	10~30 mm
Medtronic	Hyperform™	초 고탄성	단일 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	0.010"	4/7 mm	7 mm
	HyperGlide™	고 탄성	단일 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	0.010"	4 mm 5 mm	10/15/20/30 mm 15/20 mm
Codman	Ascent®	High compliant	동축 이중내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.014"	4.0 mm 6.0 mm	7/10/15 mm 9 mm
Microvention	Sceptor C™	고 탄성	동축 이중내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.014"	4.0 mm	10/15/20 mm
	Sceptor XC™	초 고탄성	동축 이중내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.014"	4.0 mm	11 mm
BALT	Eclipse	초 고탄성	단일 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.012"	4~6 mm	7/9/12/15/20 mm
	Eclipse 2 L	초 고탄성	이중 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.014"	6.0 mm	7/9/12/20 mm
	Copernic	고 탄성	단일 내강	풍선 폐쇄 검사 풍선 보조 색전술 뇌혈관연속	≤0.012"	3~5 mm	10/15/20/30 mm
	Copernic RC	고 탄성	단일 내강	장벽 경유 색전술	≤0.014"	8 mm	80 mm

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Original Article

Procedure-related Complications during Endovascular Treatment of Intracranial Saccular Aneurysms

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Department of Neurosurgery, Soonchunhyang University Cheonan Hospital, Cheonan, Korea

Objective : We evaluate the rates and outcomes of major procedure-related complications during coiling.

Materials and Methods : Between 2007 and 2015, 436 intracranial saccular aneurysms were treated. Complications are categorized as three types: intra-procedural aneurysm rupture (IAR), thromboembolism (TE), and post-procedural early rebleeding (PER). And we evaluated the risk factors of procedure related complications by multivariate analysis.

Results : Complications occurred in 61 aneurysms (14%). The overall incidence of complications in subarachnoid hemorrhage (SAH) was significantly higher than in unruptured intracranial aneurysm (UIA) (20% vs. 6%). The incidence of IAR and TE were higher in SAH than in UIA (IAR 12% vs. 4%, TE 7% vs. 3%, $p < 0.05$). Five PER occurred only in SAH. In 34 UIA which were treated with balloon-assisted coiling (BAC), all these patients had good recovery despite 3 patients had the IAR. The incidence of IAR and TE were not different between BAC and non-BAC groups ($p > 0.05$). All 7 patients who had IAR during BAC had good recovery. In multiple logistic regression analysis, female gender, SAH, and intraventricular hemorrhage were associated with procedure related complication ($p < 0.05$).

Conclusion : Endovascular coil embolization is a minimally invasive procedure, but incidence of its complication is not low, especially in SAH. BAC can be a good tool to avoid poor outcome from unexpected IAR during coiling. While IA trofinan injection is a useful therapy in TE during coiling, sometimes we are aware of the risk of the early rebleeding in SAH patients.

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ORCID : <http://orcid.org/0000-0003-4570-6763>

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Table 4. Comparison results between BAC and non-BAC in 436 intracranial aneurysms

Variables	BAC (n = 81)	Non-BAC (n = 355)	p-value
Female sex, n (%)	66 (81.5)	246 (69.3)	0.03*
SAH, n (%)	47 (58)	193 (54.4)	0.55
Location, n (%)			
ICA	52 (64.2)	136 (38.3)	
ACA	12 (14.8)	132 (37.2)	
MCA	7 (8.6)	37 (10.4)	
BA	8 (9.9)	39 (11)	
VA	2 (2.5)	11 (3.1)	
Mean aneurysm size (mm ± SD)	7.1 (± 4.2)	6.5 (± 4.0)	0.22
IAR, n (%)	7 (8.6)	28 (7.9)	0.82
Timing of IAR, n (%)			0.67
Early (< 3rd coiling)	5 (71.4)	15 (53.6)	
Late (≥ 3rd coiling)	2 (28.6)	13 (46.4)	
TE, n (%)	6 (7.4)	16 (4.5)	0.27
Permanent TE	4 (66.7)	10 (62.5)	1
Revascularized TE	2 (33.3)	6 (37.5)	1
Poor outcome (GOS < 4)	7 (8.6)	38 (10.7)	0.58
Procedure related declined status	3 (3.7)	19 (5.4)	0.78

Values are presented as number (%).
BAC = balloon assisted coil, TE = thromboembolism, SAH = subarachnoid hemorrhage, ICA = internal carotid artery, ACA = anterior cerebral artery, MCA = middle cerebral artery, BA = basilar artery, VA = vertebral artery, IAR = intraprocedural aneurysm rupture, GOS = Glasgow outcome scale.
*p < 0.05 for significance.

Table 2. Comparison results between no-complication and complication group

Variables	No-complication	Complication	Total	Odds ratio (95% CI)	p-value
Total, n (%)	375 (86)	61 (14)	436 (100)		
Female, n (%)	264 (70.4)	48 (78.7)	436 (100)	1.55 (0.80-2.97)	0.18*
Age (mean ± SD)	57.4 ± 13.4	56.9 ± 12.9	57.3 ± 13.3	0.99 (0.97-1.01)	0.79
SAH, n (%)	191 (50.9)	49 (80.3)	240 (55)	3.93 (2.02-7.63)	< 0.001 [†]
IVH, n (%)	76 (20.3)	32 (52.5)	108 (24.8)	4.34 (2.47-7.61)	< 0.001 [†]
Mean aneurysm diameter, mm (mean ± SD)	7.1 ± 4.3	6.2 ± 2.6	7.0 ± 4.1	0.93 (0.85-1.01)	0.11*
Packing density (%)	35.8 ± 11.2	37.3 ± 11.3	36 ± 11.2	1.01 (0.98-1.03)	0.36
BAC, n (%)	67 (17.9)	14 (23)	81 (18.6)	1.36 (0.71-2.63)	0.34
Selection difficulty, n (%)	70 (18.7)	17 (27.9)	87 (20)	1.68 (0.90-1.03)	0.10*
Poor outcome, n (%)	26 (6.9)	19 (42.2)	45 (10.3)	6.07 (3.09-11.89)	< 0.001 [†]

Values are presented as number (%) or mean ± standard deviation.
SAH = subarachnoid hemorrhage, IVH = intraventricular hemorrhage, BAC = balloon-assisted coil.
*p < 0.2 for comparison between two groups.
†p < 0.05 for comparison between two groups.

Balloon Remodeling May Improve Angiographic Results of Stent-Assisted Coiling of Unruptured Intracranial Aneurysms

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 Michel Plotin, MD, PhD[§]
 Charbel Mounayer, MD, PhD^{||}
 Kyriakos Lobotesis, MBBS, FRCS[#]
 Alain Bonafé, MD, PhD^{**}
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BACKGROUND: Endovascular treatment of wide-necked and complex aneurysms may require stent-assisted coiling, either as primary stenting or combined with the balloon remodeling technique (BRT).
OBJECTIVE: To compare the angiographic results and clinical outcomes of both strategies in the Safety and Efficacy of Neuroform for Treatment of Intracranial Aneurysms (SENAT) registry.
METHODS: SENAT was a prospective, multicenter registry that allowed BRT in conjunction with stenting and coiling with bare platinum coils. Clinical and angiographic outcomes of 97 patients with unruptured aneurysms treated with stenting, 51 after BRT (BRT+) and 46 without balloon assistance (BRT-), were retrieved from the SENAT database. Technical, clinical, and angiographic outcomes were compared between the 2 groups.
RESULTS: Periprocedural morbidity and midterm clinical outcomes were not different between groups. Residual aneurysms were observed in 7.8% of BRT+ and in 21.7% of BRT- ($P = .08$) at the end of the stenting procedure. Four retreatments were performed during the follow-up period (2 BRT+, 2 BRT-). Twelve- to 18-month anatomic results showed a significant difference between groups, with a residual aneurysm being observed in 6.1% of BRT+ as compared to 22.7% of BRT- patients ($P = .03$).
CONCLUSION: Primary BRT followed by stent-assisted coiling may be associated with fewer residual aneurysms at 12 to 18 months as compared to stent-assisted coiling alone.

KEY WORDS: Balloon remodeling technique, Cerebral aneurysm, Intracranial aneurysm, Stent

Neurosurgery 76:441-445, 2015 DOI: 10.1227/NEU.0000000000000039 www.neurosurgery-online.com

Single lumen balloon

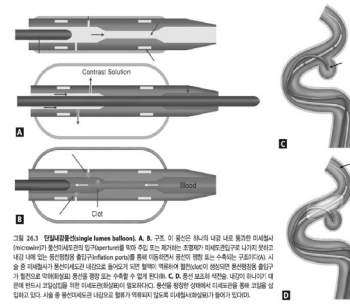


그림 26.3 단일루멘용(single lumen balloon). A, B, C는 이 용기는 혈관의 내강 내로 통과한 뒤(incubation) 용액(contrast)을 단일루멘(single lumen)을 따라 주입 또는 제거하는 과정에서 사용된다. A는 용액만 주입된 상태, B는 용액과 혈액이 혼합된 상태, C는 용액과 혈액이 혼합된 상태이다. 이 용기는 사용 후 용액이 혈관 내로 주입되고 용액이 제거된 후 용액이 혈관 내로 주입된다. 이 용기는 사용 후 용액이 혈관 내로 주입되고 용액이 제거된 후 용액이 혈관 내로 주입된다. 이 용기는 사용 후 용액이 혈관 내로 주입되고 용액이 제거된 후 용액이 혈관 내로 주입된다.

Dual lumen balloon

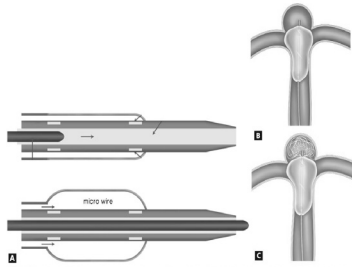


그림 26.4 이중루멘용(dual lumen balloon). A, B, C는 이 용기는 혈관의 내강 내로 통과한 뒤(incubation) 용액(contrast)을 이중루멘(double lumen)을 따라 주입 또는 제거하는 과정에서 사용된다. A는 용액만 주입된 상태, B는 용액과 혈액이 혼합된 상태, C는 용액과 혈액이 혼합된 상태이다. 이 용기는 사용 후 용액이 혈관 내로 주입되고 용액이 제거된 후 용액이 혈관 내로 주입된다. 이 용기는 사용 후 용액이 혈관 내로 주입되고 용액이 제거된 후 용액이 혈관 내로 주입된다.

BAC

- CLARITY & ATENA
- SAH (20.8%) , UIA (37.3%)
- Low frequency in Acom & ACA
- OJS 7% 전후
- 최근 사용 빈도는 감소 추세
- 하지만 반드시 익히면 도움이 됩니다~!

Balloon time

An Analysis of Inflation Times During Balloon-Assisted Aneurysm Coil Embolization and Ischemic Complications

Alejandro M. Spiotta, MD; Tarun Bhalla, MD; Muhammad S. Hussain, MD; Thinesh Sivapatham, MD; Ayush Batra, BS; Ferdinand Hui, MD; Peter A. Rasmussen, MD; Shaye I. Moskowitz, MD, PhD

Background and Purpose—The introduction of balloon remodeling has revolutionized the approach to coiling of wide-neck aneurysms. We studied the effects of balloon inflation during coil embolization on ischemic complications.
Methods—A retrospective review was undertaken of the most recent 147 patients undergoing balloon remodeling for unruptured intracranial aneurysm coil embolization at a single institution (81 balloon, 66 unassisted). All underwent postprocedural MRI.

Results—Among patients in the “balloon” group, the mean total inflation time was 18 minutes (range, 1–43), a mean number of inflations of 4 (range, 1–9), a mean maximum single inflation time of 7 minutes (range, 1–19), a mean reperfusion time of 2.2 minutes between inflations, and an average procedure time of 2 hours and 10 minutes. Asymptomatic diffusion-weighted imaging abnormalities were detected on postprocedural MRI in 21.5% of patients and symptomatic lesions were identified in 3.8%. Both silent and symptomatic ischemic rates were similar in the internal control group. Patients with ischemic findings were older and more likely have diabetes; no differences were found with respect to total balloon inflation time, number of inflations, maximum inflation time, or reperfusion times.

Conclusions—We found no significant relationship between balloon inflation practices and ischemic events. Older and diabetic patients were more likely to have ischemic events develop. (*Stroke*. 2011;42:1051-1055.)

혈류차단시간

- 평균 총 풍선 팽창 시간은 18분(1~43분)
- 평균 풍선팽창 횟수는 4회(1~9회)
- 평균 1회 풍선 팽창시간은 7분 (1~19분)
- 각 풍선 팽창 사이의 재관류시간(reperfusion time) 은 2.2분
- 평균 시술 시간은 2시간 10분
- 시술 후 시행한 DWI에서 무증상의 양성 병변은 환자의 21.5%, 유증상의 양성 병변은 3.8%에서 발견됨
- 이 결과는 고식적인 치료군과 차이가 없어 풍선팽창 지속시간과 허혈성 뇌졸중 간에 의미 있는 상관 관계는 없다고 하였다.
- 하지만 1회 풍선팽창시간이 길 수록 분수계성 뇌경색(watershed pattern infarction)과 의미 있는 상관관계가 있다고 보고하였기에 1회 풍선팽창시간을 가 능한 짧게 하여야 하고 최대 10분 미만으로 하는 것이 중요함.
- 측부혈행을 미리 파악해두면 도움

Stroke 2011;42:1051

BAC의 장점

- 모동맥의 보호
- 코일 삽입중 미세도관 안정성 유지 및 재진입 용이
- 동맥류 충전밀도 증가
- 일시적 보조기구
- 파열시 혈류 차단 가능

BAC 합병증

- 혈전 생성의 위험
- 혈액 저류로 인한 혈전 생성
- 코일의 이동
- 동맥류 파열
 - Overinflation or rapid inflation
 - 미세도관의 압박으로 동맥류 파열
 - 풍선으로 미세도관 kick back 이 사라짐

헤파린 사용시기

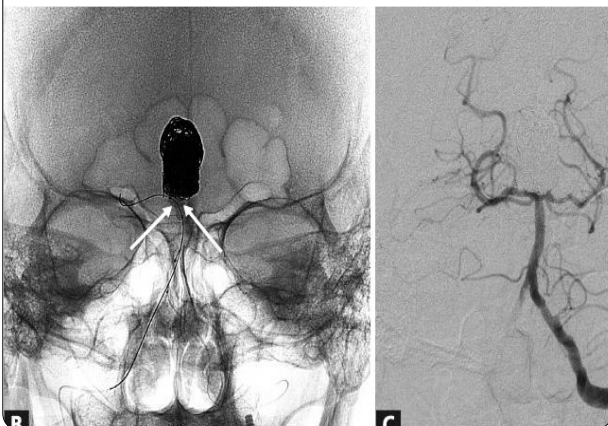
- 일반적으로는 UIA 는 바로 시술 시작때
- SAH는 first or second frame coil 마쳤을때
- 발룬 시작하면서 바로 ACT 2-3 배 맞추기 위해 사용

Ballon preparation

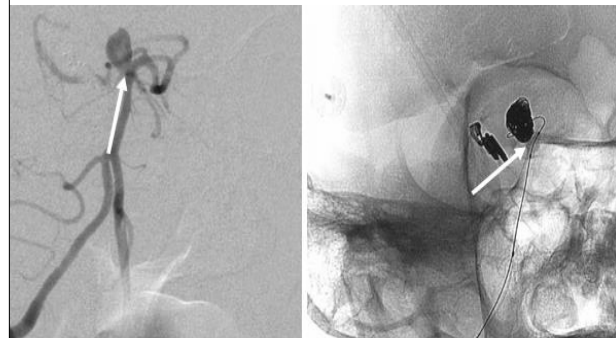
- 제일 중요한 step
- Air bubble 이 생기지 않게
- 천천히
- 직접



