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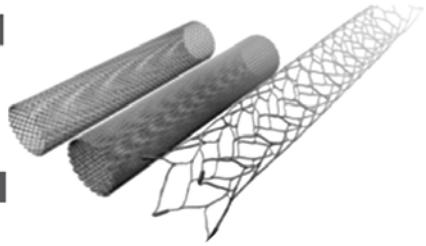
ENDOVASCULAR NERUOSURGICAL SYMPOSIUM UPDATE on CBF REDIRECTING ENDOPROSTHESIS

ENSURE



FLOW DIVERTERS FOR CEREBRAL ANEURYSM

뇌동맥류 혈류전환유도 스텐트 심포지엄 및 대한뇌혈관내수술학회 2019 추계보수교육

일시 | 2019년 9월 28일(토)

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주관 | 대한신경외과학연구재단

평점 | 6점

ENSURE 2019 인사말

존경하는 대한뇌혈관내수술학회 회원 여러분!

2019년 2월 성황리에 진행되었던 "뇌졸중 재개통 심포지엄(ARCS) 및 대한뇌혈관내수술학회 춘계보수교육"에 이어 9월에는 "뇌동맥류 혈류전환유도 스텐트 심포지엄(ENSURE) 및 대한뇌혈관내수술학회 추계보수교육"이 개최 됩니다. 뇌동맥류 혈류전환유도 스텐트(Flow-Diverter)의 국내 임상 적응증이 미파열 대형 또는 거대동맥류, 그리고 일부 추골동맥의 박리성동맥류 등에 국한되어 있기에 일반적인 동맥류에 비해 접할 기회가 적고 아직까지도 혈류전환유도 스텐트 시술과 관련된 장,단기 합병증들이 무시할 수 없을 정도로 보고되고 있기에 고식적인 뇌혈관내수술치료를 고집하는 경향도 존재합니다. 이에 저희 학회에서는 지난 10여년간 뇌동맥류 혈류전환유도 스텐트를 사용하면서 축적한 회원들의 임상경험을 공유하고 이와 관련된 기초지식과 최근까지 발표되었던 연구들을 되짚어 보며 "ENSURE flow diverters for cerebral aneurysm" 할 수 있는 소중한 시간을 가지려고 하오니 이 분야를 담당하고 계시는 분들의 많은 참여와 열띤 토론을 부탁 드립니다.

이번 추계보수교육을 통해서 flow-diverter에 대한 충분한 지식을 습득하고 이를 통해 향 후 회원 여러분들의 임상적용에 많은 도움이 될 수 있기를 기대하면서 "뇌동맥류 혈류전환유도 스텐트 심포지엄(ENSURE) 및 대한뇌혈관내수술학회 2019 추계보수교육"을 꼼꼼히 준비해주신 수련교육이사님과 도움주신 상임이사님들께 깊이 감사 드립니다.

대한뇌혈관내수술학회 회장 **고 준 석**

2018–2019 대한뇌혈관내수술학회 임원진

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제9대	김범태	순천향대학교 부천병원
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ENSURE

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08:30–09:15	Registration		
09:15–09:30	Course Introduction	**권순찬** (대한뇌혈관내수술학회 수련교육이사)	
	Opening Remark	**고준석** (대한뇌혈관내수술학회 회장)	
	Welcoming Address	**오창완** (대한신경외과학회 이사장)	
SESSION I. Overview		**좌장: 성재훈** (가톨릭대), **장인복** (한림대)	
	1. Pathogenesis and natural history of unusual aneurysm		
09:30–09:50	A. Dissecting aneurysms	**권오기** (서울대)	11
09:50–10:10	B. Giant thrombosed aneurysm	**고준경** (부산대)	12
10:10–10:30	**2.** Dynamic blood flow analysis with aneurysmal CFD study	**김용배** (연세대)	13
10:30–10:50	**3.** Endovascular role of flow-diverter & its world-wide indication	**권순찬** (울산대)	14
10:50–11:10	Coffee Break		
SESSION II. Flow-diverter for 10 years, what did we learn?		**좌장: 정진영** (연세에스병원), **신승훈** (차의과학대)	
	1. Review of recent trial for flow diversion		
11:10–11:30	A. Pros.	**권현조** (충남대)	21
11:30–11:50	B. Cons.	**김택균** (서울대)	28
11:50–12:05	**2.** Flow diversion beyond the circle of Willis	**박석규** (순천향대)	34
12:05–12:20	**3.** Evolving flow-diverters and its supporting devices	**김대원** (원광대)	36
12:20–13:30	Photo time & Lunch		
	4. Parallel hands on training with vessel model		
SESSION III. Practical tactics & pitfalls of cerebral flow-diverter		**좌장: 김범태** (순천향대), **장철훈** (영남대)	
13:30–13:50	**1.** Flow-diverter for anterior circulation aneurysm	**신용삼** (가톨릭대)	39
13:50–14:10	**2.** Flow-diverter for posterior circulation aneurysm	**강현승** (서울대)	40
14:10–14:25	**3.** How to prevent and get out of complications due to FD	**김성림** (가톨릭대)	44
14:25–14:40	**4.** How to do? medication & imaging follow-up for FD	**김태곤** (차의과학대)	45
14:40–15:00	Coffee Break		
SESSION IV. Round table panel discussion, How I do it?		**좌장: 윤석만** (순천향대), **임용철** (아주대)	
15:00–16:30	Panel: **이창영** (계명대), **신용삼** (가톨릭대), **권오기** (서울대), **김성림** (가톨릭대), **강현승** (서울대)		
15:00–15:15	**1.** Unruptured basilar fusiform aneurysm, How I do it?	**임종국** (제주대)	53
15:15–15:30	**2.** A giant aneurysm on vertebrobasilar junction: How I do it?	**신희섭** (경희대)	54
15:30–15:45	**3.** Endovascular treatment using coil versus flow diverter stent for vertebrobasilar aneurysm	**이종영** (한림대)	55
		지정토론: 정진영 (연세에스병원)	
15:45–16:00	**4.** Parent artery occlusion for giant intracranial aneurysm in a 11-year-old girl	**김영우** (가톨릭대)	56
16:00–16:15	**5.** Endovascular treatment of ruptured fusiform aneurysm of the basilar artery	**김대원** (원광대)	57
16:15–16:30	**6.** Multi-session endovascular treatment of ruptured recurrent M1 dissecting aneurysm	**이재일** (부산대)	58
16:30–	Closing Remark	**고준석** (대한뇌혈관내수술학회 회장)	

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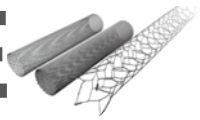

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SESSION I. Overview

좌장: 성재훈 (가톨릭대), 장인복 (한림대)

1. Pathogenesis and natural history of unusual aneurysm	
A. Dissecting aneurysms	권오기 (서울대)
B. Giant thrombosed aneurysm	고준경 (부산대)
2. Dynamic blood flow analysis with aneurysmal CFD study	김용배 (연세대)
3. Endovascular role of flow-diverter & its world-wide indication	권순찬 (울산대)

1. Pathogenesis and natural history of unusual aneurysm
A. Dissecting aneurysms

권오기 (서울대)

1. Pathogenesis and natural history of unusual aneurysm
B. Giant thrombosed aneurysm

고준경 (부산대)

거대 뇌동맥류는 뇌내 동맥류의 약 5%를 차지하고, 40세에서 70세 사이에 증상이 나타나며 여성 우세의 빈도를 보인다. 소아 인구에서 거대 동맥류 비율은 성인 인구보다 더 높다. Saccular, fusiform 그리고 serpentine 으로 분류되는 거대 뇌동맥류의 자연사는 혈전증, 성장, 파열로 특징지어진다. 이 거대 동맥류의 병인은 유전적 변수를 포함한 많은 위험 인자에 의해 영향을 받는다. 이러한 거대 동맥류는 작은 동맥류와 같은 위치에서 발생할 수 있지만, cavernous location을 선호하는 결과가 관찰되었다. 거대 동맥류의 증상은 그들의 위치에 의존하는 mass effect 또는 파열에 의해 야기된다; 허혈성 징후는 매우 드물다. 거대 동맥류의 연간 파열률은 전방순환계 8%, 후방순환계 10% 정도로 보고된다. 치료되지 않은 환자의 나쁜 결과는 치료의 위험을 정당화한다. 이러한 동맥류의 치료는 단일 팀으로 대응해서는 안되며 환자의 임상 상태, 특히 나이, 동맥류의 크기 및 위치에 따라 결정해야 한다. 이 치료 전략은 morbidity가 가장 낮은 치료법을 선택하기 위해 높은 수준의 다원적 논의를 거친 후에만 확립될 수 있다.

2. Dynamic blood flow analysis with aneurysmal CFD study

김용배 (연세대)

It is generally believed that the initiation, growth, and rupture of intracranial aneurysms result from bio-mechanical interaction between exo-vascular environment and endo-vascular hemodynamics. To date, the best way to obtain information about the intracranial vasculature is mainly to rely on catheter angiography. However, it provides only structural understanding, not hemodynamic factors. One of the ways to simulate and analyze hemodynamic factors is to utilize computational fluid dynamics (CFD) tools, which provide an effective and safe method to assess velocity magnitude, fluid streamlines, wall shear stress (WSS) distribution, and oscillatory shear index (OSI). Since the current technology limits the ability to measure these hemodynamic factors in vivo, the CFD simulation studies are valuable in the exploration of the cerebral vascular system. The reasons for aneurysm initiation, growth, and rupture are complicated and are still not well understood. Generally, it is recognized that hemodynamics play a key role in these processes. Ideas about aneurysm growth and rupture can generally be divided into two theories: high flow theory and low flow theory. The high flow theory speculates that high wall shear stress (WSS) and high flows cause endothelial injury and thus initiate wall remodeling and potential degeneration. The low flow theory suggests that low flows within aneurysms cause localized stagnation of blood flow against the wall in the dome, triggering a dysfunction of flow-induced nitric oxide and wall degrading inflammatory processes. Both theories capture the importance of the interaction between the hemodynamic environment within the aneurysm and the cellular elements of the wall in wall weakening. In this presentation, the authors will provide their methodological progression regarding CFD analysis for aneurysm hemodynamics to share their knowledge and to promote fruitful discussion with interested researchers as well.

3. Endovascular role of flow-diverter & its world-wide indication

권순찬 (울산대)

Endovascular Role of Flow-Diverter & It's World-wide Indication

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ULSAN UNIVERSITY HOSPITAL

Aneurysm characteristics

PUFS trial(2013, Radiology)

Mean AN Size : 18.2mm

Table 1 (continued)

Baseline Characteristics (n = 108)

Characteristic	Value
Location	
Petrous	4 (3.7)
Cavernous	44 (40.7)
Carotid cave	2 (1.9)
Superior hypophyseal	10 (9.3)
Lateral clinoidal	2 (1.9)
Paraophthalmic	35 (32.4)
Supraclinoid	10 (9.2)
Posterior communicating	1 (0.9)
Mean maximum fundus diameter (mm)*	18.2 (6.4, 6.2*–36.1)
Small: <10 mm	1* (0.9)
Large: 10 to <25 mm	85 (78.7)
Giant: ≥ 25 mm	22 (20.4)
Mean neck size (mm)*	8.8 (4.3, 4.1–36.1)
No. with neck measurement ≥ 4 mm	85 (78.7)
No. with neck measurement < 4 mm	22 (20.4)
Mean dome size (mm)*	14.8 (5.5, 4.4–29.5)
No. of target aneurysms partially thrombosed	17 (15.7)

Results from Pipeline for Uncoilable or Failed Aneurysms Clinical Trial. Radiology Volume 267: Number 3, June 2013

PFLEX trial (2018, JNIS)

Mean AN Size : 8.8mm

Sizes of Aneurysm (mean : 8.8±6.15mm)	
Small An (<10mm)	38 / 50 (76%)
Large An (>10 and <25mm)	11/50 (22%)
Giant An (>25mm)	1/50(2%)
Locations of Aneurysm	
ICA	47/50(94%)
Vertebral artery	3(6%)

Martinez-Galdamez M, et al. J NeuroIntervent Surg 2018;0:1-4. doi:10.1136/neurintsurg-2018-014204

PREMIER trial (2019, J NeuroIntervent Surg)

Mean AN Size : 4.6mm

Aneurysms characteristics (median (mean±SD))	
Aneurysm size (mm)	4.6 (5.0±1.9)
Neck width (mm)	3.7 (4.0±1.4)
Dome to neck ratio	1.1 (1.1±0.3)
Aneurysm location (n/N (%))	
ICA	134/141 (95.0)
ICA–petrous segment (C2)	1/134 (0.7)
ICA–clinoid segment (C4)	11/134 (8.2)
ICA–cavernous segment (C5)	3/134 (2.2)
ICA–ophthalmic segment (C6)	108/134 (74.6)
ICA–PCom segment (C7)	19/134 (14.2)
Vertebral artery	7/141 (5)

119 (84.4%) measured **<7 mm** in size and **22 (15.6%)** measured **7–12 mm** on the largest diameter.

Hanel RA, et al. J NeuroIntervent Surg 2019;0:1–6. doi:10.1136/neurintsurg-2019-015091

US FDA Approval for Flow Diverters in 2011

- Pipeline Embolization Device (PED)
- In adults (≥ 22 yrs. of age), large & giant wide-necked IAs
- Petrous to Hypophyseal ICA

- Off-label uses

보건복지부 고시 제2014 - 191호

「국민건강보험법」 제41조제2항 및 제3항, 「국민건강보험법 시행령」 제19조제1항 관련 별표2 제1호나목, 제3호 및 「국민건강보험 요양급여의 기준에 관한 규칙」 제5조제2항에 의한 「요양급여의 적용기준 및 방법에 관한 세부사항(보건복지부 고시 제2014-190호, 2014.10.27.)」을 다음과 같이 개정·발령합니다.

2014년 10월 30일

보건복지부 장관

「요양급여의 적용기준 및 방법에 관한 세부사항」 일부개정

요양급여의 적용기준 및 방법에 관한 세부사항 일부를 다음과 같이 개정한다.

Ⅲ. 치료재료 5. 중재적시술료의 제목 및 세부인정사항 및 Ⅳ. 국민건강보험요양급여의기준에 관한 규칙 제10조에 의거 신의료기술로 신정된 항목중 이미 심사기준으로 운영되고 있는 항목 제1장 기본진료료, 제2장 검사료 및 제9장 처치 및 수술료 등의 항목, 제목 및 세부인정사항을 각각 별지1과 같이 신설하고 제6장 마취료의 제목 및 세부인정사항을 별지2와 같이 변경한다.

부 칙

이 고시는 2014년 11월 1일부터 시행한다. 다만, Ⅲ. 치료재료 5. 중재적시술료 및 Ⅳ. 국민건강보험요양급여의기준에 관한 규칙 제10조에 의거 신의료기술로 신정된 항목중 이미 심사기준으로 운영되고 있는 항목 제9장 처치 및 수술료 등의 개정사항은 이 고시를 발령한 날부터 시행한다.