거대동맥류 BAC



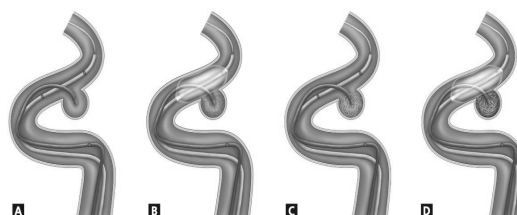
동맥류 경부에서 분지혈관 기시



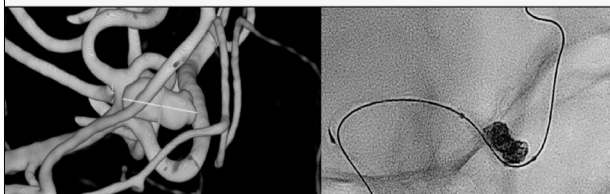
모호한 경계의 모동맥 보호



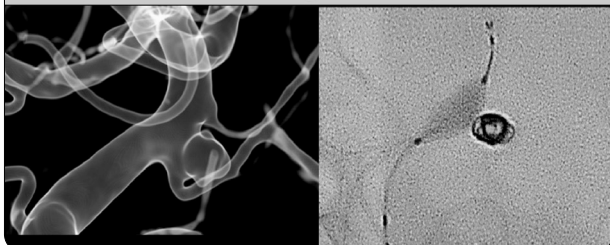
BAC의 기본적인 술기 방법



Balloon assisted coiling for ruptured MCBF



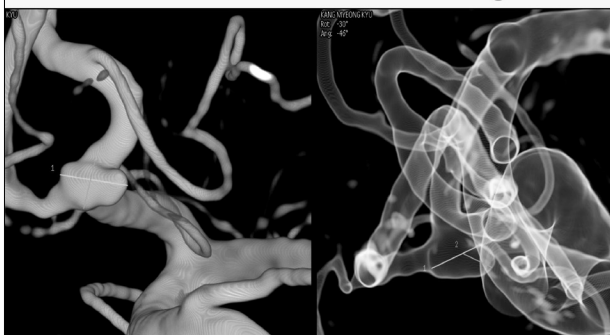
Balloon assisted coiling for unruptured Pcom



Balloon angioplasty for vasospasm



Balloon for Intraoperative rupture & Balloon and then stenting

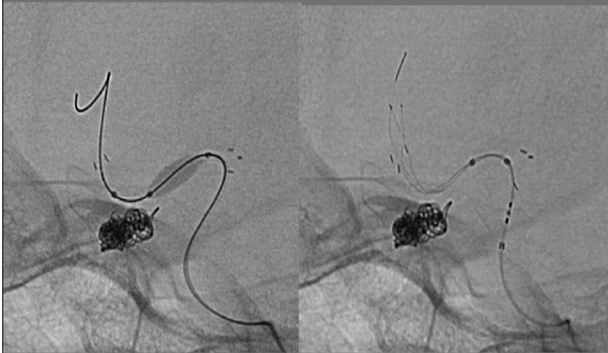


Very Small aneurysm on Acom
Hx: SLE , Cerebral infarction with Intracranial Dissection
Medication : Anticoagulant

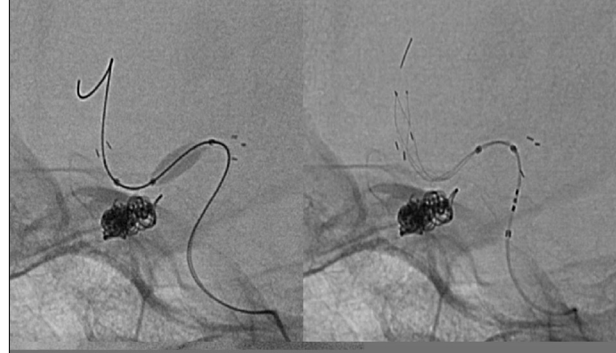
Balloon for Intraprocedural rupture & Balloon and then stenting



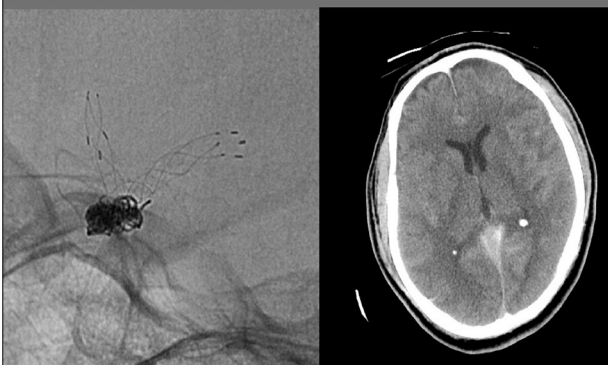
Balloon for Intraprocedural rupture & Balloon and then stenting



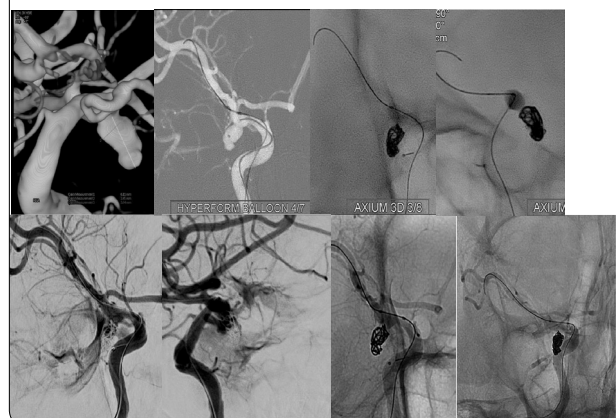
Balloon for Intraprocedural rupture & Balloon and then stenting



Balloon for Intraprocedural rupture & Balloon and then stenting

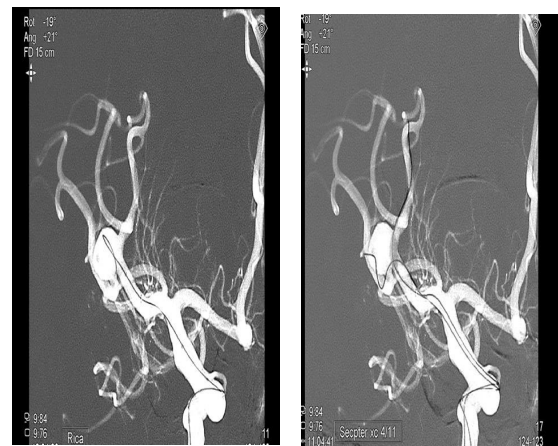


Intraprocedural rupture risk: BAC



MCA broad neck aneurysm

MCC selection difficulty

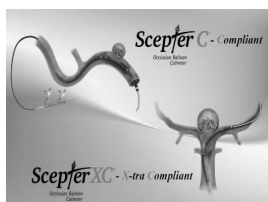




Balloon-mounted micro catheter 로 할 수 있는 것들?

Balloon-mounted micro catheter

What can we do?



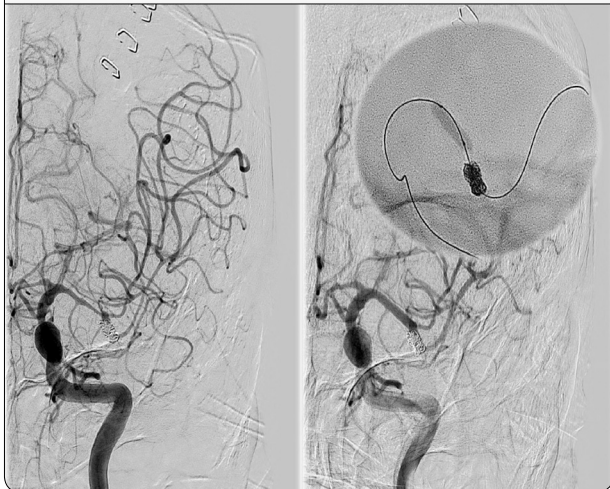
1. Balloon occlusion test
2. Balloon assisted coiling
3. Intra-procedural aneurysmal rupture
4. Balloon and then Stenting using LVIS Jr
5. Balloon angioplasty in vasospasm

Balloon occlusion test



PNS Cancer
BTO for pre-op evalaution

Balloon angioplasty for vasospasm



Dual lumen balloon microcatheter

Recent in a case of..

1. Balloon occlusion test
2. Balloon assisted coiling
3. Intra-procedural aneurysmal rupture
4. Balloon and then Stenting using LVIS Jr
5. Balloon angioplasty in vasospasm
6. Liquid (Onyx, Phil) injection

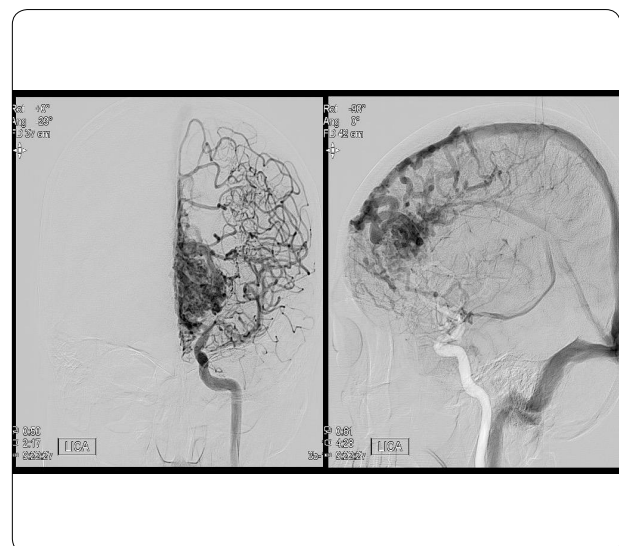
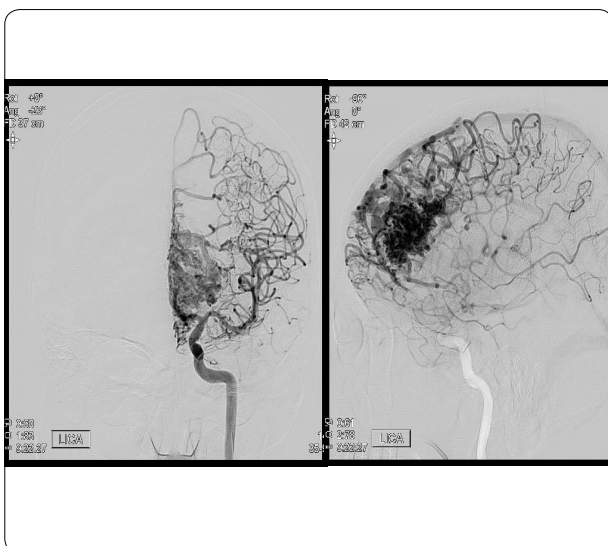
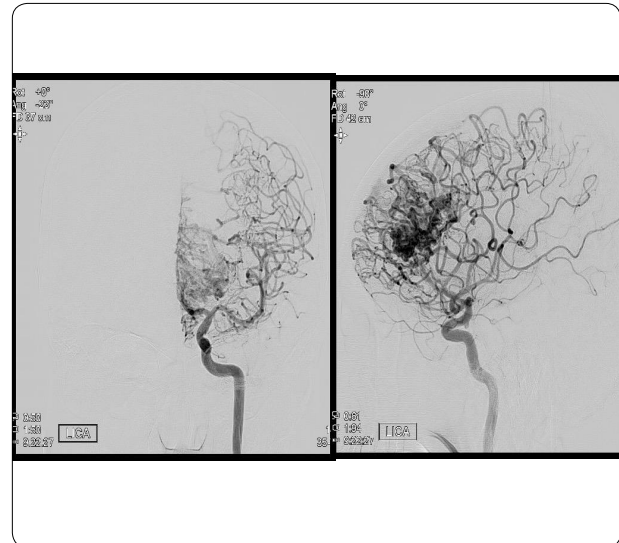
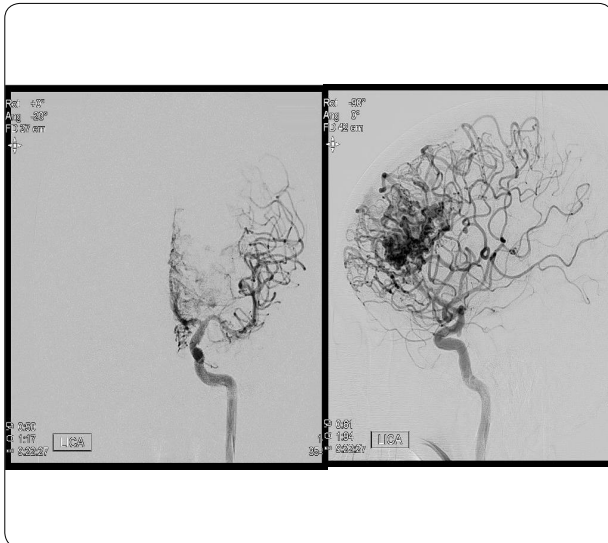
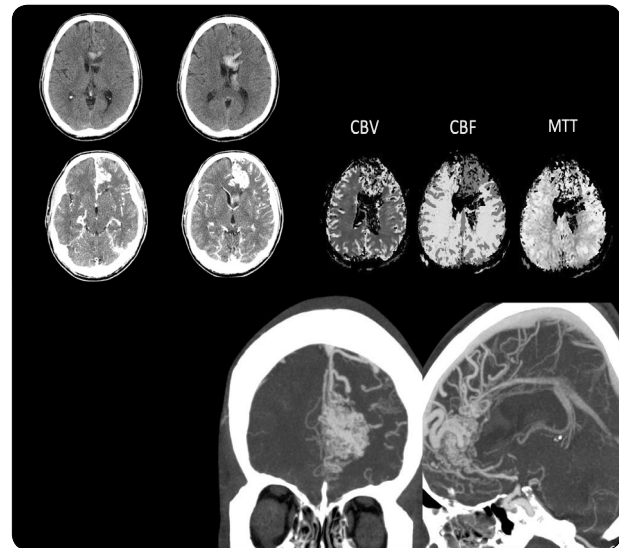
Case 1

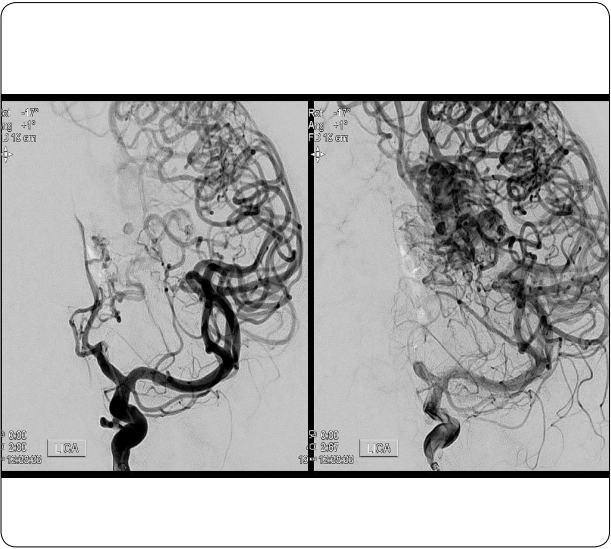
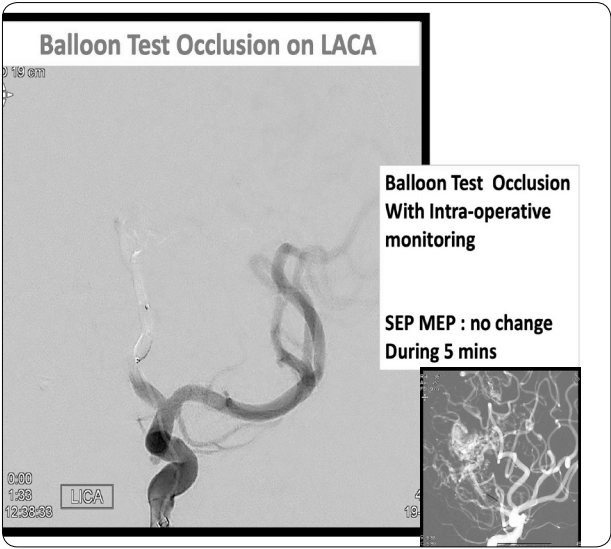
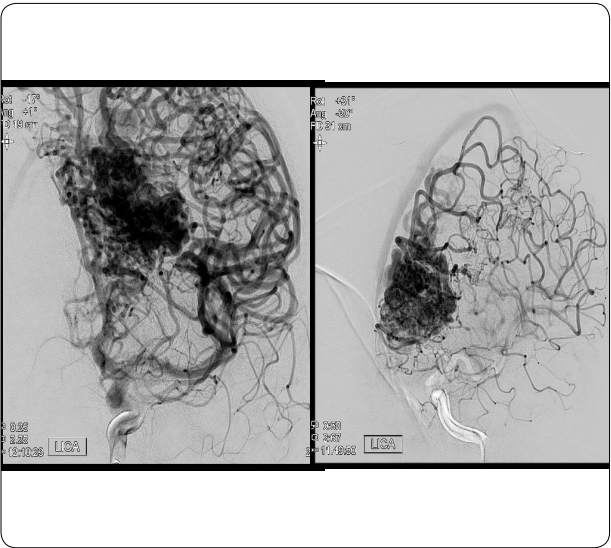
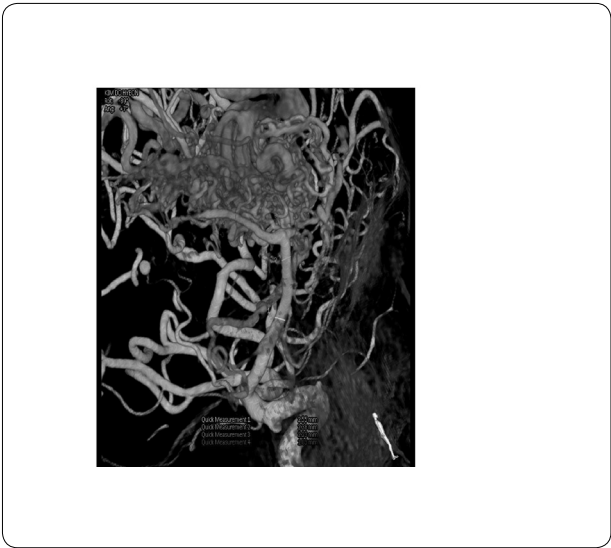
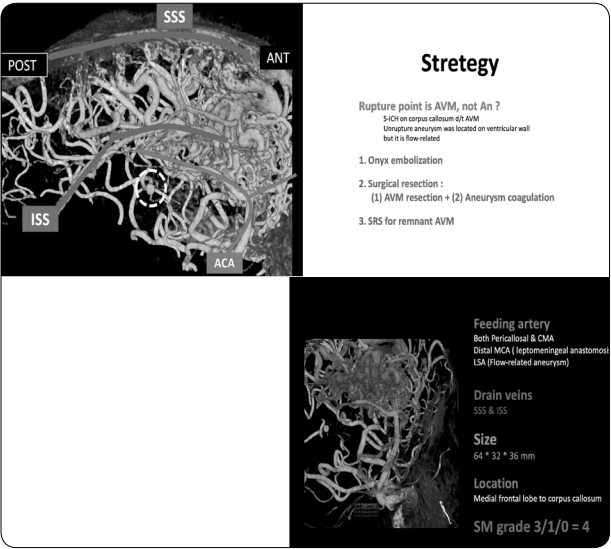
53/M