[별지 1]

신 설

Ⅲ. 치료재료

5. 중재적시술료

제 목	세부인정사항
Flow-diverter를 이용한 뇌동맥류의 색전술용 색전 기구(Embolization Device)의 급여기준	Flow-diverter를 이용한 뇌동맥류 색전술시 사용하는 색전 기구(Embolization Device)의 인정기준은 다음과 같음. - 다 음 - 가. 적용증 (1) 직경 15mm이상의 비파열성 뇌동맥류 (2) 직경 15mm미만의 비파열성 뇌동맥류 중 다음의 경우 사례별로 인정 - 내경동맥 원위부의 수포성 뇌동맥류 - 방추형 뇌동맥류 - 척추동맥의 박리형 뇌동맥류 나. 인정개수 : 1개 다만, 환자의 상태나 동맥류의 해부학적 특성 등으로 불가피하게 인정개수를 초과하여 사용하는 경우에는 의사소견서 및 진료기록부 등 관련 자료를 첨부하여야 하며 제출된 관련 자료를 참조하여 요양급여를 인정함. 다. 뇌동맥류 색전술용 Micro Coil과의 병용사용은 인정하지 아니함.

US FDA Approval on Expanded Ix. for PED in 2019

- The new indication opens options for pts. with small or medium, wide-necked Cbr. Ans. in the territory from the petrous to the terminus of the internal carotid artery.

  : based on clinical data from the PREMIER trial

Company (Medtronic) Recommendation for PED based on FDA Approval

- Indication for Use

1. the endovascular tx. of adults (≥ 22 yrs. of age) with large or Gt. wide-necked IAs in the ICA from petrous to the sup. hypophyseal segments.

2. also indicated for use in the ICA up to the terminus for the endovascular tx. of adults with small and medium wide-necked (neck width ≥ 4mm or dome-to-neck ratio <2) saccular or fusiform IAs arising from a parent vessel with a diameter ≥ 2.0mm and ≤ 5.0mm.

Company (Medtronic) Recommendation for PED based on FDA Approval

- Contra-Ix.

1. Pts. with active bacterial infection
2. Pts. in whom dual antiplatelet and/or anticoagulation therapy is contraindicated.
3. Pts. who have not received dual antiplatelet agents prior to the procedure.
4. Pts. in whom a preexisting stent in place in the parent artery at the target An. location.
5. Pts. in whom the parent vessel size does not fall within the indicated range.

PED Indication by region

Region	Approved Device	Intended Use
US	FLEX : PREMIER INDICATION	The device is intended to treat small or medium brain aneurysms with a wide-neck (neck width 4 mm or wider or dome-to-neck ratio less than 2) saccular or fusiform (elongated, spindle shaped aneurysm involving the entire vessel) aneurysms in the internal carotid artery with a vessel diameter between 2 mm and 5 mm. The device is also intended to treat large or giant brain aneurysms with a wide-neck in certain regions of the internal carotid artery.
EU, APAC, Latam	FLEX SHIELD	Endovascular embolization of intracranial aneurysms (all sizes)
CHINA, INDIA	FLEX	The endovascular treatment of adults with wide-neck, intracranial aneurysms ≥ 10 mm in size
JAPAN	FLEX SHIELD	The endovascular treatment of adults with wide-neck, intracranial aneurysms ≥ 10 mm in size
KOREA	FLEX SHIELD	The endovascular treatment of adults with wide-neck, intracranial aneurysms ≥ 15 mm in size

International FD marketing franchise

US FDA Approval for Surpass Streamline Flow Diverter

- IAs in pts. 18yrs. of age & older
- Ans. with a wide-neck (neck width 4 mm or wider, or dome-to neck ratio less than 2) or fusiform IAs. in the ICA with a diameter between 2.5 mm and 5.3mm

2019.01.

Flow Diverter in EU

❖ Endovascular Embolization of Intracranial Aneurysms (all sizes)

Flow Diverter in Australia

❖ Very high level of acceptance for Flow Diversion of Ans. (Ixs. For use vary from centre.)

1. An. Size is not much of a selection criteria for case selection. Any wide-necked An. is considered for FD irrespective.
2. Coils: the use of coils along with FD is an accepted technique. Degree of packing varies between physicians .

Cf. similar Ixs. in New Zealand

Flow Diverter in Australia

❖ SCOPE-AUS Trial (SNIS 2019)

- 294 pts., 318 Ans., 344 Devices (Flex Shield)
- Acute SAH, 19 (6%)
- Ant. Circulation, 285 (90%)
  Post. Circulation, 33 (10%)
- Size range, 1 – 32mm (Average size, 7.5mm)

- mortality, 4 pts. (1.36%)
  permanent ischemic Cxs., 4 pts. (1.4%)

Flow Diverter in Taiwan

❖ Above Petrous ICA, and meets any one of the Ixs. Below

1. An. diameter larger than 15mm
2. Fusiform An. diameter larger than 10mm
3. Dissecting An. diameter larger than 10mm
4. Recurrence after coiling, & An. diameter larger than 10mm
5. Two or more Ans. at the same vessel

Flow Diverter in Taiwan

❖ One stent for each time
: if coils are needed at the same time, maximum for 5 coils

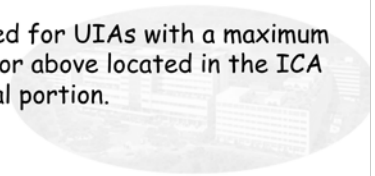
❖ Need to apply before the procedure
❖ Only Pipeline and FRED (Not FRED Jr.)

Taiwan NHI reimbursement guideline of FD

Flow Diverter in Japan

❖ The endovascular treatment of adults with wide-neck, only Intracranial ICA Ans. ≥ 10mm in size. (PED)

❖ Surpass is indicated for UIAs with a maximum diameter of 10mm or above located in the ICA except the terminal portion.



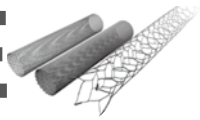
Flow Diverter in Japan

- FRED got an approval, and their indication could be more wider. (Effective most likely next year)
  : ≥ 5mm ?? on ICA, MCA & post. circulation
  not on ACA, A-com.

- PED indication still unchanged.
  cf. submitted PREMIER to the government
  : ongoing negotiation to align with FDA Ix. or a little bit wider.

ENDOVASCULAR NERUOSURGICAL SYMPOSIUM UPDATE on CBF REDIRECTING ENDOPROSTHESIS

ENSURE



FLOW DIVERTERS FOR CEREBRAL ANEURYSM

뇌동맥류 혈류전환유도 스텐트 심포지엄 및
대한뇌혈관내수술학회 2019 추계보수교육

SESSION II. Flow-diverter for 10 years, what did we learn?

좌장: 정진영 (연세에스병원), 신승훈 (차의과학대)

1. Review of recent trial for flow diversion	
A. Pros.	권현조 (충남대)
B. Cons.	김택균 (서울대)
2. Flow diversion beyond the circle of Willis	박석규 (순천향대)
3. Evolving flow-diverters and its supporting devices	김대원 (원광대)

1. Review of recent trial for flow diversion
A. Pros.

권현조 (충남대)

1991년에 Guglielmi detachable coil[1]이 처음 소개되고, 이를 이용한 코일색전술의 효과가 International Subarachnoid Aneurysm Trial (ISAT)[2]에 의하여 입증된 이후 뇌동맥류의 치료법에서 코일색전술의 비중은 점점 커져가고 있다. 하지만 코일색전술도 입구가 넓은 large and giant aneurysm이나 blister aneurysm, branch와 가깝게 있거나 dome에서 branch가 나오는 동맥류 등의 치료에서는 한계 또는 개선의 여지를 보이고 있다. 이러한 점들을 극복하기 위한 하나의 대안으로 시도된 Flow diverter (FD)는 2006년경에 개발되기 시작하여 2011년 6월에 미국 FDA에서 ICA의 cavernous and paraclinoid region에 있는 large or giant, wide-necked intracranial aneurysm의 치료에 대하여 승인을 받았고, 세계적으로 임상경험을 축적하면서 그 적응증을 확대해 나가고 있다[3]. 현재 우리나라 건강보험에서 인정하고 있는 FD indication들은 다음과 같다.