평소 자주 두통을 호소하던 환자로
갑작스런 Confused mental status

By) Suddenly
Onset) 2018.5. 10

HTN (+)
DM (+)





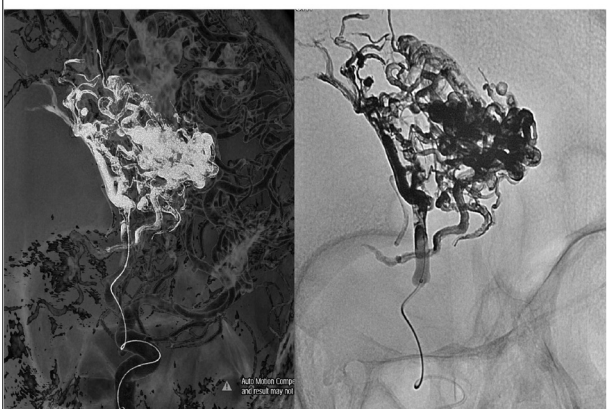
Pressure Cooker Technique using Dual-lumen microcatheter
Onyx Injection with Pericallosal artery trapping

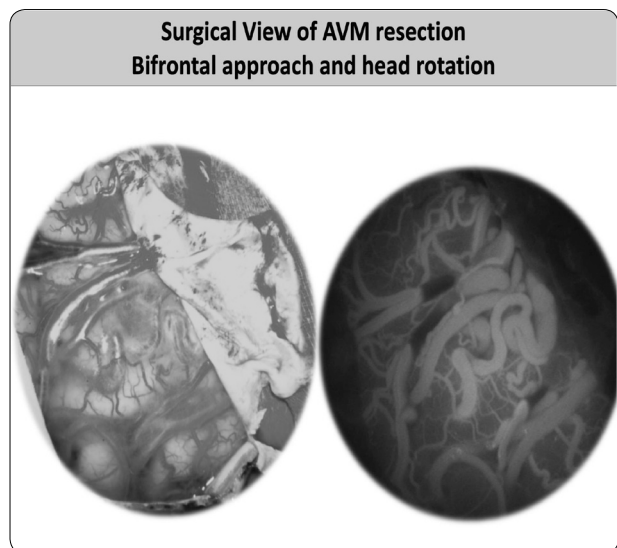
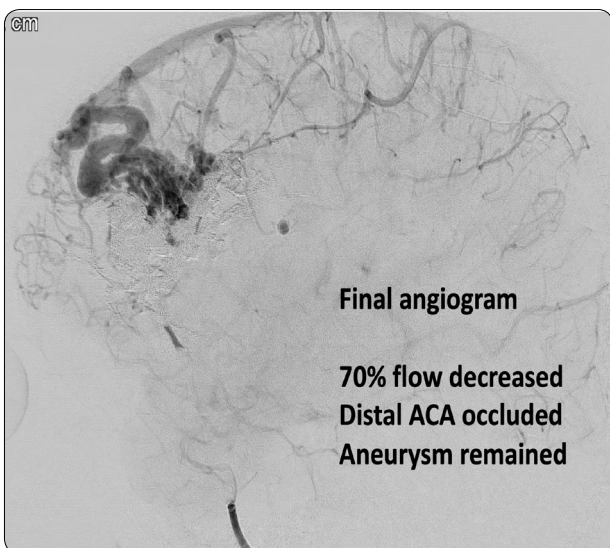
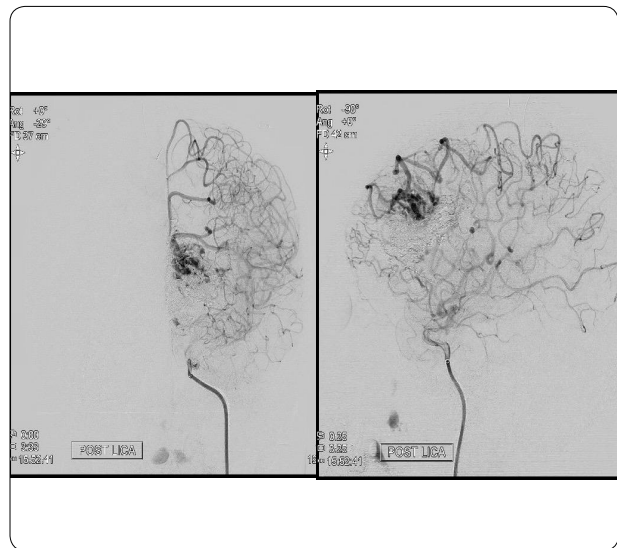
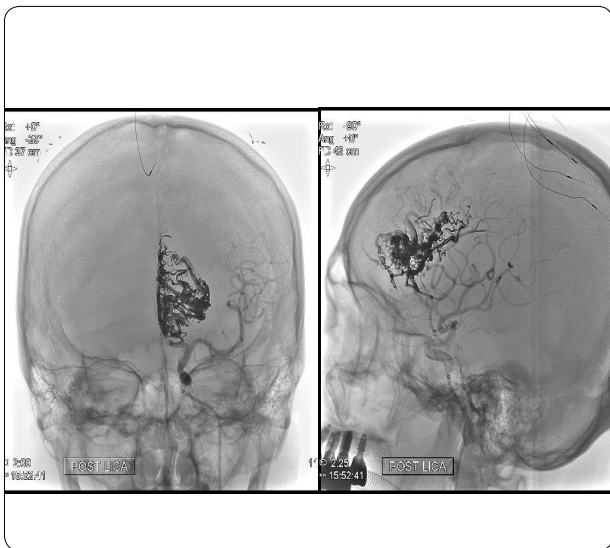


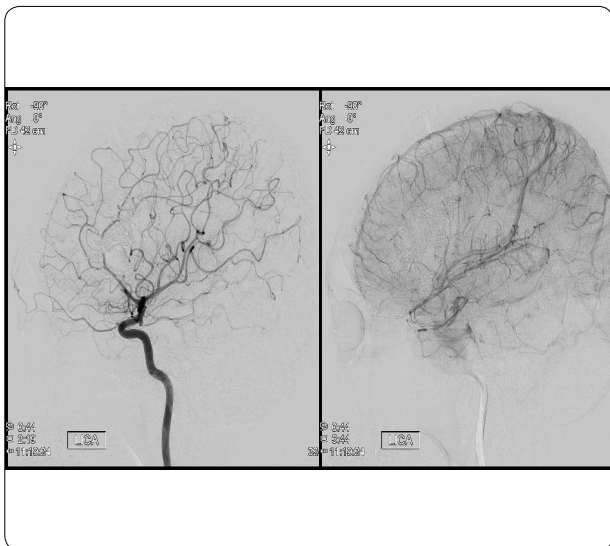
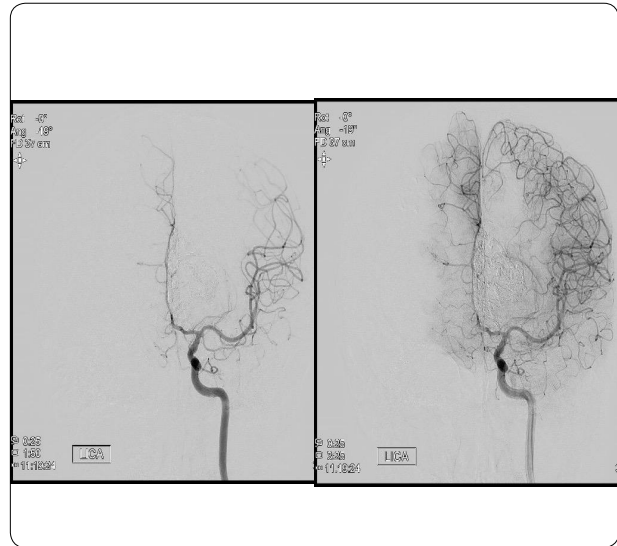
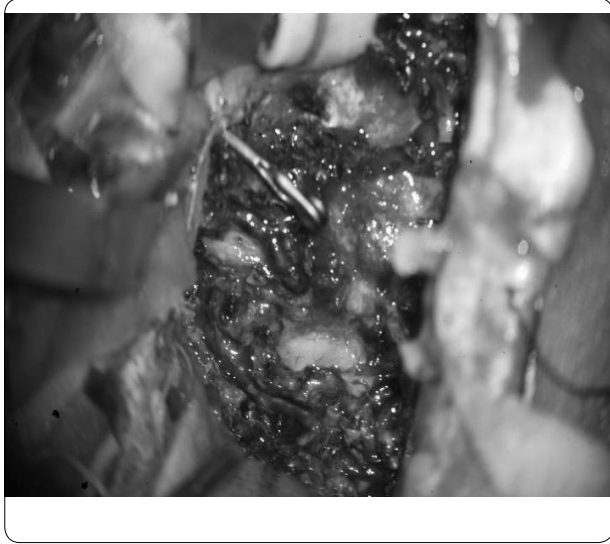
Pressure Cooker Technique using Dual-lumen microcatheter
Onyx Injection 12 cc with Pericallosal artery trapping



Pressure Cooker Technique using Dual-lumen microcatheter
Onyx Injection 6 cc with Pericallosal artery trapping







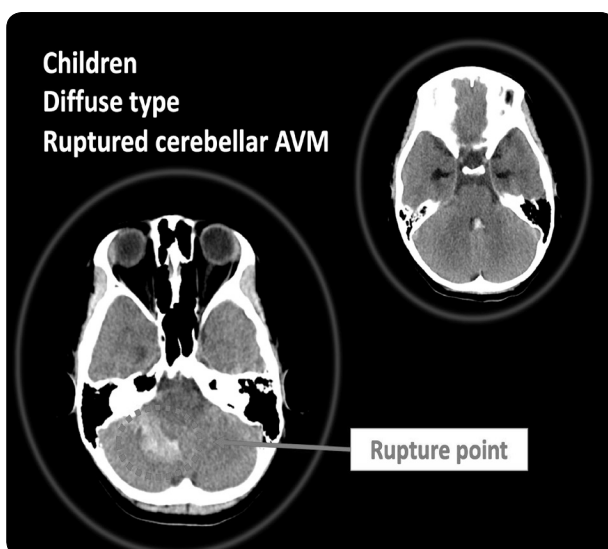
Case 4

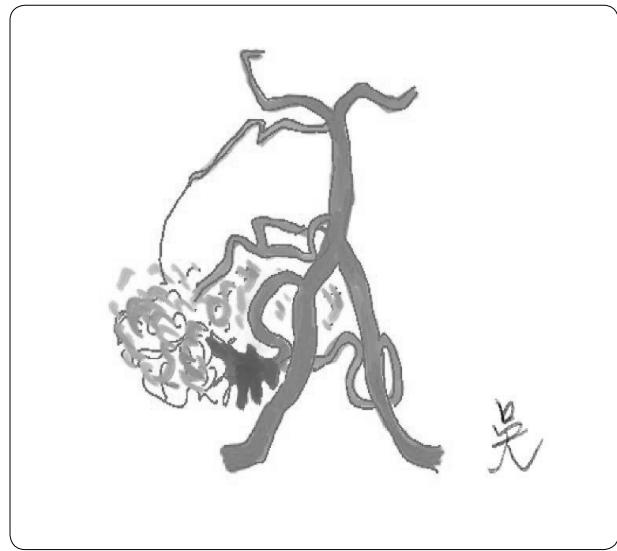
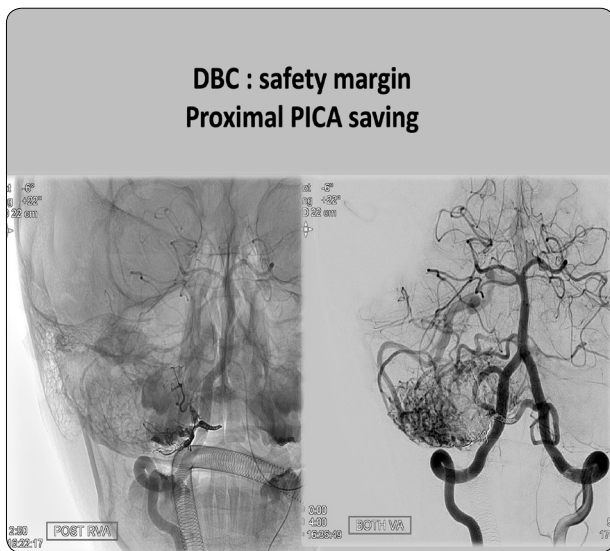
9/F

Dizziness and Headache

Family Hx : Daddy-Ruptured AVM (mRS 4)

Onset) 2018.8. 7



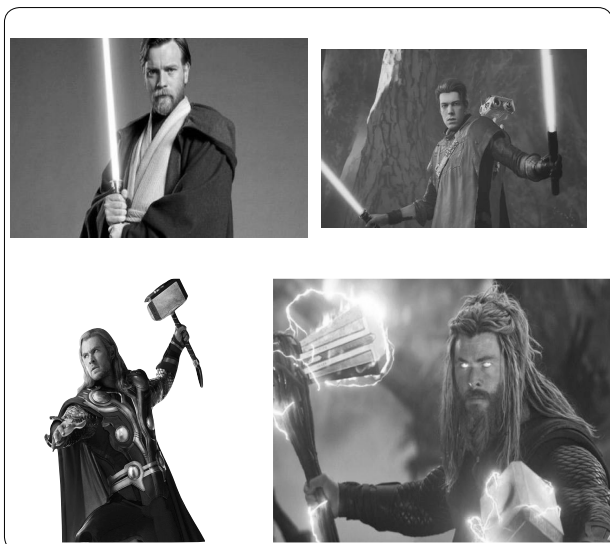


**Post clinical course #30 months
fu**
SRS # 36 months FU

Diffuse type cerebellar AVM in children

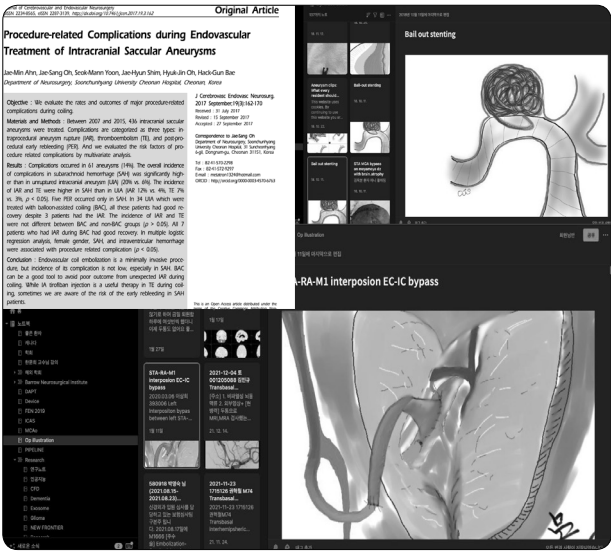
Balloon 으로 PICA proximal saving margin

현재 : mRS 0



Keynote

- Now Stent era... SAC and Flow diverter ..
- Balloon is the double edged sword.
- If you use the balloon-mounted micro catheter,,
- You make the patients better ... in some cases



이창호 9단

재능을 가진 상대를 넘어서는 방법은 노력뿐이다.
더 많이 집중하고 더 많이 생각하는 수 밖에 없다.
바둑에는 ‘복기’라는 훌륭한 교사가 있다.