(1) 직경 15mm이상의 비파열성 뇌동맥류
(2) 직경 15mm미만의 비파열성 뇌동맥류 중 다음의 경우 사례별로 인정
– 내경동맥 원위부의 수포성 뇌동맥류
– 방추형 뇌동맥류
– 척추동맥의 박리형 뇌동맥류

이로써 그동안 진행되어 온 개두술에 의한 경부결찰술과 코일색전술 간의 경쟁 체재가 코일색전술과 FD간의 경쟁 체재로 바뀌고 있는 상황이다. 하지만 아직까지 코일색전술이 가능한 wide-necked ICA aneurysm에 대하여 코일색전술과 FD (Pipeline) 둘 만의 안전성과 효과를 직접 비교한 randomized study는 COCOA study (the Complete Occlusion of Coilable Aneurysms [COCOA] Study)[4] 하나이며, 이 study도 2008년에서 2015년 사이에 13명만을 enroll 하다가 중단되었다. 현재 세계적으로 FD의 사용은 점점 늘고 있고, 그 indication도 확장되고 있지만 여전히 상당수의 large and giant aneurysm들이 coil embolization으로 치료되고 있다. 또한, 아직도 대부분의 FD관련 논문들은 retrospective이거나 long-term data가 아니며, 아직 FD와 standard coiling 또

는 microsurgical clipping을 직접 비교한 major study는 없는 상태이다. 따라서 최선의 치료방법은 수술자의 경험을 고려하고, 다른 치료법 또는 단순 관찰 등과의 효과-위험성 비교를 통하여 환자별로 판단하여야겠다. 이번 강의에서는 최근 보고들을 중심으로 coil embolization에 비하여 FD의 사용을 favor하는 근거들과 확장되고 있는 indication들을 소개하고자 한다.

2017년에 발표된 prospective & multicenter trial인 PUFS (Pipeline for Uncoilable or Failed Aneurysms clinical trial) study 5년 추적 결과[5]에서는 Pipeline으로 치료한 107명, 109개 complex ICA aneurysms의 장기 추적 결과를 보고하고 있는데, complete aneurysm occlusion 비율이 180일, 1년, 3년, 5년 경과에 따라 73.6%, 86.8% (79/91), 93.4% (71/76), and 95.2% (60/63)로 향상되었다고 한다. 재치료한 동맥류는 6개 (5.7%)였다. 1, 3, 5년 동안 발생한 심각한 device-related events들은 각각 1% (1/96), 3.5% (3/85), 0% (0/81) 였다. 사망자는 4명 (3.7%)이었으며, 5년간 추적된 81명 중 78명 (96.3%)이 mRS scores ≤2이었다. 시술 6개월 이후에 발생한 Delayed neurological deaths 또는 hemorrhagic or ischemic cerebrovascular events는 없었다. 완전 폐색이 된 동맥류에서 recanalization이 된 경우도 관찰되지 않았다.

Agnoletto 등[6]은 2011년부터 wide-neck large and giant aneurysm의 치료결과에 대해 보고한 문헌들을 검색 및 정리하여 발표하였는데, 주로 stent-assisted coiling 결과를 정리한 11개의 보고들을 모아보면, complete occlusion rate는 40.2% – 82.8%정도이며, adjusted regression을 하면 53% (95% confidence interval [CI] 22%-81%)를 보이고 있다. 14개의 문헌으로 보고된 FD에서는 완전폐색율이 40.5% – 87.8%를 보이며, adjusted regression 후 87% (95% CI 76% – 93%)으로 코일색전술에 비하여 약간 더 높은 경향을 보이고 있다. Safety 면에서는 simple analysis에서 death 와 stroke rate가 coil이 6%, FD가 8%를 보였으며, adjusted regression model에서는 coil이 3%, FD가 6% 로 flow diverter에서 더 높았다.

최근에 발표된 Pipeline을 이용한 small/medium aneurysm 치료 결과에 대한 전향적 연구(Prospective study on embolization of intracranial aneurysms with the pipeline device: the PREMIER study 1 year results)[7]를 보면 ICA와 VA의 12mm이하 unruptured, wide necked aneurysm 141개 (크기 평균 5mm, 84.4%가 7mm 이하)에 대하여 Pipeline을 설치한 결과 1명을 제외한 모든 환자에서 성공적으로 설치되었으며, 1년 경과 시점에서 76.8% (106/138)에서 major parent vessel stenosis나 retreatment없이 complete occlusion을 보였다고 한다. combined major morbidity and mortality는 2.1% (3/140)이었다. Malhotra 등[8]의 보고에서도 FD가 health benefit이 더 많고 재치료율도 15.6%인 coiling에 비하여 낮은 9.5%로 나타나고 있다.

Delayed recur 문제에 있어서도 Chalouhi 등[9]은 평균 8.4mm의 동맥류를 가진 146명의 환자들이 FD시술을 받은 후 short-term follow-up DSA에서 90.4%인 132명에서 complete occlusion을 보였고 이들이 29.7개월의 추적기간 동안 전혀 재발 소견을 보이지 않았으며, near complete occlusion을 보였던 14명 중 7명에서 추가 폐색을 보였으므로 일단 flow diverter로 complete occlusion이 된 환자에서는 추가 angiography를 추천하지 않는다고 보고하였다.

경험의 축적에 따른 합병증의 발생률 변화를 관찰한 Dmytriw 등[10]의 연구는 2011년에서 2013년 사이 미국 내 3개 대학병원에서 한 개의 pipeline을 이용하여 치료한 전방순환계 동맥류의 결과를 후향적으로 분석하였다. 총 321개의 전방순환계 동맥류에 대하여 284 procedures를 행하였고, median 13개월, mean 18개월 추적에서 complete or near complete occlusion (〉90%)이 85.9%에서 관찰되었다. 시술 횟수의 증가에도 aneurysm occlusion rate이나 procedure length의 차이는 없었지만, Thromboembolic complication는 8.1%에서 발생하였는데 2011/2012년도 기간에 16.3%에서 2016년도에 3.3% 발생으로 감소하는 경향을 보였다 (P=0.14). 출혈성 합병증도 2011/2012년도 기간에 8.2%에서 2014-2016년도 기간에 0 to 1.0%로 뚜렷하게 감소하였다 (P=0.1). 저자들은 이러한 결과에 platelet function test 결과 확인, clopidogrel nonresponder에 대한 ticagrelor 사용, adjuctive coiling을 덜 사용한 것 등이 기여한 것으로 판단하였다.

Device의 개선도 합병증 발생 저감에 기여한다는 결과도 발표되었다. Bhatia 등[11]은 미파열 동맥류에 Pipeline flex를 이용한 8개 연구 879명, 901개 동맥류의 치료를 분석한 결과 30일 이내의 periprocedural death은 0.8% (5/901; 95% CI 0.4% to 1.5%; I2=0%). 이후 death, major ischemic stroke, symptomatic intracranial hemorrhage은 1.8% (14/901; 95% CI 1.0% to 2.7%; I2=0%)였다고 보고하였다. 10 mm 이상의 동맥류 크기가 통계적으로 유의한 major complication predictor (OR 6.4; 95% CI 2.0 to 20.7; p=0.002)였으며, 10mm 미만의 동맥류에서 major complication risk는 0.9% (95% CI 0.3% to 1.7%; I2=0%)였다.

파열동맥류에 대한 치료 효과도 여러 편의 보고가 있었는데 Cagnazzo 등[12]이 223명의 지주막하출혈 환자들을 포함하는 20개 연구들 분석한 결과 immediate angiographic occlusion은 32% (29/86; 95% CI, 15.4%- 48%; I2 79.6%)에서 관찰되었지만 long-term complete/near-complete aneurysm occlusion은 88.9% (162/189; 95% CI, 84%-93.5%; I2 20.9%) (mean radiologic follow-up of 9.6 months)으로 증가하였다고 보고하였다. Treatment-related complication rate는 17.8% (42/223; 95% CI, 11%-24%; I252.6%)였다. Complications은 posterior circulation (16/72 27%; 95% CI, 14%-40%; I2 66% versus 18/149 11.7%; 95% CI, 7%-16%; I2 0%) (P=.004)과 multiple stents (14/52 26%; 95% CI, 14%-45%; I2 59%)를 사용한 경우에 더 빈번했다. 재출혈은

4% (5/223; 95% CI, 1.8%-7%; I2 0%)에서 발생했고 최초 72 시간 내에 많이 발생하였다. 따라서 coiling이나 microsurgical clipping이 어려운 경우 전방순환계에서는 사용 stent 개수를 최소화하면서 flow diversion을 시도해 볼 수 있겠고, 27%의 합병율을 보인 후방 순환계에서는 신중하게 선택해야 한다고 결론내리고 있다.

FD 사용으로 FD에 덮히게 된 branch들의 patency를 보고자 21개 연구를 통해 1152개의 supraclinoid ICA branch에 대한 meta-analysis를 시행한 Cagnazzo의 연구[13]를 보면, OphtA occlusion의 incidence는 5.9% (95 CI% = 3.1-8.6%)(incidence rate = 6% per patient-year)였고 증상이 있는 경우는 0.8% (95% CI = 0.1-1.4%) (incidence rate = 0.8% per patient-year)였다. 모든 경우에서 증상이 없었지만, PcomA은 더 높은 occlusion rate (20.7%, 95%CI = 8.9-32.4%) (incidence rate = 19.5% per patient-year)를 보였다. AchorA는 1% (95% CI = 0.3-2.4%)에서 관찰되었는데, transient hemiparesis와 hemianopsia만이 관찰되었다. 환자 요인이나 multiple stents 사용이 고위험과 연관은 없었으며, arterial occlusion이 생긴 환자의 94.5%에서 적절한 collateral circulation이 관찰되었다. Wagner 등[14]은 5개 병원의 data를 후향적으로 검토하여 Lenticulostriate artery가 FD 설치 구간에 포함된 52명의 결과를 분석하였는데 2명에서 시술 중 transient occlusion of MCA가 발생하였고, 5명에서 영상에서 변화가 없는 transient symptom이 관찰되었다고 한다. 또한, 6개월 이내에 dual antiplatelet을 중단한 환자 중 2명에서 in-stent thrombosis로 인한 MCA infarction이 발생하였다고 보고하였다.

Essbaiheen[15] 등은 midterm 혈관조영술 결과에서 in-stent stenosis가 관찰된 16(16/36, 44%)명을 분석하였는데, 이중 11명이 mild, 3명이 moderate, 2명이 severe stenosis를 보였고, 11명이 diffuse, 5명이 focal type이었다. 모든 환자들은 무증상이었고, 장기 결과에서 dual antiplatelet을 투약한 11명이 complete resolution, 3명이 호전, 2명이 악화를 보였다. 새로 관찰된 in-stent stenosis는 없었다. 18명을 추적 관찰한 Mühl-Benninghaus 등[16]의 결과에서도 short-term 검사의 30%에서 관찰되던 것이 long-term 검사에서는 12%로 ($p<0.0001$) 호전되었다고 한다.

Mokin 등[17]은 43명 45개의 ICA blood blister aneurysm (BBA)에 대한 FD 치료 결과를 분석하였는데, 혈관조영술 추적검사가 시행된 30명, 32개 BBA 중 87.5% (28/32)에서 complete obliteration을 보였고, 9.4% (3/32)에서 reduced filling, 3.1% (1/32)에서 persistent filling을 보였다고 한다. size of aneurysm ($\leq$2 mm vs $>$2 mm) 이나 use of adjunct coiling이 연관은 없었다고 한다. 임상적 추적은 38명에서 가능하였는데 68% (26/38)에서 3개월 째 good clinical outcome (modified Rankin scale score of 0-2)을 보였다고 한다. 7개(16%)와 2개(5%)의 immediate procedural 또는 delayed complications이 발생하였고, 1 case의 fatal delayed re-rupture가 있었다고 한다.

Maus 등[18]은 15개의 VB artery ruptured dissecting aneurysm 치료 결과를 분석하였는데, 9개가 intradural portion of the vertebral artery에서 발생하였고, 3개가 PICA였으며 AICA, PCA, BA에 각각 1개씩이었다. FD 설치는 14명 (93%)에서 성공하였으며, 재출혈한 경우는 없었다고 한다. 설치 직후 7례 (50%)에서 favorable occlusion이 관찰되었고, 급성기에 임상적 위중한 상태로 인하여 사망한 7명과 추적 검사를 못한 1명을 제외한 6명의 CTA 또는 DSA에서 모두 complete obliteration소견을 보였다.

Laukka 등[19]은 FRED를 이용하여 5례의 후방순환계 ruptured fusiform aneurysm 치료 결과를 발표하였다. PICA와 PCA에 각각 2개, SCA에 1개였다. 모든 환자에서 성공적으로 시술되었으며, rebleeding을 보인 환자는 없었고 3–22개월 추적에서 모두 complete occlusion을 보였다. 한 환자에서 시술 중 in–stent thrombosis가 발생하여 infarction이 발생하였다고 한다.

Ghorbani 등[20]은 TSA나 FESS 등의 수술이나 car accident, gun shot 등의 사고로 발생한 ICA injury 5례에 Surpass를 이용한 치료 결과 모든 경우에서 좋은 결과를 얻었다고 보고하였다. 모든 환자들이 작은 carotid defect를 보였고, occlusion test를 견디지 못하는 상태였다.

Silva 등[21]은 visual symptom에 대한 FD의 효과를 meta–analysis하여 clipping이나 coiling과 비교하였는데, paraclinoid aneurysm으로 인한 visual symptom에 대한 improvement가 clipping후에 58%, coiling 49%, FD 71%에서 관찰되었고, 악화된 경우는 clipping후에 11%, coiling 9%, FD 5%에서 관찰되었으며, 새로운 visual deficit는 clipping후에 1%가 발생하였지만, coiling이나 FD후에는 발생하지 않았다.

Heiferman 등[22]은 failed stent–assisted embolization 25례에서의 FD 사용 결과를 보고하였는데, 12개월 추적에서 19 (76%)례가 occlusion rate가 향상되었으며, 38%가 완전 폐색을 보였고, 모든 동맥류가 decreased filling을 보였다고 한다. 한 명에서 moderate permanent neurologic deficit이 발생하였다. 저자들은 적절한 size를 선택하고 기존 스텐트 설치 구간을 충분히 cover해 wall apposition을 향상시키고 endoleak을 방지하면 FD가 기존 stent–assisted coil embolization이 실패한 동맥류의 치료에 합리적인 치료대안이 될 수 있다고 결론지었다.

Colby 등[23]은 large and giant aneurysm의 치료에 따른 피폭양의 차이를 비교하였는데, FD 치료에서 평균 radiation dose 는 2840mGy였고 coiling에서는 4010mGy로 더 많았다. (p=0.048; 29% decrease with PED). 평균 fluoroscopy time도 FD가 56.1분인 반면 coiling이 85.9분으로(p=0.0087; 35% decrease with PED) 더 길

었다. 이것은 FD를 이용한 환자의 aortic arch가 해부학적으로 더 어려운 형태를 보인 상황에서 나온 결과였다. 조영제 사용양도 FD를 설치한 환자에서 37.5% 감소하였다. (75mL versus 120, p=0.0008).