승리한 대국의 복기는 ‘이기는 습관’을 만들어주고
패배한 대국의 복기는 ‘이기는 준비’를 만들어 준다

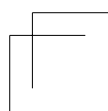
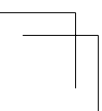
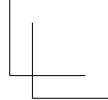
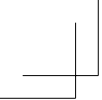
MEMO //////////////////////////////////////

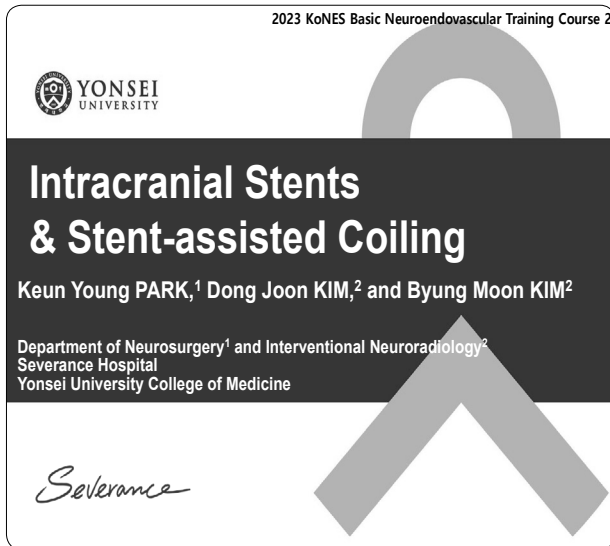
MEMO //////////////////////////////////////

Stent-assisted coiling technique - including stent 종류와 특성

박근영

연세대 세브란스병원





Why or for What ?

- **Scaffold for coil mass**
 - Wide-neck and/or shallow, and fusiform aneurysms that are **otherwise NOT** coilable.
- **Prevention of recurrence**
 - Large/Giant aneurysm
- **Re-enforcement of fragile vessel wall**
 - Blood blister-like, dissecting or pseudoaneurysm
- **Prevention of microcatheter kickback**

Contents

- ✓ **Stent Architectures**
- ✓ **Stent Characteristics**
- ✓ **Stent-assisted Coiling**
- ✓ **Antiplatelet Usage**

Stent Materials

✓ Nitinol: Nickel + Titanium

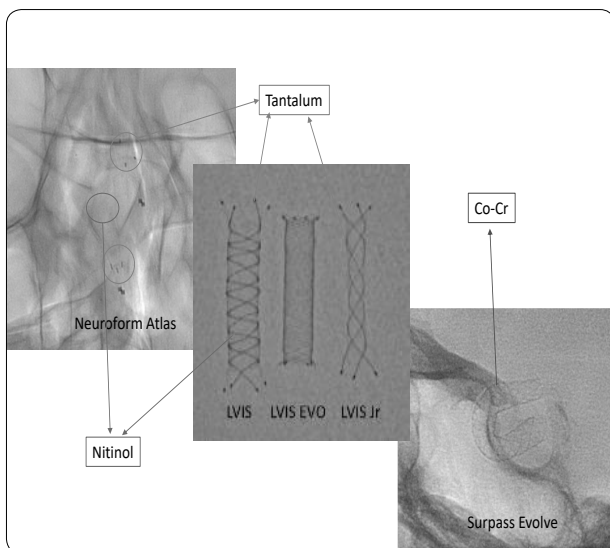
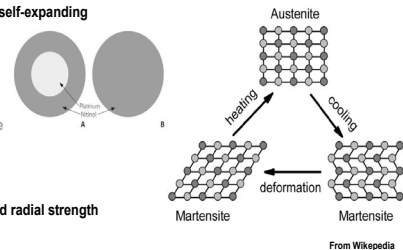
- **Shape-memory** alloy; self-expanding
- Superelasticity
- DFT

✓ Co-Cr: Cobalt + Chrome

- High load resistance
- **Radiopaque**
- Balancing visibility and radial strength

✓ Radiopacity: Tantalum or Platinum

- ✓ Biocompatible
- ✓ Fatigue tolerance
- ✓ Corrosion resistance



Laser Cutting versus Wire Braiding

LASER cutting

✓ From Nitinol tube



- ✓ Less shortening
 - ✓ More chronic outward force (COF)
 - ✓ Lower Metal coverage
- Neuroform Atlas, Enterprise, Acclino

Wire braiding

✓ From fine wires



- ✓ More shortening
 - ✓ Less chronic outward force (COF)
 - ✓ Higher metal coverage
- LVIS, Accero, Flow Diverters

Stent Cell

Open cell (semi-)

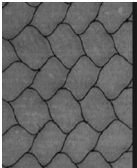
✓ Less inter-cell connections
✓ Relatively larger cell size
✓ More wall apposition
✓ Less stiff / More conformability
✓ Retrieval X



Neuroform EZ, Atlas, Wingspan

Closed cell

✓ More inter-cell connections
✓ Relatively smaller cell size
✓ Less wall apposition
✓ More stiff / Less conformability
✓ Retrieval O

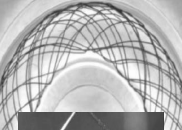
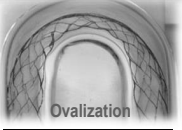
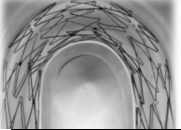


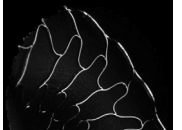
Enterprise, Acclino

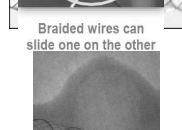
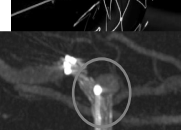
<Open cell>

<Closed cell>
Ovalization

<Closed cell, Braid>



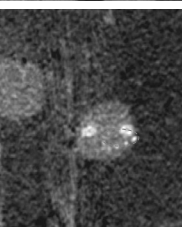
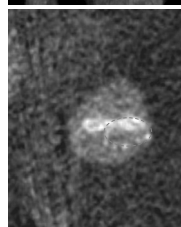
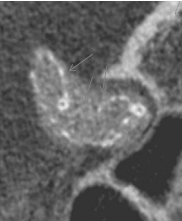
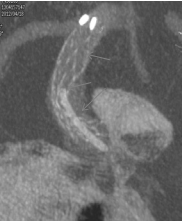
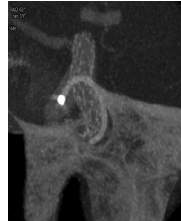




Braided wires can slide one on the other

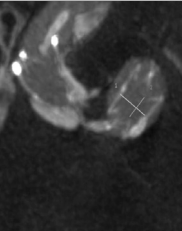
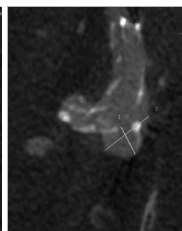
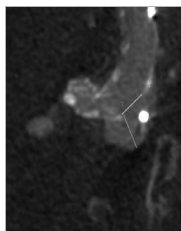
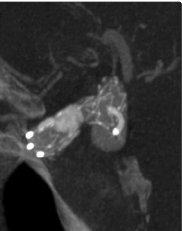
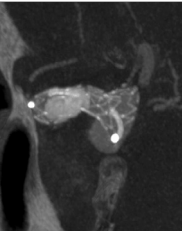
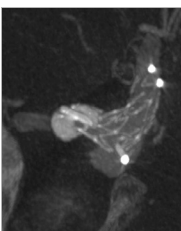
F/64, ICA aneurysms, unruptured





F/76 Lt ICA, unruptured





Stent Cell

✓Pore density and Porosity

✓Cell size and Metal Coverage



Pore Density & Porosity

Porosity: Ratio of metal free surface area in a stented vessel
Pore Density: Number of pores per unit surface area

DIAGRAM A



DIAGRAM B



Schematic showing equal porosity (50%) but different pore densities.
 Diagram A has 16 times higher pore density than diagram B.

Stent Cell Size & Metal Coverage

✓Cell Size: Diameter(mm) of inscribed circle or Area(mm²)

✓Metal coverage: Theoretical area of stent mesh contacting the vessel wall ↔ Porosity

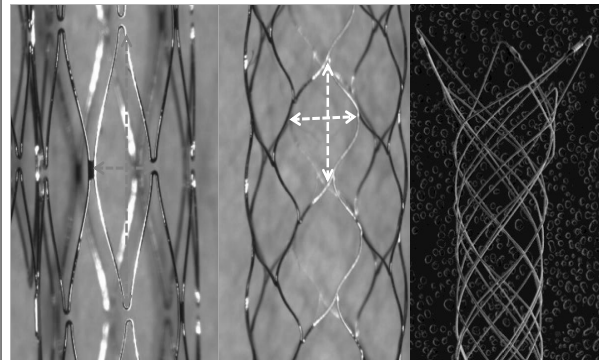
Affected by

1. Cell size
2. Strut width
3. Number of Wire

✓ Cell size ↓ (pore density ↑) & Metal coverage ↑

-
- Flow diversion effect ↑
 - Neointima formation ↑ (In-stent stenosis)
 - Perforator occlusion ↑

✓ Flow diverters > LVIS blue > LVIS Jr > Enterprise, Neuroform Atlas, Acclino



Stent Characteristics

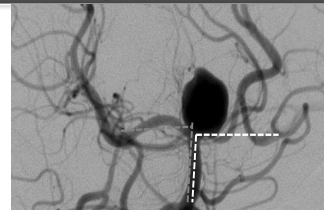
✓Conformability

✓Foreshortening

✓Radial Force



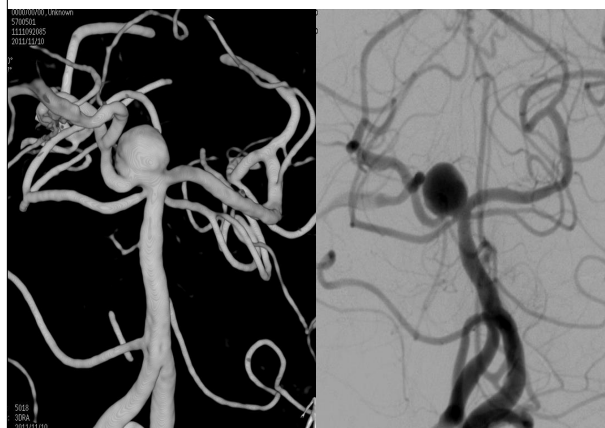
Conformability



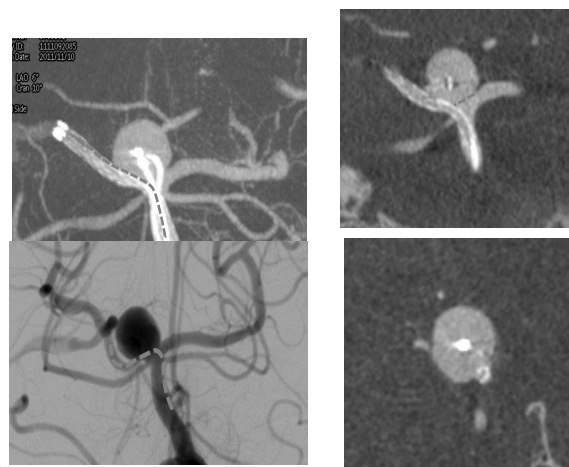
Moyamoya disease, BA tip and SCA aneurysms



What effect of conformability on procedure and outcome ?

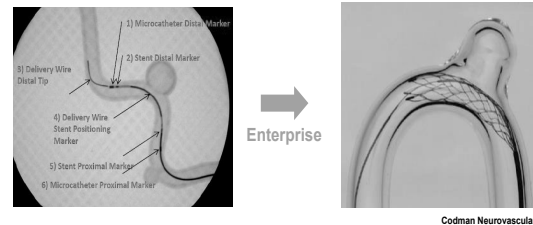


VasoCT after laser-cut closed cell stent with catheter jailing

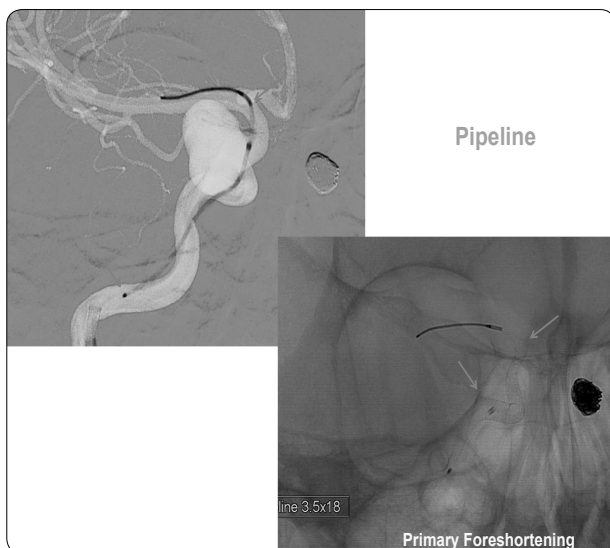


Foreshortening

Definition: Reduction of stent length between constrained and unconstrained states.



✓Laser cut < Wire braid

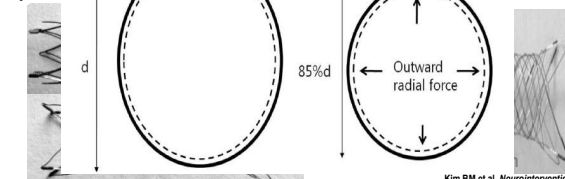


Chronic Outward Force

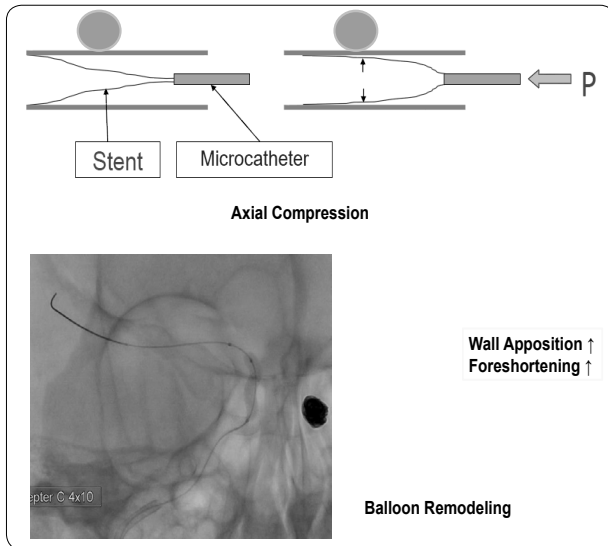
Definition: A stored elastic force against the surrounding vessel wall for self-expansion

✓Measured by 360° circumferential compression test

✓Laser cutting > Wire braiding



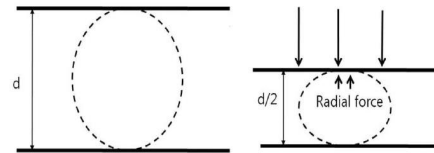
Kim BM et al. Neurointervention. 2011



Radial Restrictive Force

Definition: A force that stents exert on the vessel wall and supports coil mass

✓ Measured by two-plates compression test



✓ LVIS blue > Enterprise > Neuroform > LVIS Jr.

Kim BM et al. Neurointervention. 2011.