이상의 현재까지 보고들을 검토할 때, FD는 추후 분명히 그동안 coil embolization으로는 부족했던 부분들을 보완 및 해결해 줄 수 있는 역할을 할 것으로 판단되지만 아직은 한계 또는 단점이 있는 것이 사실이다. 이러한 상황에서는 operator가 환자의 임상적 상태와 영상학적 소견을 충분히 검토하고, 자신의 경험과 능력을 냉철하게 판단한 후에, 가장 합리적인 치료방법을 결정하는 노력을 기울이는 것이 좋은 결과를 얻는 가장 중요한 요인임을 잊지 말아야 하겠다.

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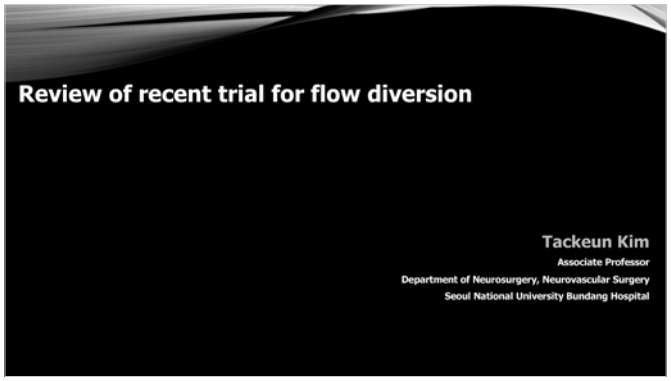
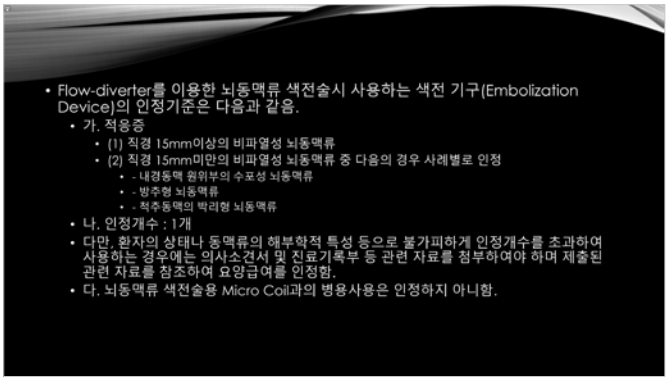
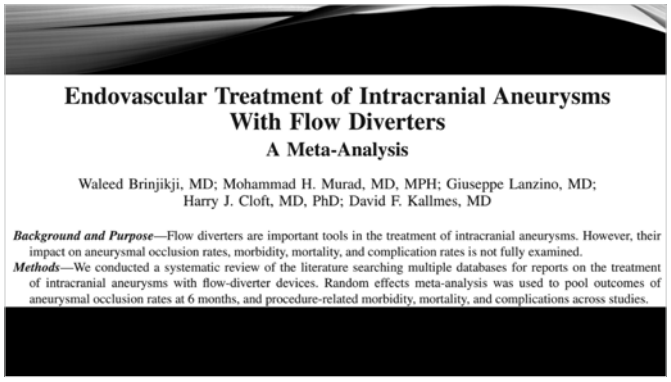
1. Review of recent trial for flow diversion
B. Cons.

김택균 (서울대)







Endovascular Treatment of Intracranial Aneurysms With Flow Diverters

A Meta-Analysis

Waleed Brinjikji, MD; Mohammad H. Murad, MD, MPH; Giuseppe Lanzino, MD; Harry J. Cloft, MD, PhD; David F. Kallmes, MD

Background and Purpose—Flow diverters are important tools in the treatment of intracranial aneurysms. However, their impact on aneurysmal occlusion rates, morbidity, mortality, and complication rates is not fully examined.

Methods—We conducted a systematic review of the literature searching multiple databases for reports on the treatment of intracranial aneurysms with flow-diverter devices. Random effects meta-analysis was used to pool outcomes of aneurysmal occlusion rates at 6 months, and procedure-related morbidity, mortality, and complications across studies.

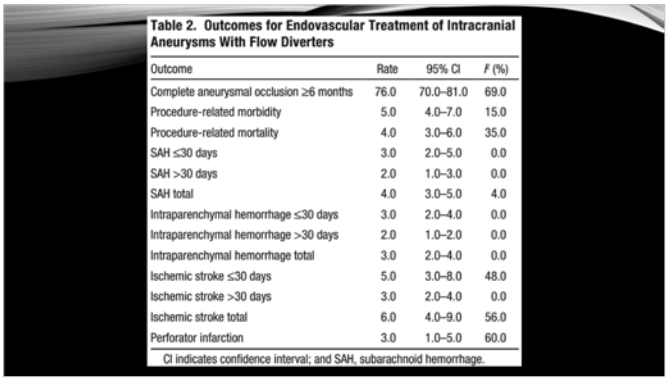


Table 2. Outcomes for Endovascular Treatment of Intracranial Aneurysms With Flow Diverters

Outcome	Rate	95% CI	I^2 (%)
Complete aneurysmal occlusion ≥6 months	76.0	70.0–81.0	69.0
Procedure-related morbidity	5.0	4.0–7.0	15.0
Procedure-related mortality	4.0	3.0–6.0	35.0
SAH ≤30 days	3.0	2.0–5.0	0.0
SAH >30 days	2.0	1.0–3.0	0.0
SAH total	4.0	3.0–5.0	4.0
Intraparenchymal hemorrhage ≤30 days	3.0	2.0–4.0	0.0
Intraparenchymal hemorrhage >30 days	2.0	1.0–2.0	0.0
Intraparenchymal hemorrhage total	3.0	2.0–4.0	0.0
Ischemic stroke ≤30 days	5.0	3.0–8.0	48.0
Ischemic stroke >30 days	3.0	2.0–4.0	0.0
Ischemic stroke total	6.0	4.0–9.0	56.0
Perforator infarction	3.0	1.0–5.0	60.0

CI indicates confidence interval; and SAH, subarachnoid hemorrhage.

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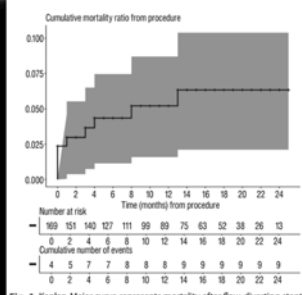


Fig. 1. Kaplan-Meier curve represents mortality after flow-diverting stent procedure. Solid line indicates mortality rate over time, and gray shading shows 95% confidence interval.

TABLE. Comparison of Patients With and Without PED In-stent Stenosis[a]

Variable	Total, N = 51	In-stent Stenosis (N = 5)	No In-stent stenosis (N = 46)
Age, y, mean ± SD	55.5 ± 13.2	57.6 ± 20.8	55.2 ± 12.5
Female, n (%)	40 (78.4)	4 (80)	36 (78.2)
Presentation, n (%)			
Ruptured	7 (13.7)	0	7 (15.2)
Unruptured	44 (86.2)	5 (100)	39 (84.7)
Largest diameter, mm, mean ± SD	11.9 ± 8.9	15.8 ± 9	11.5 ± 8.9
Location, n (%)			
Cavernous	11 (21.6)	1 (20)	10 (21.7)
Ophthalmic	28 (54.9)	3 (60)	25 (54.3)
Communicating	2 (3.9)	0	2 (4.3)
ACA	1 (2.0)	0	1 (2.2)
Basilar	4 (7.8)	1 (20)	3 (6.5)
Vertebral	5 (9.8)	0	5 (10.9)
Previous treatment, n (%)	8 (15.7)	0	8 (19.5)
No. PED stents, mean ± SD	1.5 ± 0.7	1.4 ± 0.5	1.5 ± 0.8
Patients with >1 stent, n (%)	20 (39.2)	2 (40)	18 (39.1)
Concurrent coiling, n (%)	9 (17.6)	0	9 (19.5)
Balloon angioplasty, n (%)	3 (5.8)	2 (40)	1 (2)
Duration of follow-up, mo, mean ± SD	12.5 ± 8.6	14.0 ± 11.9	12.3 ± 8.3

[a]PED, Pipeline Embolization Device; ACA, anterior cerebral artery.