Summary of Stents

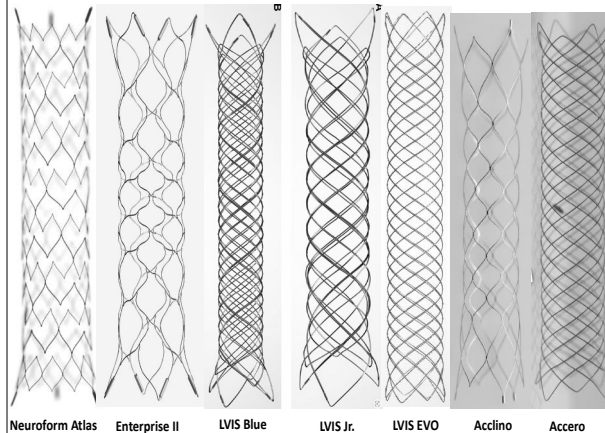
표 28-1 스텐트 종류 및 특징

	Neuroform EZ	Neuroform Atlas	Enterprise II	Solitaire AB	LVIS blue	LVIS Jr	LVIS EVO	Acclino	Accero
Material	Nitinol	Nitinol	Nitinol	Nitinol	Nitinol	Nitinol	Nitinol (DFT)	Nitinol	Nitinol (DFT)
Manufacture	Laser-cutting	Laser-cutting	Laser-cutting	Laser-cutting	Wire-braiding (16)	Wire-braiding (12)	Wire-braiding (16)	Laser-cutting	Wire-braiding (12/16)
Cell design	Open-cell	Open-cell	Closed-cell	Closed-cell	Closed-cell	Closed-cell	Closed-cell	Closed-cell	Closed-cell
Compatible Microcatheter ID (inches)	0.027	0.0165~0.017	0.021	≥ 0.0195 for 4mm, 0.021 for 5mm, 0.027 for 6mm	0.021 (3.5~4.5)	0.0165~0.017 (2.5, 3.5)	0.0165~0.017 (2.5~4.0)	0.0165 for 3.0~5.5mm, 0.021 for 6.5mm, 0.027 for 8.0mm	0.0165~0.017 (2.5~4.0, 4.5)
Recapture	Non-recapturable	Non-recapturable	Recapturable, 3/4 deployment of full length	Completely recapturable	Recapturable, 3/4 deployment of full length	Recapturable, 3/4 deployment of full length	Recapturable, Up to 90% [†]	Recapturable, Up to 90%	Recapturable, Up to 90%
Radiopaque stent markers	4 markers at each end	3 markers at each end	4 markers at each end	3 or 4 distal markers; 1 proximal marker	4 markers at each end	3 markers at each end +3 strands	4 markers at each end	3 markers at each end	3 markers at each end
Delivery wire distal tip length (mm)	19	Zero	12/Zero	Zero	10	5	8	12 (J shape)	12 (J shape)
Flare ends	No	Minimal	Yes	No	Yes	Yes	Minimal	Minimal	Yes
Foreshortening (%)	1.8~5.4	2.9~6.3	2.5~9.9	*	39.3~56.6	13.2~28.3	~90%	10~15%	~25%
Conformability	+++	+++	+	++	++	++	+++	7	+++
Technical demand	+++	+	+/+	+/+	+++	++	++	+	+
Prevention of recurrence	+	+	+/+	+/+	++++	+++	++++	+/+	++++

ID, inner diameter; *, non-available data

†BlueXide surface finishing

Summary of Stents



Basic Techniques of SAC

Deployment technique

Sequence of stent and catheter for coiling insertion

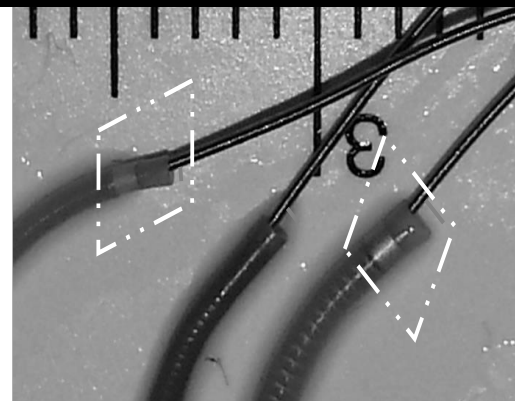
- Through-struts (Trans-cell)

- Jailing

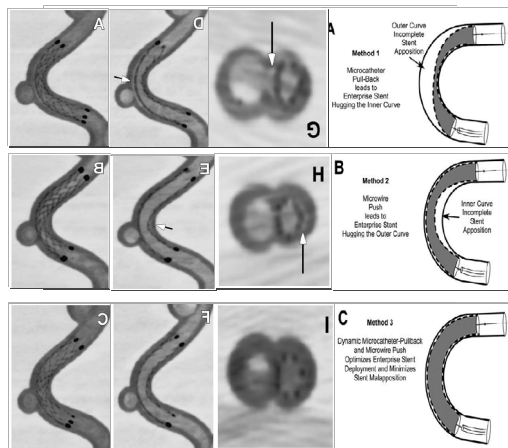
- Stent-jack

Ledge effect – wire and catheter

0.014" wire in 0.017", 0.021", and 0.027" ID catheters

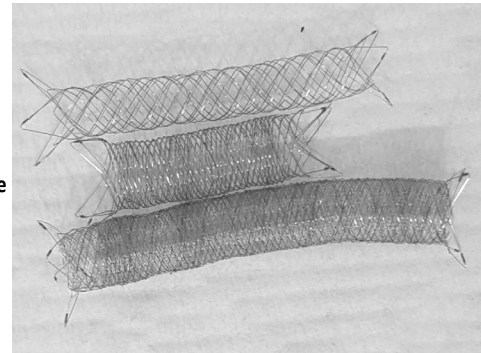


Deployment – laser-cutting stent

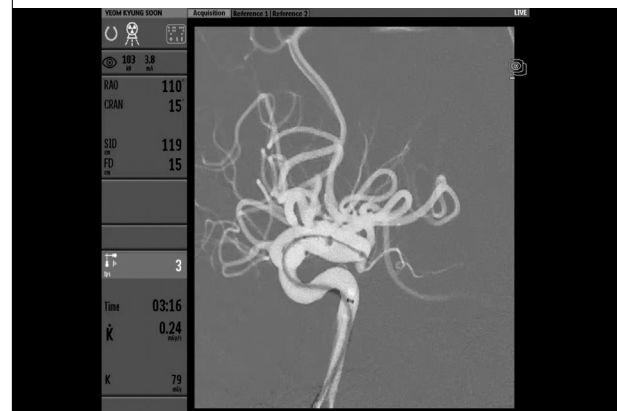
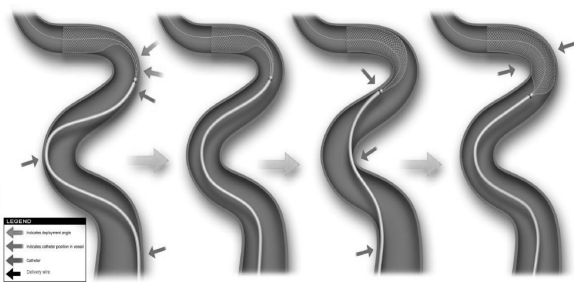


Braided type stent

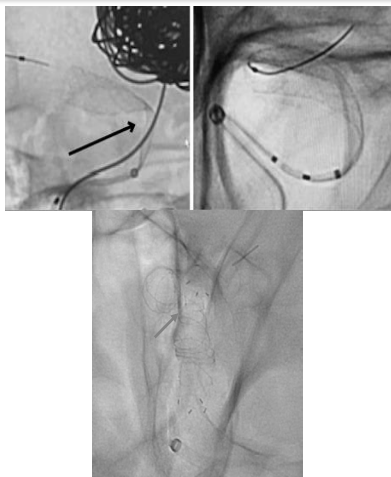
LVIS Jr
LVIS Blue
FRED



Deployment, Braided type stent



"Twist" or "Ribbon"

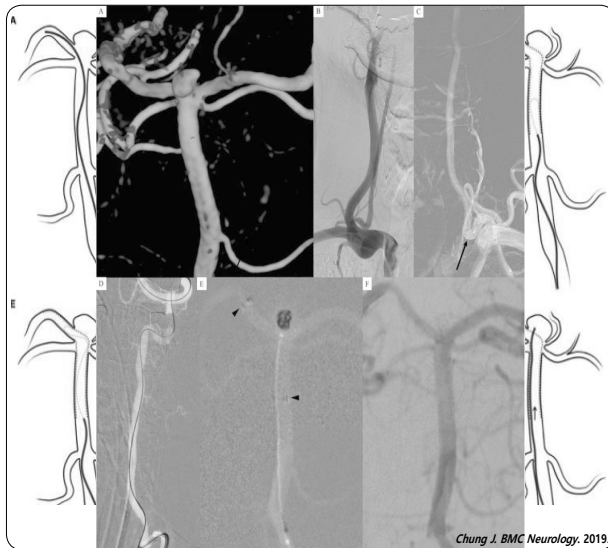


Basic Techniques of SAC

Deployment technique

Sequence of stent and catheter for coiling insertion

- Through-struts (Trans-cell)
- Jailing
- Stent-jack



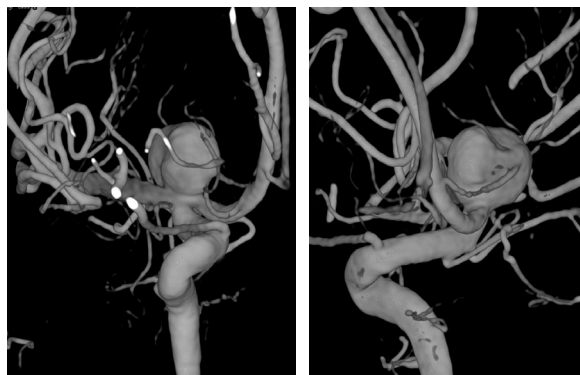
Basic Techniques of SAC

Deployment technique

Sequence of stent and catheter for coiling insertion

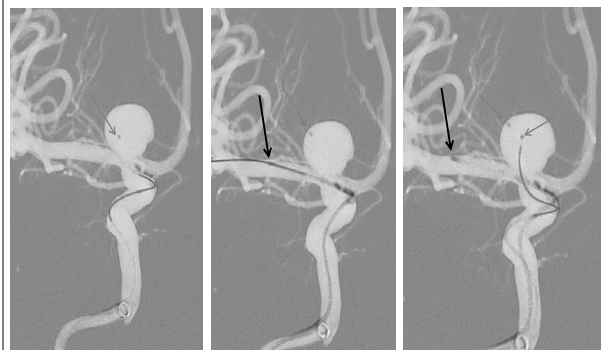
- Through-struts
- Jailing
- Relation of catheter tip to stent
- Semi-jailing or Stent-jack

F/51, large ICA bifurcation aneurysm, unruptured



Relation of catheter tip to stent

catheter 1 for coil → catheter for stent → catheter 2 for coil



Stent placement

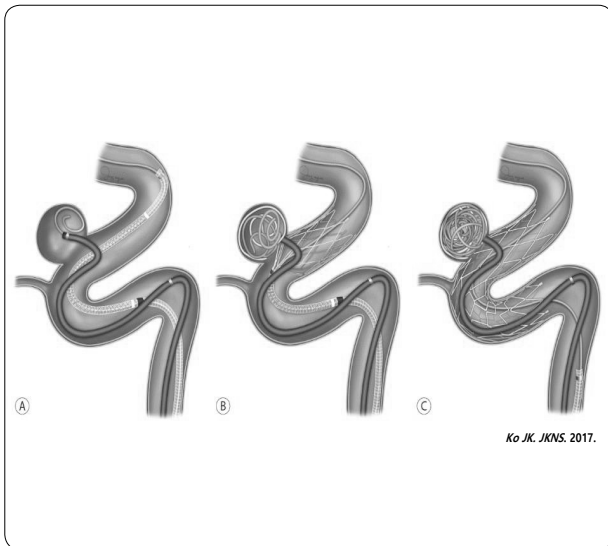


Basic Techniques of SAC

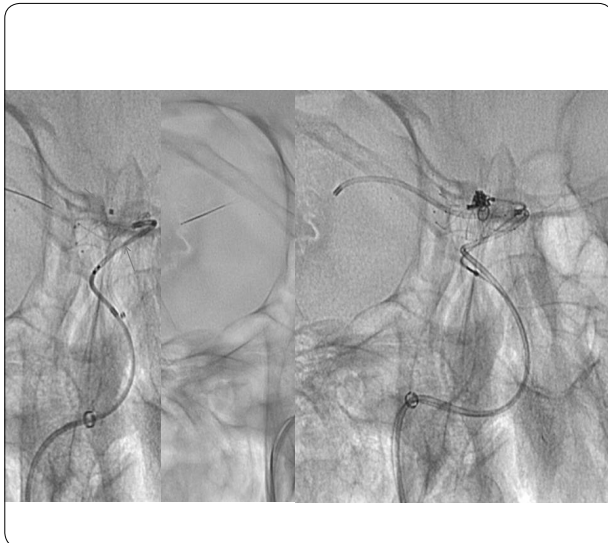
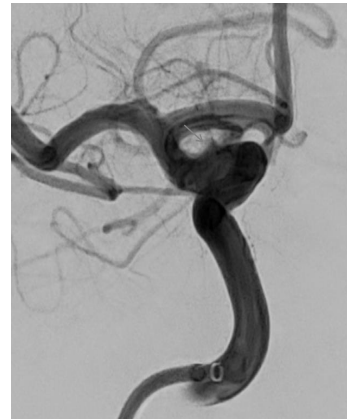
Deployment technique

Sequence of stent and catheter for coiling insertion

- Through-struts
- Jailing
- Semi-jailing or Stent-jack



F/55, right ICC2 blood-blister like aneurysm



Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

Y-configuration: through struts vs. parallel vs. non-overlapping

Waffle-cone

Stent + multi-catheter

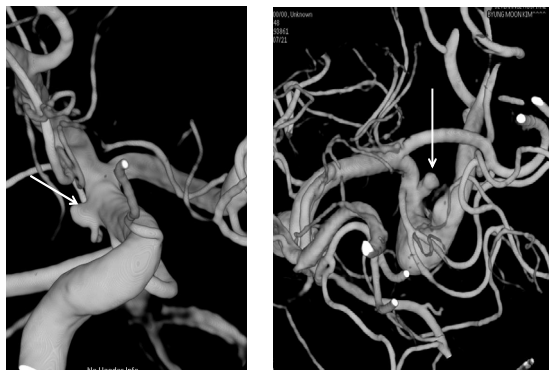
Balloon-in-stent

Overlapping stent (stent-within-stent)

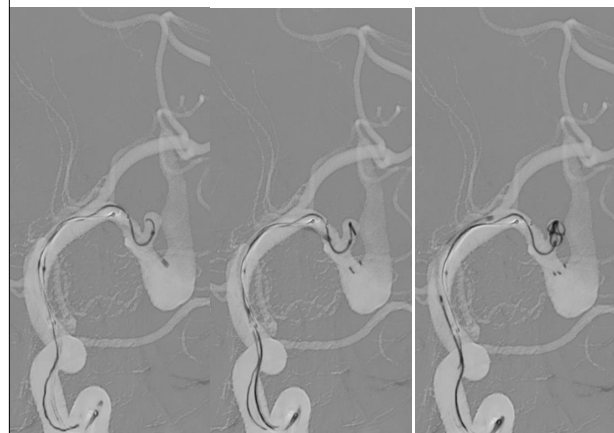
Temporary stenting

M/49, Rt AchoA, Lt MCA M2 saccular and fusiform aneurysms

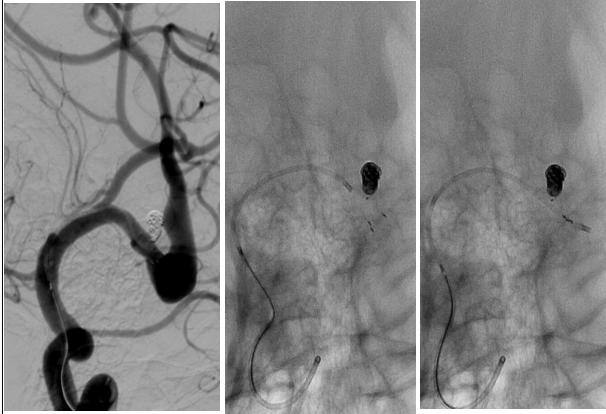
His son died due to aneurysmal SAH



Solitaire AB



Solitaire AB → resheathing



Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

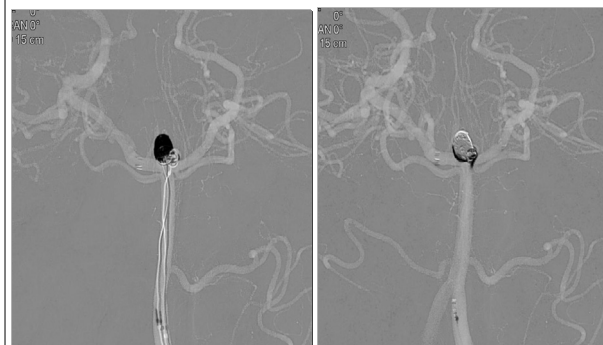
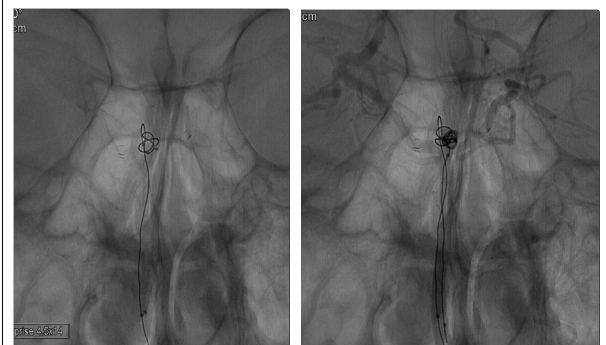
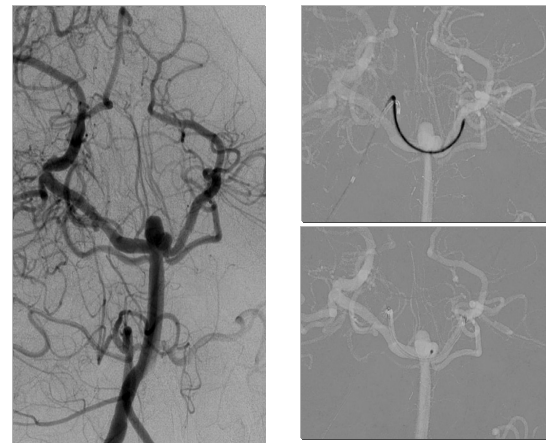
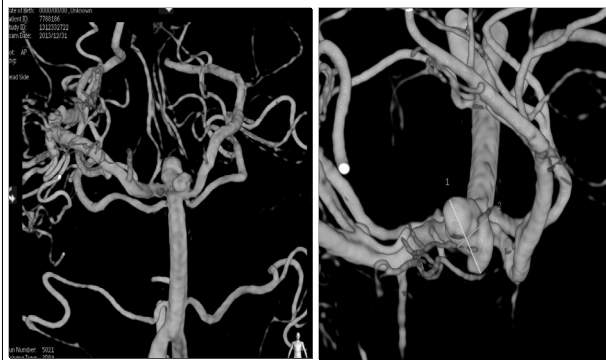
Y-configuration: through struts vs. horizontal vs. non-overlapping