ISR

TABLE 3. In-Stent Stenosis Rates in Treated Vessels

Degree of stenosis	Percentage with In-Stent Stenosis[a]		
	1-yr (n = 91)	3-yr (n = 76)	5-yr (n = 66[b])
<25% stenosis	93.4% (85/91)	86.8% (66/76)	87.9% (58/66)
25% to 50% stenosis	1.1% (1/91)	10.5% (8/76)	6% (4/66)
50% to 75% stenosis	1.1% (1/91)	0 (0/76)	1.5% (1/66)
>75% stenosis	1.1% (1/91)	2.6% (2/76)	4.5% (3/66)[c]
Indeterminate	3.3% (3/91)	N/A	N/A

[a]Based on total number of intracranial aneurysms at each follow-up.
[b]Includes 3 treated patients excluded from the PUFS effectiveness arm as previously reported.[7]
[c]All are complete carotid occlusions.

TABLE 3. Patency of ICA branch vessels after PED placement*

Vessel	No. of Vessels	Immediate		Follow-Up		Post-procedure PCOM patency	PCOM patency at follow-up	Length of follow-up (months)
		Patent	Occluded	Patent	Occluded			
OphA	76	76 (100)	0	68 (89.4)	8 (10.5)	Patent	Patent	26
PCoA	28	28 (100)	0	25 (89.3)	3 (10.7)	Patent	Occluded	26
Adult	24	24 (100)	0	21 (88)	3 (13)	Patent	Patent	12
Fetal	4	4 (100)	0	4 (100)	0 (0)	Patent Patent	Patent Patent	12 6
AChA	21	21	0	21 (100)	0 (0)	Diminished but patent	Diminished but patent	6
ACA	2	2	0	0 (0)	2 (100)	Patent	Patent	6
						Patent	Patent	13
						Diminished but patent	Diminished but patent	9
						Diminished but patent	Occluded	13
						Diminished but patent	Occluded	12

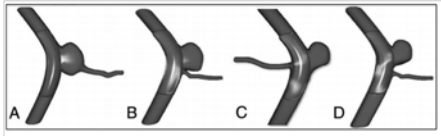
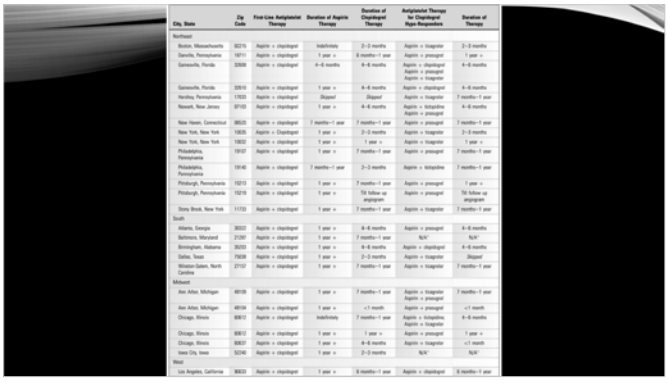
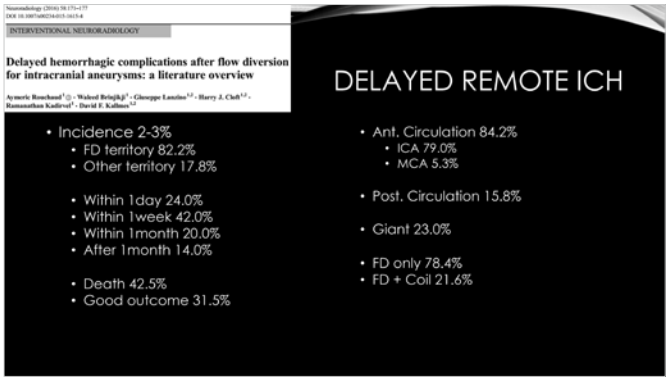


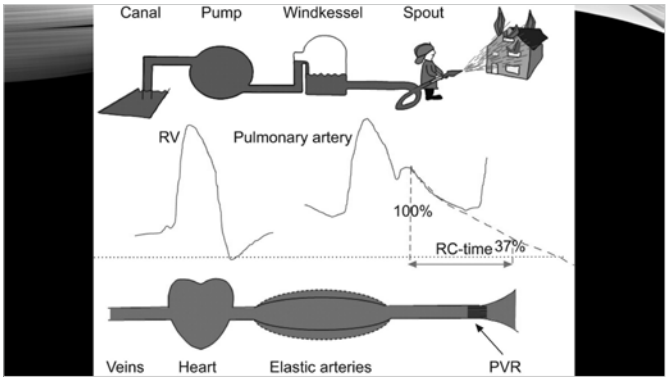
FIG 1. Classification according to the anatomy of the origin of the covered ophthalmic artery: the ophthalmic artery aneurysm classification. *A*, Type A: ophthalmic artery originating from the aneurysm sac. *B*, Type B: ophthalmic artery ophthalmic artery originating in the inner artery not involved in the aneurysm but cc

Table 2: Outcomes*

	Overall (n = 28)	Type			
		A (n = 5)	B (n = 6)	C (n = 4)	D (n = 13)
Normal patency of ophthalmic artery[b]					
Immediately after procedure	24 (85.7)	5 (100)	5 (83.3)	2 (50.0)	12 (92.3)
At 3 mo	27 (96.4)	5 (100)	6 (100)	4 (100)	12 (92.3)
At 12 mo	27 (96.4)	5 (100)	6 (100)	4 (100)	12 (92.3)
Ophthalmic complications					
Retinal emboli	5 (17.9)	4 (80.0)	0	0	1 (7.7)
Optic atrophy	3 (10.7)	0	0	3 (75.0)	0
New clinical symptoms	11 (39.3)	4 (80.0)	1 (16.7)	3 (75.0)	3 (23.1)
Transient	6 (21.4)	1 (20.0)	1 (16.7)	1 (25.0)	3 (23.1)
Permanent	5 (17.9)	3 (60.0)	0	2 (50.0)	0







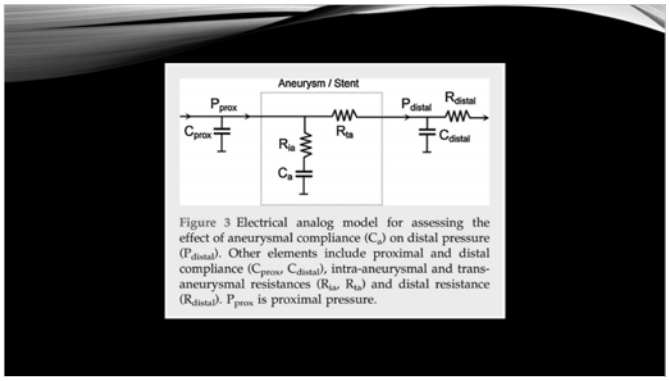
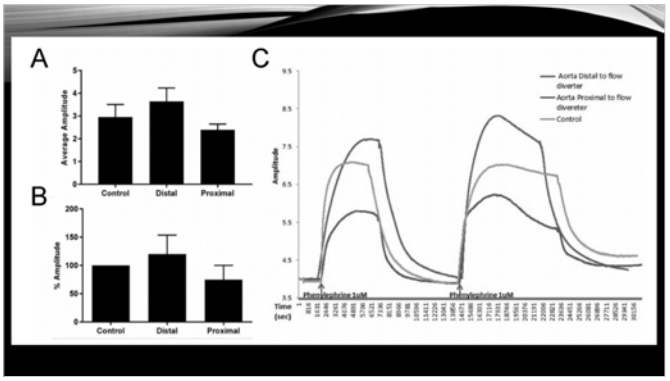
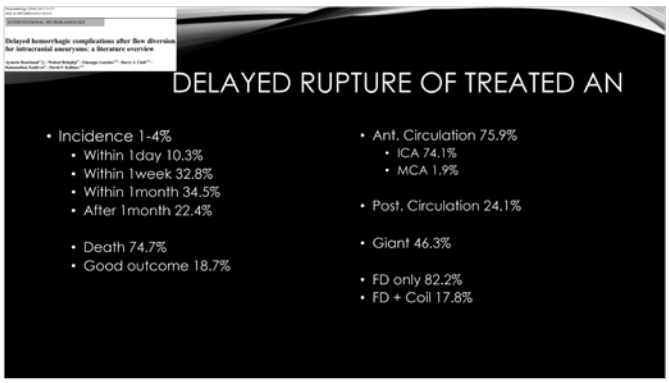


Figure 3 Electrical analog model for assessing the effect of aneurysmal compliance (C_a) on distal pressure (P_{distal}). Other elements include proximal and distal compliance (C_{prox}, C_{distal}), intra-aneurysmal and trans-aneurysmal resistances (R_{ia}, R_{ta}) and distal resistance (R_{distal}). P_{prox} is proximal pressure.