Waffle-cone

Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)





Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

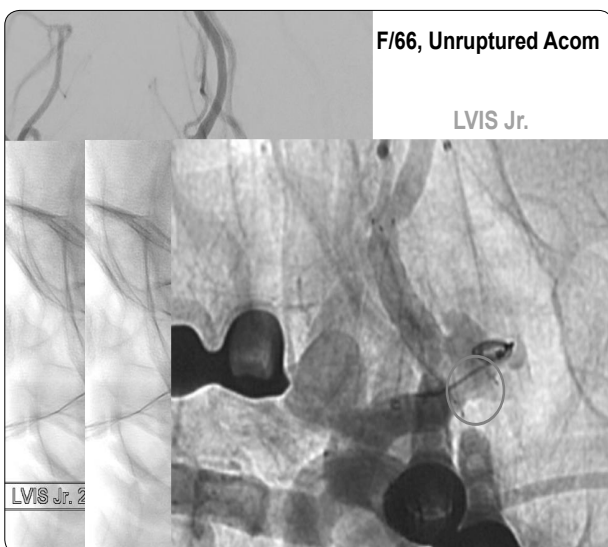
Y-configuration: through struts vs. parallel vs. non-overlapping

Waffle-cone

Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)



Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique: open-cell or braided stent

Y-configuration: through struts vs. horizontal vs. non-overlapping

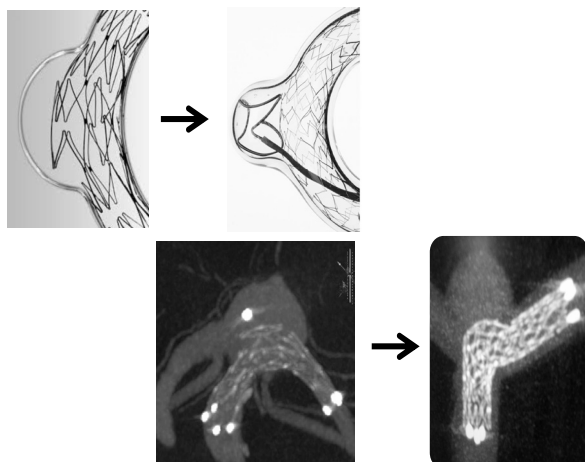
Waffle-cone

Stent + multi-catheter

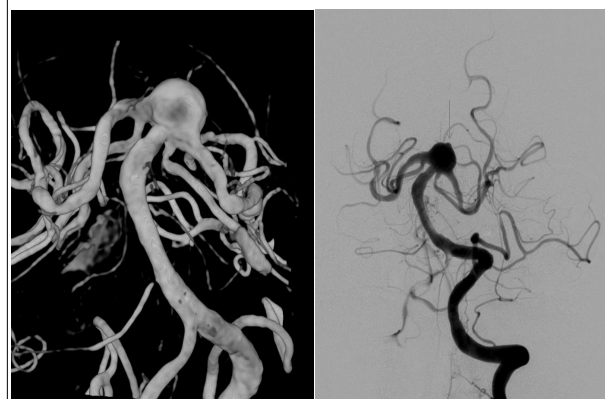
Balloon-in-stent

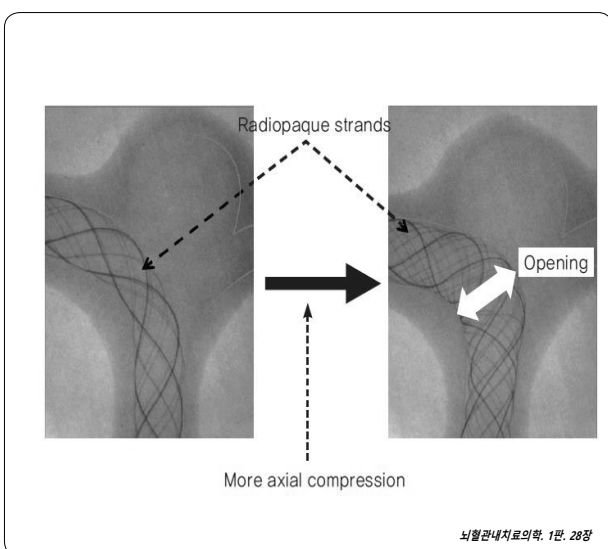
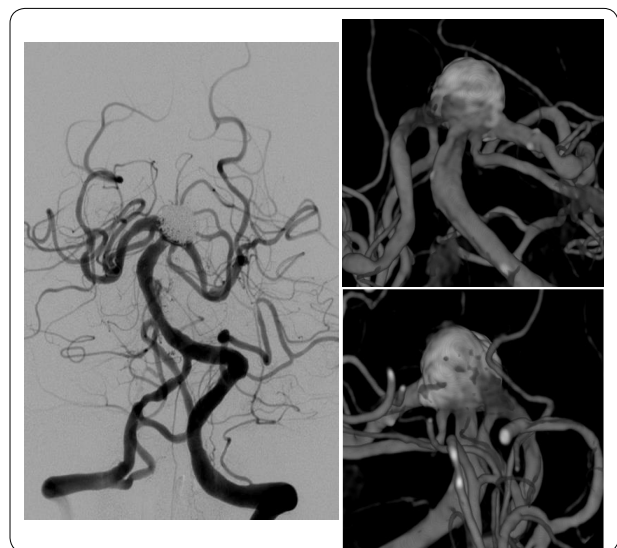
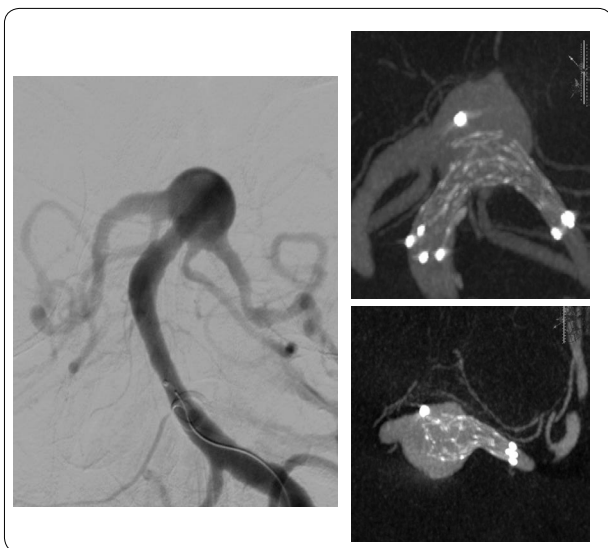
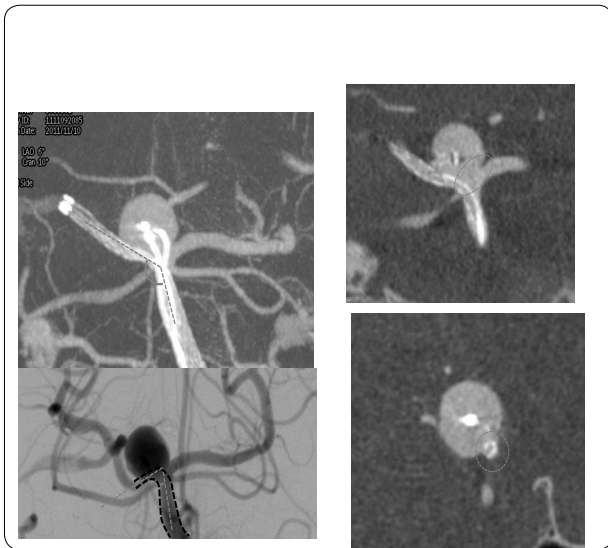
Overlapping stent (stent-within-stent)

Shelf technique – open cell stent

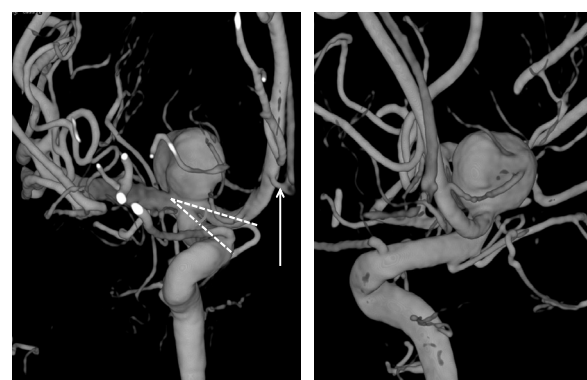


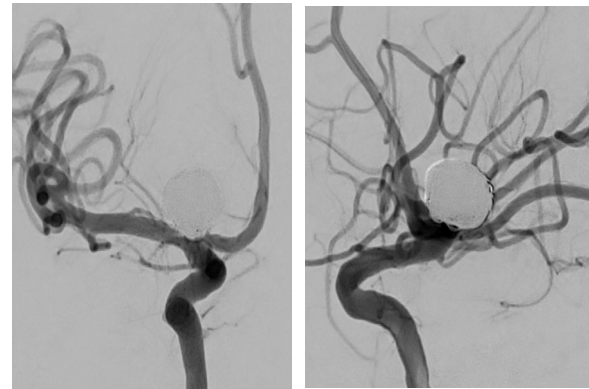
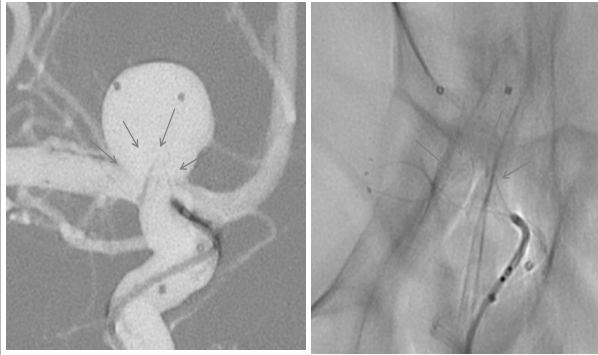
- Poor development of both posterior communicating arteries
- Hypoplastic Rt VA, tortuous bilateral VA with orifice stenosis
- About 11mm sized large aneurysm
(Neck, 11mm, Height 5.5mm, AP x lateral, 10.5 x 9mm)





F/51, large ICA bifurcation aneurysm, unruptured





Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

Y-configuration: through struts vs. parallel vs. non-overlapping

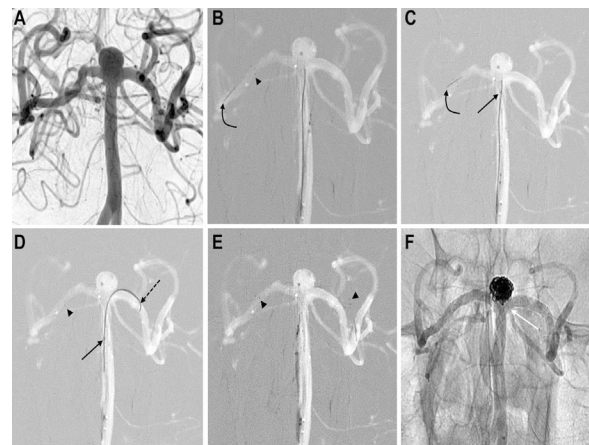
Waffle-cone

Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)

M/60s, BA bifurcation aneurysm, unruptured



Park KY and Kim BM. JNIS. 2019.

Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

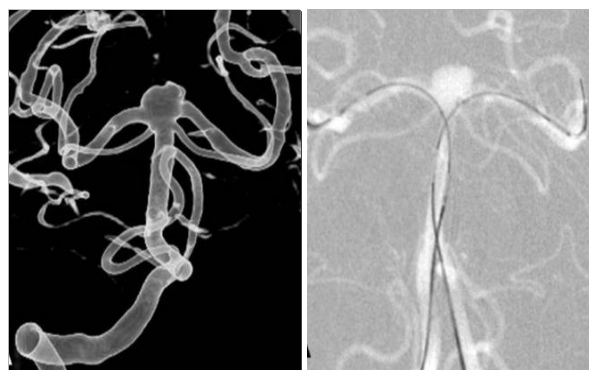
Y-configuration: through struts vs. parallel vs. non-overlapping

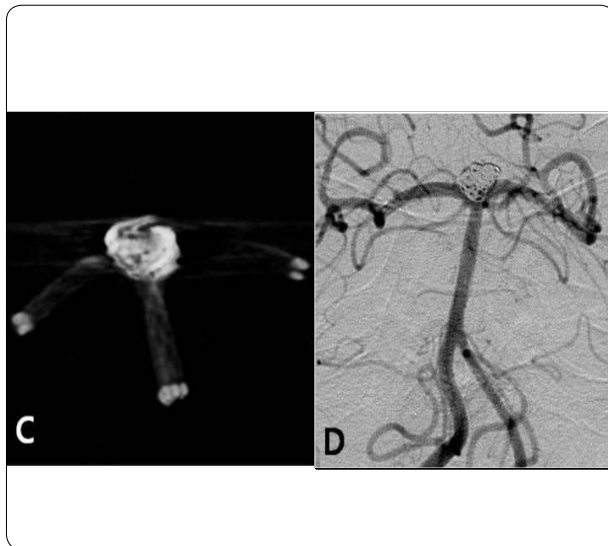
Waffle-cone

Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)





Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

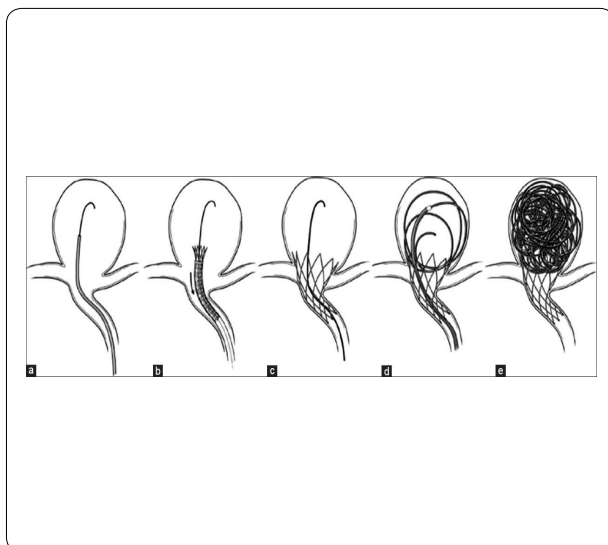
Y-configuration: through struts vs. horizontal vs. non-overlapping

Waffle-cone

Stent + multi-catheter

Balloon-in-stent

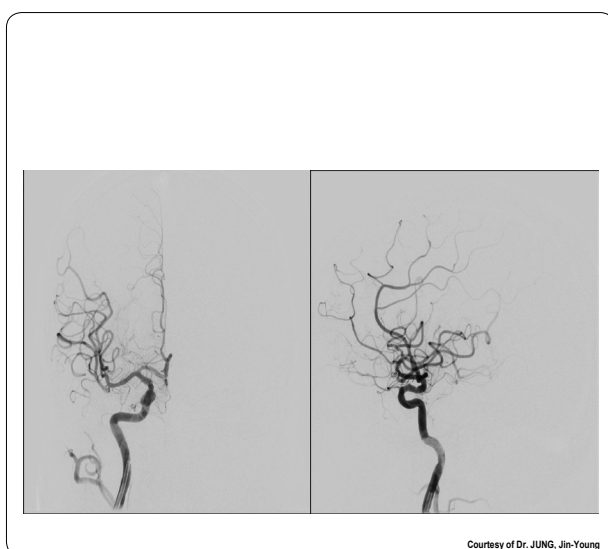
Overlapping stent (stent-within-stent)



F/65, MCA bifurcation aneurysm, unruptured



Courtesy of Dr. JUNG, Jin-Young



Courtesy of Dr. JUNG, Jin-Young

Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

Y-configuration: through struts vs. horizontal vs. non-overlapping

Waffle-cone

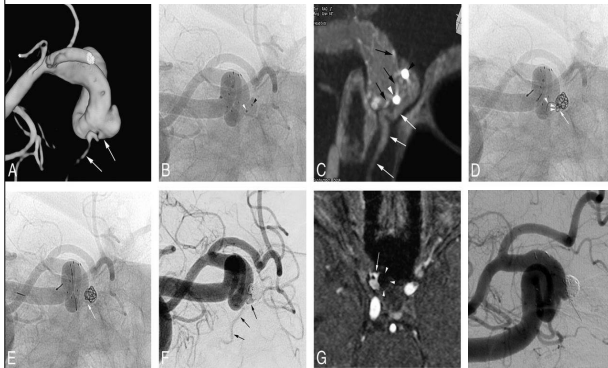
Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)

F/59, ICA-ophthalmic aneurysm, unruptured

Poor ECA collateral to ophthalmic artery



Jeon HJ and Kim BM. AJNR. 2016.

Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

Y-configuration: through struts vs. horizontal vs. non-overlapping

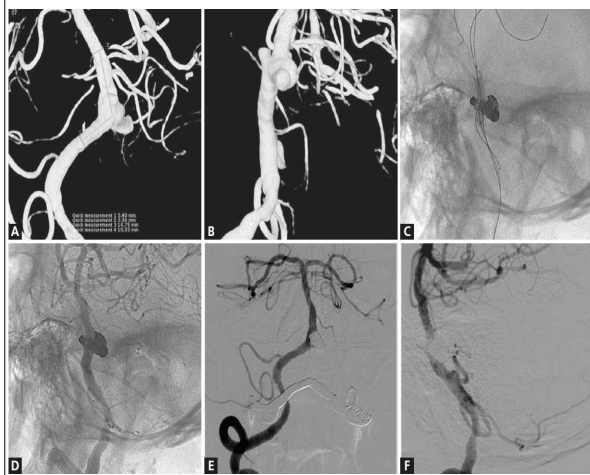
Waffle-cone

Stent + multi-catheter

Balloon-in-stent

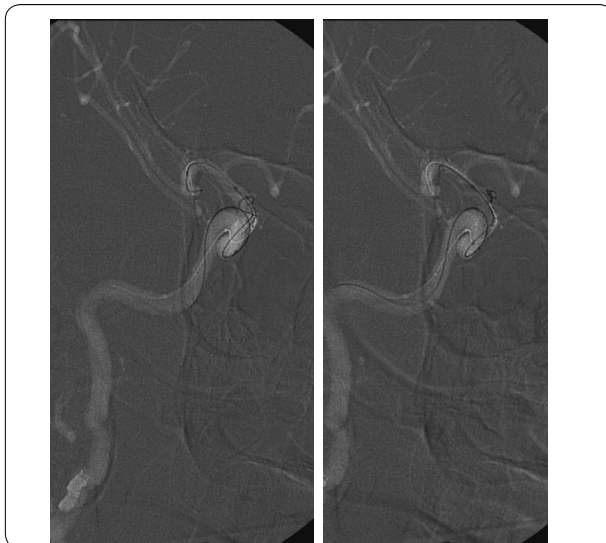
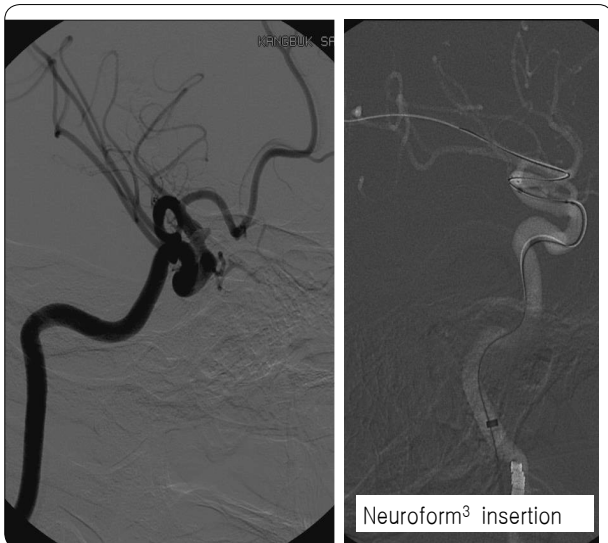
Overlapping stent (stent-within-stent)

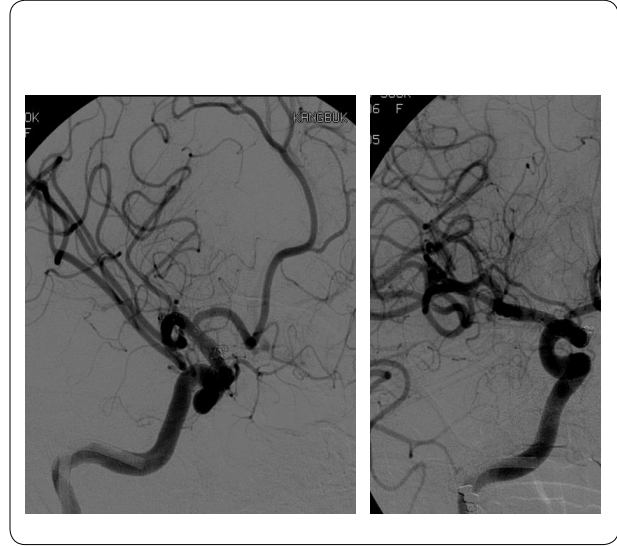
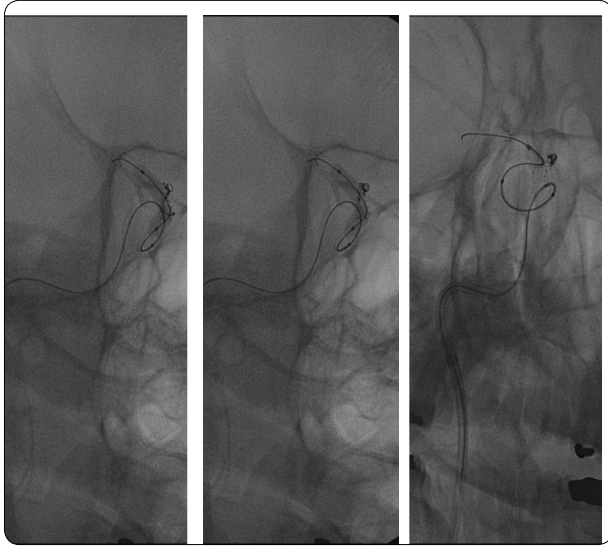
VB junction aneurysm, ruptured



뇌혈관내치료의학. 1판. 28장

ICA blood blister-like aneurysm





Advanced Techniques of SAC

Temporary

Trans-communicating: retrograde

Antegrade horizontal

Shelf technique

Y-configuration: through struts vs. horizontal vs. non-overlapping

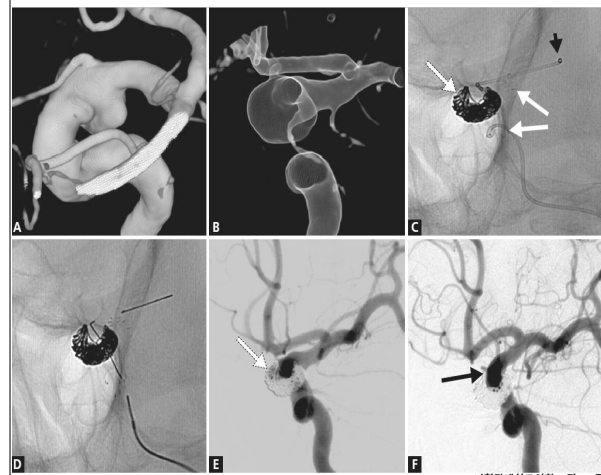
Waffle-cone

Stent + multi-catheter

Balloon-in-stent

Overlapping stent (stent-within-stent)

ICA-paraclinoid aneurysm, unruptured



뇌혈관내시료의학, 1판, 28장

Antiplatelets Preparation

AlBBS Am J Neuroradiol 2007 Oct 26;26(10):1774-82. Epub 2007 Sep 20.

Effect of antiplatelet therapy on thromboembolic complications of elective coil embolization of cerebral aneurysms.

Yamada NH*, Cross DT, Jost, Elmagr TK, Moran CJ, Dordick GP, Dacey RG Jr.
* Author information

Abstract

BACKGROUND AND PURPOSE: Thromboembolic events are the most common complications of elective coil embolization of cerebral aneurysms. Administration of oral clopidogrel and/or aspirin could lower the thromboembolic complication rate.

MATERIALS AND METHODS: Records over a 10-year period were reviewed in a retrospective cohort study. For 369 consecutive elective coil embolization procedures, 25 patients received no antiplatelet drugs, 86 received antiplatelet drugs only after embolization, and 258 received antiplatelet drugs before and after embolization.

RESULTS: Symptomatic thromboembolic complications (transient ischemic attack or stroke within 60 days) occurred in 4 (16%) of 25 when no antiplatelet drugs were given, in 6 (7%) of 86 when antiplatelet drugs were administered only after embolization, and in 6 (1.5%) of 258 when antiplatelet drugs were administered before and after embolization. The lower symptomatic thromboembolic complication rate in the patients who received any antiplatelet therapy was statistically significant ($P = .004$). Clots were visible intraprocedurally in 5 (4.5%) of 111 when no antiplatelet drugs were administered before procedures and in 4 (1.6%) of 258 when they were (P value not significant). None of the 9 was symptomatic postprocedurally, but 7 were lysed or mechanically disrupted. Extracerebral hemorrhagic complications occurred in 0 (0%) of 25 when no antiplatelet drugs were given and in 11 (3.2%) of 344 when they were (P value not significant).

CONCLUSION: Oral clopidogrel and/or aspirin significantly lowered the symptomatic thromboembolic complication rate of elective coil embolization of unruptured cerebral aneurysms. There were trends toward a lower rate of intraprocedural clot formation in patients given antiplatelet drugs before procedures and a higher hemorrhagic complication rate in patients given antiplatelet drugs. Benefits of antiplatelet therapy appear to outweigh risks.

Antiplatelets preparation is mandatory, especially in SAC.

Non-responsiveness to Clopidogrel

✓ 5 – 44 % of patients taking clopidogrel

Why & How?

• Initial form: Prodrug

• Only 15% can be metabolized by CYP in the liver

• Factors: Age, Co-morbidities, Co-medications, Genetic polymorphism

✓ Various assays to evaluate a platelet response

✓ No standardized definition or cut-off value regarding clopidogrel responsiveness

✓ Routine evaluation and modification: controversial

Antiplatelets Modification

High incidence of P2Y12 receptor antagonist poor-responder in Asia

Table 3. Primary and Secondary Outcomes of the Standard and Modified Preparation Groups

Variable	Modified Preparation, No. (%)	Standard Preparation, No. (%)	Crude Risk Difference, % (95% CI)	Adjusted Risk Difference, % (95% CI) ^a	P Value
Thromboembolic event, d					
≤7	1/63 (1.6)	7/63 (11.1)	-9.5 (-17.9 to -1.2)	-11.7 (-21.3 to -2.0)	.02
≤30 ^b	1/63 (1.6)	7/63 (11.1)	-9.5 (-17.9 to -1.2)	-11.7 (-21.3 to -2.0)	.02
Bleeding event	6/63 (9.5)	4/63 (6.3)	3.2 (-6.2 to -12.6)	5.6 (-4.2 to -15.4)	.26

Hwang G. JAMA Neurol. 2015.

The thromboembolic event rate was low in the modified preparation group (1 of 63 [1.6%]) compared with the standard preparation group (7 of 63 [11.1%]; adjusted risk difference, -11.7% [95%CI, -21.3%to -2.0%]; P = .02).

Antiplatelets Modification

✓ How Modification?

1. Dose Up

2. Triple

3. Prasugrel, Ticagrelor

Heterogeneous practice patterns regarding antiplatelet medications for neuroendovascular stenting in the USA: a multicenter survey

Ryan W F Faught¹, Sudhakar R Satti², Robert W Hurst³, Bryan A Pukenas³, Michelle Janine Smith¹

Specific point of care assessments utilized

Test	No %
VerifyNow P2Y12 assay (Accumetrics)	36 (76.6)
VerifyNow ASA Reaction (Accumetrics)	13 (27.7)
"I don't know"	7 (14.9)
Light transmission (Born) aggregometry (LTA)	3 (6.4)
Other ^a	2 (4.3)
VASP assay (Biocytex and Stago)	0 (0)

^a *Other: Test both Plavix and ASA platelet inhibition (n=1); Haemonetics thromboelastogram with platelet mapping (n=1).

Faught RW, et al. J Neurointerv Surg. 2014

Changes to medical management for Plavix non-responders, as determined by point of care testing

Action	Responses (No C/D)	Specific action
Double dose	22 (43.1)	Prasugrel (n=1) Did not specify medication (n=8) Augment with IV Abciximab (n=3) Augment with intracranial A.abciximab (n=1) Aggrenox (n=1)
Change medication	19 (37.3)	
Re-bolus with Plavix 600 mg and recheck	3 (5.88)	
Ticagrelor alone	1 (1.96)	For PED cases
Ignore and track outcomes	1 (1.96)	
Answer is not clear for neuroendovascular patients. A PRU <200 is associated with fewer adverse events in coronary stent population	1 (1.96)	Action not specified
Depends on inhibition testing	1 (1.96)	If inhibition is <20% Plavix 75 mg daily and repeat test in 4-7 days. If inhibition is 20-40% add Plavix 75 mg every other day, repeat P2Y12 test in 7 days
Double dose and change medication	1 (1.96)	Will often 'double dose' Plavix and recheck with VerifyNow, if PRU still >200, will switch to Effient
Neuroform and Enterprise goal of PRU >10 and PRU <200, PED goal of PRU 50-150	1 (1.96)	Action not specified
Increase dose, retest, and/or change medication and retest	1 (1.96)	If close to therapeutic, increase Plavix dose and retest after 1-2 weeks; if little response to Plavix then switch to prasugrel 10 mg daily and retest after 1-2 weeks

Faught RW, et al. J Neurointerv Surg. 2014

Multiple Antiplatelets: How long?

✓ Undefined in Neurovascular Field

✓ Experience in Coronary

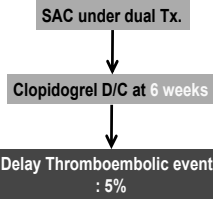
Incidence of cerebral ischemic events after discontinuation of clopidogrel in patients with intracranial aneurysms treated with stent-assisted techniques

Clinical article

^aJAMES D. ROSSEN, M.D.,² NOBIRA CHALOUH, M.D.,² SHAFIK N. WASSER, M.D.,^{1,4,5} JACOB THOMAS, B.S.,² TAYLOR J. ABEL, M.D.,² PASCAL M. JABBOUR, M.D.,² DAVID K. KUNG, M.D.,² AND DAVID M. HASAN, M.D.²

¹Departments of Neurosurgery and Internal Medicine, Division of Cardiovascular Medicine, University of Iowa, Iowa City, Iowa; ²Department of Neurological Surgery, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania; ³McConnell Brain Imaging Centre, Montreal Neurological Institute and Hospital; and ⁴Department of Neurology and Neurosurgery, McGill University, Montreal, Quebec, Canada

J Neurosurgery. 2012.



Multiple Antiplatelets: How long?

J Stroke Cerebrovasc Dis. 2014 Apr 23;4(7):1-7. doi: 10.1016/j.jstrokecerebrovasdis.2013.07.008. Epub 2013 Aug 15.

Onset Time of Ischemic Events and Antiplatelet Therapy after Intracranial Stent-assisted Coil Embolization.

Matsumoto Y¹, Nakai K², Tsutsumi M³, Ito M⁴, Niki K⁵, Naito S⁶, Eto A⁷, Mitohata T⁸, Aikawa H⁹, Kazekawa K⁵.

Author information

Abstract

BACKGROUND: Stent-assisted coil embolization is effective for intracranial aneurysms, especially wide-necked aneurysms, however, the optimal antiplatelet regimens for ischemic events that develop after coil embolization have not yet been established. We aimed to determine the onset time of such postoperative ischemic events and the relationship between these events and antiplatelet therapy.

METHODS: We performed coil embolization using a vascular reconstruction stent for 43 cases of intracranial aneurysms and evaluated the incidence of postoperative ischemic events in these cases.

RESULTS: Nine patients showed postoperative ischemic events during the follow-up period (13 ± 7 months). Two patients developed cerebral infarction within 24 hours. Five patients developed transient ischemic attack within 40 days while they were receiving dual antiplatelet therapy. In addition, 1 patient showed cerebral infarction 143 days postoperatively during single antiplatelet therapy, and a case of transient visual disturbance was reported 191 days postoperatively (49 days after antiplatelet therapy had been discontinued). We increased the number of antiplatelet agents in 4 of these patients. The other 5 patients were under strict observation with dual antiplatelet therapy. All these patients were shifted to single antiplatelet therapy 3-13 months postoperatively. No recurrence of ischemic events was noted.

CONCLUSIONS: Postoperative ischemic events are most likely to occur within 40 days postoperatively. For patients with postoperative ischemic events, additional ischemic events can be prevented by increasing the number of antiplatelet agents; subsequently, they can be shifted to single antiplatelet therapy after the risk of recurrence has decreased.

Multiple Antiplatelets: How long?

Radiology. 2014 Oct;273(1):194-201. doi: 10.1148/radiol.14140070. Epub 2014 Jun 11.

Delayed ischemic stroke after stent-assisted coil placement in cerebral aneurysm: characteristics and optimal duration of preventative dual antiplatelet therapy.

Hwang G¹, Kim JG, Song KS, Lee YJ, Villavicencio JB, Suroto NS, Park NM, Park SJ, Jeong EA, Kwon OK.

@ Author information

Abstract

PURPOSE: To evaluate characteristics of delayed ischemic stroke after stent-assisted coil placement in cerebral aneurysms and to determine the optimal duration of dual antiplatelet therapy for its prevention.

MATERIALS AND METHODS: This retrospective study was approved by the institutional review board, and the requirement to obtain written informed consent was waived. Of 1579 patients with 1661 aneurysms, 395 patients (25.0%) with 403 aneurysms (24.3%) treated with stent-assisted coil placement were included and assigned to groups stratified as early (126 patients [31.9%]; 3 months of coil placement), midterm (160 patients [40.5%]; 6 months), or late (109 patients [27.6%]; ≥ 9 months), according to the time points of switching dual antiplatelet therapy to monotherapy from coil placement. Cumulative rates of delayed ischemic stroke in each group were calculated by using Kaplan-Meier estimates that were compared with log-rank tests. Risk factors of delayed ischemic stroke were identified by using Cox proportional hazard analysis.

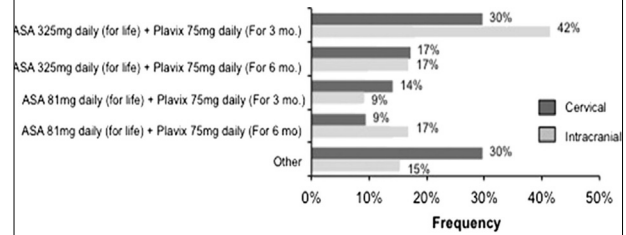
RESULTS: Delayed ischemic stroke occurred in 3.5% of all cases (embolism: 3.0%, thrombotic occlusion: 0.5%) within 2 months following the switch. Late switch yielded no delayed ischemic stroke, unlike early (seven of 126 patients [5.6%]; $P = .013$) or midterm (seven of 160 patients [4.4%]; $P = .028$) switch. Incomplete occlusion (hazard ratio, 6.68 [95% confidence interval: 1.490, 29.900]) was identified as a risk factor.

CONCLUSION: Delayed ischemic stroke after stent-assisted coil placement is caused by embolism from or thrombotic occlusion of stent-containing vessels after switching from dual antiplatelet therapy to monotherapy. The stent-containing vessel with incomplete aneurysm occlusion presents as a long-term thromboembolic source. Therefore, dual antiplatelet therapy for more than 9 months and late switch to

Bleeding: 1%

Heterogeneous practice patterns regarding antiplatelet medications for neuroendovascular stenting in the USA: a multicenter survey

Ryan W F Faught¹, Sudhakar R Satti², Robert W Hurst³, Bryan A Pukenas³, Michelle Janine Smith¹



Faught RW, et al. J Neurointerv Surg. 2014

Stent-assisted Coiling

Increasing of its usage

- ✓ **Procedure: Simple and Easy**
- ✓ **Knowledge of stent & antiplatelets ↑↑**

Summary

1) Stents

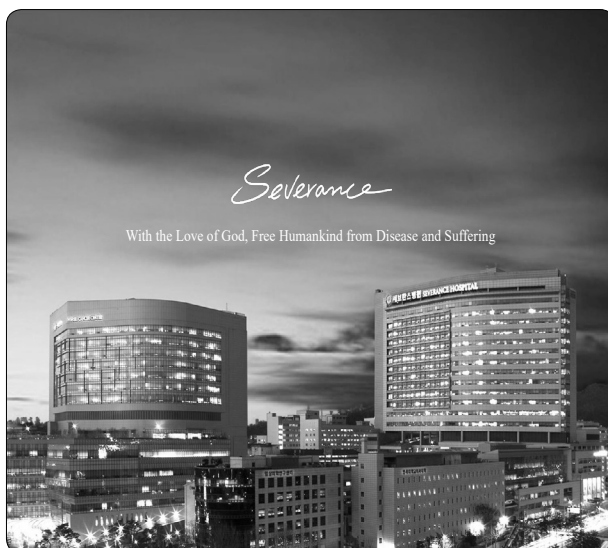
- ✓ Laser cutting vs Wire braiding
- ✓ Open cell vs Closed cell

2) Basic Techniques of SAC

- ✓ Deployment
- ✓ Laser cutting vs Wire braiding

3) Advanced Techniques of SAC

- ✓ Various, combined
- ✓ Low-profile stents

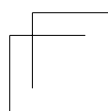
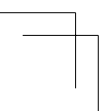
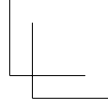
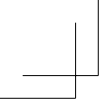


MEMO //////////////////////////////////////

Management of complications - including perioperative rupture, thrombus formation

윤 원 기

고려대 구로병원



COMPLICATION MANAGEMENT IN COIL EMBOLIZATION PROCEDURE

Wonki Yoon, MD, PhD
Korea University, Seoul, Korea

CONTENTS

- Access Site Complication
- Intraoperative Aneurysm Rupture
- Thromboembolic Event
- Prevention
- Management

ACCESS SITE COMPLICATION

- Minor hematoma > 5%
 - Major hematoma requiring surgical therapy < 0.5%
 - AVF 0.05%
 - Pseudoaneurysm 0.01%
 - Vessel thrombosis 0.1%
 - Neuritis
 - Infection
- Primer of Diagnostic Imaging (Fifth Edition) 2011

Groin Hematoma

- Risk factor – obesity, anticoagulation, large sheath, premature ambulation, peripheral vascular disease
- Poor hemostatic technique – compression on the site of skin incision
- Short duration of compression
- Management – additional compression, reversal of anticoagulation



Cardiac Intensive Care (Second Edition), 2010

Retroperitoneal Hematoma

- Diagnosis
 - Challenging – high level of suspicion
 - Obesity, uncontrolled hypertension, high femoral puncture, unguided femoral puncture, multiple femoral puncture attempts
 - Signs – hypotension, diaphoresis, lower abdominal or back pain, bradycardia, tenderness on abdominal or suprapubic area
 - Within 3hrs of procedure
 - Vascular closure device – does not exclude possibility of retroperitoneal hematoma

Femoral artery Pseudoaneurysm

- Cause – superficial femoral artery puncture, inadequate hemostasis
- Signs – increasing hematoma
- Diagnosis – ultrasonography, angiography
- Treatment – US guided compression, thrombin injection, Stent, Coil, Surgery



Prevention

- Prevention
 - Anatomical Knowledge
 - Technique of Access – Ultrasound guided, landmark femoral head
 - Hemostasis method
 - Distal pulsation monitoring

IAR (INTRAOPERATIVE ANEURYSM RUPTURE)

- Frequency 1-5%
- vs. clip
 - Less frequent but poorer prognosis
 - 40% poor outcome

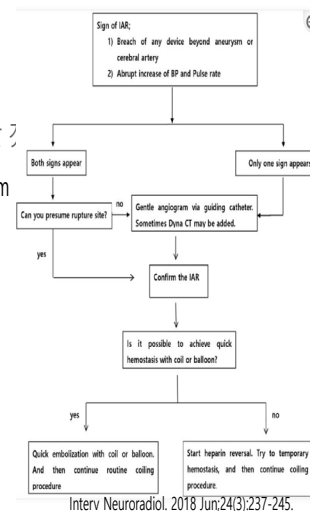
Factors associated with IAR

- Microinstrument
 - Microwire / Coil / Microcatheter
- Packing density, Coil oversize
- Smaller aneurysm
- A-com aneurysm
- Use of balloon – controversial
- Vascular tortuosity
- Local anesthesia

Neurointerv Surg-2017
Am J Neuroradiol 2012; 33: 2017-2021
Stroke 2008; 39: 2776-2782
J Neurointerv Surg 2013; 5: iii56-iii61
Neurosurgery 2011; 68: 731-737

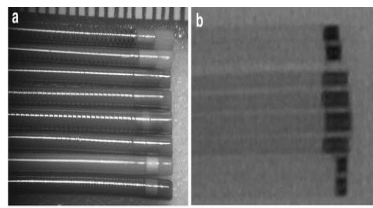
Management

- Mindset- 절대로 카테터 빼지 말 것
- Continuing packing - mushroom
- Blood Pressure
- Proximal Occlusion
- Temporary Balloon occlusion
- Adenosine
- Rapid ventricular pacing
- Protamine sulfate



Prevention of IAR

- Aneurysm Selection
 - Catheter selection vs Wire selection
 - Position of catheter tip
- Coil packing
 - Size of framing coil
 - Backward pressure
 - When to stop
 - Swaying of catheter
 - Back support of catheter



Neuroradiology, volume 50, pages423-427 (2008)

TEC (THROMBOEMBOLIC COMPLICATION)

- 2-15%
- More frequent than IAR
- Difficult to detect/ascertain TEC
 - Vigorous analysis of angiography
 - Postop. Diffusion MRI
- Guiding catheter
- Coil meshes
- Air embolism
- Atheroma dislodge
- Lack of coaxial fluid
- Hypercoagulable state, vasospasm (ruptured an.)
- Heparin induced thrombocytopenia
- Antiphospholipid-antibody syndrome
- Large aneurysm

Prevention

- Systemic heparinization, sufficient coaxial fluid mixed with heparin
- ACT monitoring – unresponsive to heparin
- Perioperative antiplatelet
 - Resistance test – switch from clopidogrel to ticagrelor or prasugrel , add antiplatelet
- Working angle
- Vascular Anatomy, Reference Image
- Avoidance of Excessive manipulation

Management

- Medical
 - Fibrinolytics (Urokinase, t-PA)
 - GpIIb/IIIa receptor antagonist (reopro, tirofiban)
 - Nitroglycerin, nimodipine
- Mechanical
 - Stent
 - Balloon
 - Suction aspiration, Stentriever
- Surgery

MEMO //////////////////////////////////////

MEMO //////////////////////////////////////

Basic NeuroEndovascular Training Course 2 (BNET Course)

인 쇄: 2023년 4월 5일

발 행: 2023년 4월 8일

발행처: 대한뇌혈관내치료의학회

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Tel_02-2279-9560 / E-mail_kones@konesonline.or.kr

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회 장: 장철훈

부회장: 권순찬

총 무: 김영우

수련교육: 김태곤, 박중철

optima™ coil system

optimal design,
optimal detachment

Distributed by: **TaeWoong**
MEDICAL 

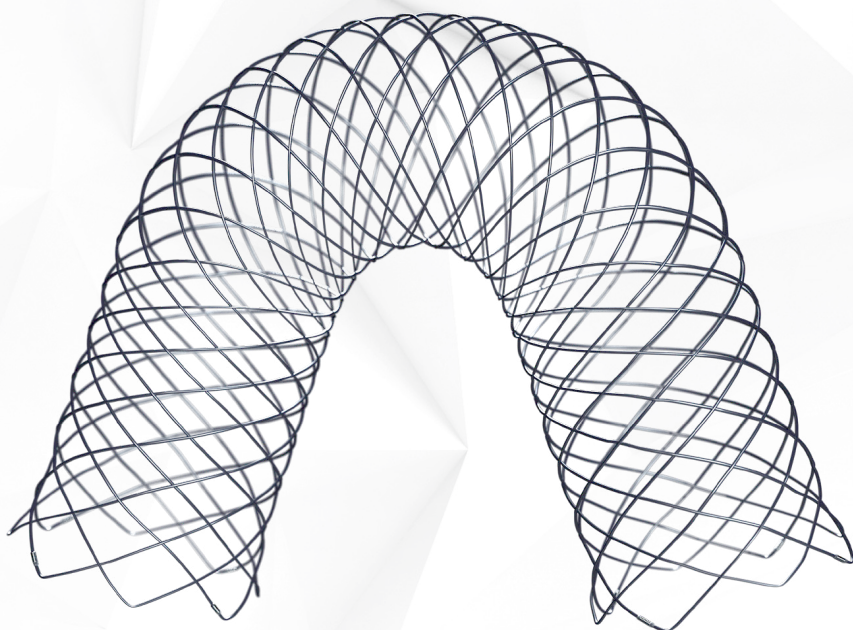
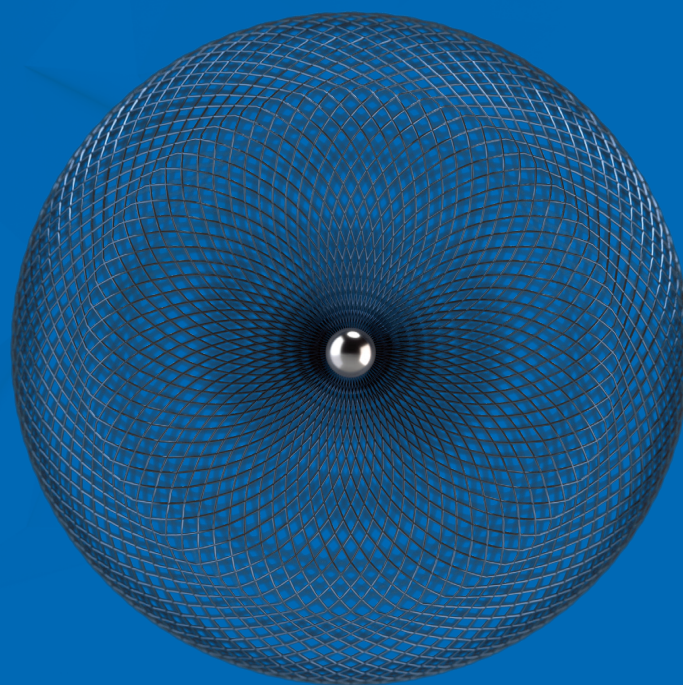
Optima Coil System is manufactured by Balt USA, 29 Parker, Irvine, CA 92618. The Optima Coil System is intended for the endovascular embolization of intracranial aneurysms and other neurovascular abnormalities such as arteriovenous malformations and arteriovenous fistulae. The Optima Coil System is also intended for vascular occlusion of blood vessels within the neurovascular system to permanently obstruct blood flow to an aneurysm or other vascular malformation and for arterial and venous embolizations in the peripheral vasculature. The content of this document, in particular data, information, trademarks and logos are BALT S.A.S and affiliates' sole property. Consequently, all representation and/ or reproduction, whether in part or in full, is forbidden and would be considered a violation of BALT S.A.S and affiliates' copyrights and other intellectual proprietary rights ©2018 BALT S.A.S and affiliates all rights reserved. This document with associated pictures are non-contractual and are solely dedicated to healthcare professionals and BALT S.A.S and affiliates' distributors. The products commercialized by BALT S.A.S and affiliates shall exclusively be used in accordance with the package inserts which have been updated and included in the boxes. Optima Coil System is Class III CE marked (DQS CE0297) according to the Medical Device Directive 93/42/EEC Annex II Section 4 since July 2017 (535003 W). (05/2018).

 **balt**
inspiring innovation

WEB™

Aneurysm Embolization System

**LEADING THE WAY IN
INTRASACULAR
FLOW DISRUPTION**



LVIS™ EVO™

Intraluminal Support Device

**SEEING IS
BELIEVING**



Indications for Use:

The LVIS EVO device is intended for use with embolic coils for the treatment of intracranial neurovascular diseases.

The WEB Aneurysm Embolization System is intended for the endovascular embolization of ruptured and unruptured intracranial aneurysms and other neurovascular abnormalities such as arteriovenous fistulae (AVF). The WEB Aneurysm Embolization System is also intended for vascular occlusion of blood vessels within the neurovascular system to permanently obstruct blood flow to an aneurysm or other vascular malformation. The device should only be used by physicians who have undergone training in all aspects of the WEB Aneurysm Embolization System procedures as prescribed by Sequent Medical, Inc.

The VIA™ Catheter is intended for the introduction of non-liquid interventional devices (such as coils/stents/flow diverters) and infusion of diagnostic (such as contrast media) or non-liquid therapeutic agents into the neuro, peripheral, and coronary vasculature.

For Healthcare Professional Intended Use Only. Please refer to IFU for the full list of risks, contraindications, warnings, and precautions.

RX Only: Federal law restricts this device to sale by or on the order of a physician.

Class III - CE0297

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