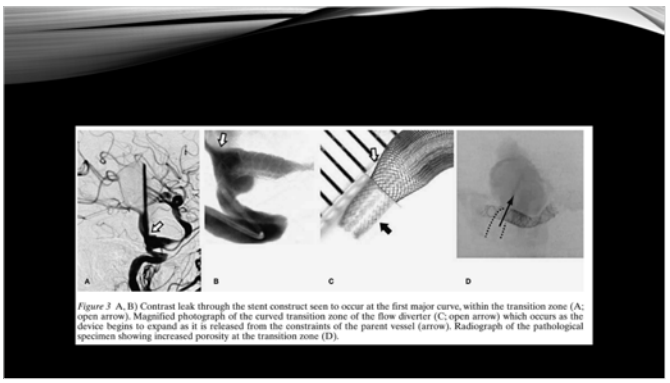


Figure 3 A, B) Contrast leak through the stent construct seen to occur at the first major curve, within the transition zone (A; open arrow). Magnified photograph of the curved transition zone of the flow diverter (C; open arrow) which occurs as the device begins to expand as it is released from the constraints of the parent vessel (arrow). Radiograph of the pathological specimen showing increased porosity at the transition zone (D).

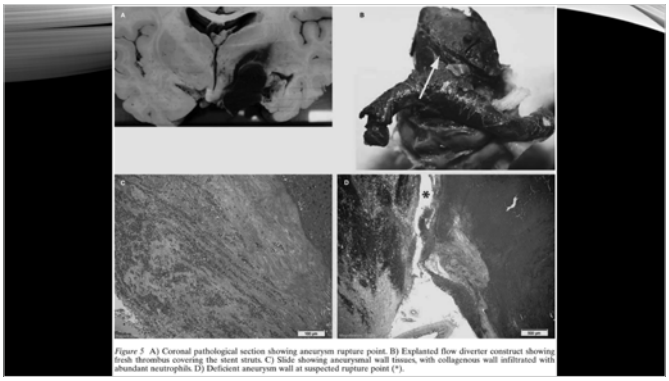
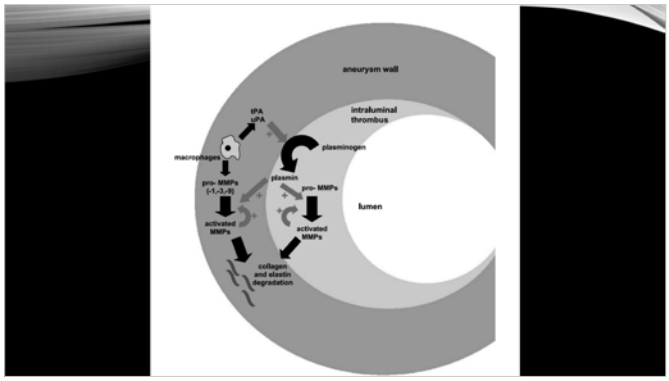
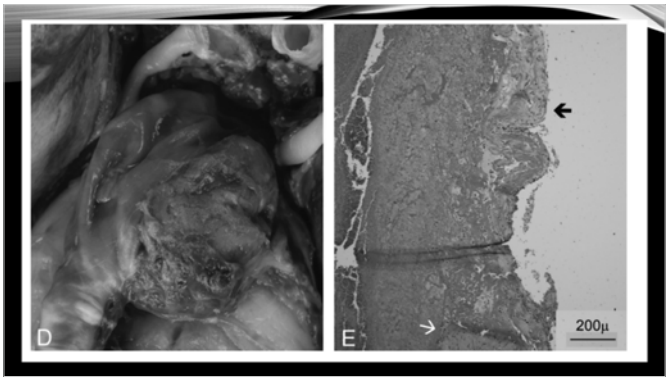
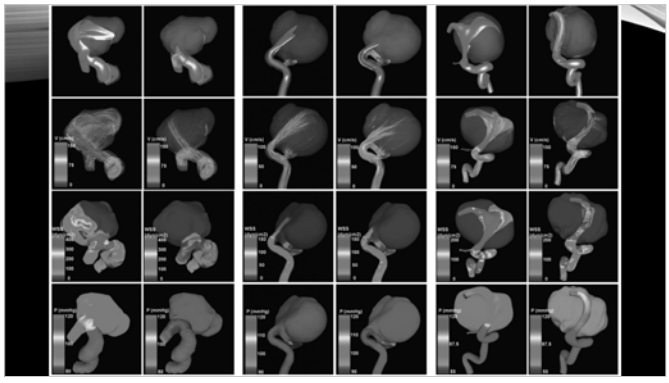
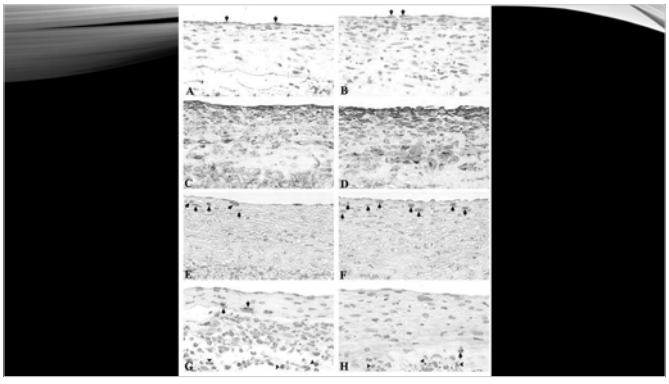


Figure 5 A) Coronal pathological section showing aneurysm rupture point. B) Explanted flow diverter construct showing fresh thrombus covering the stent struts. C) Slide showing aneurysmal wall tissues, with collagenous wall infiltrated with abundant neutrophils. D) Deficient aneurysm wall at suspected rupture point (*).









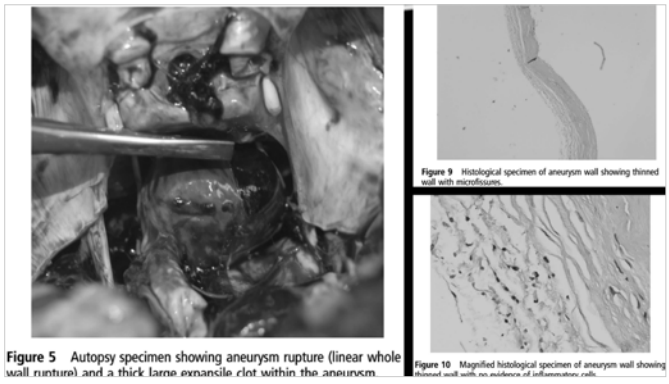


Figure 5 Autopsy specimen showing aneurysm rupture (linear whole wall rupture) and a thick large expansile clot within the aneurysm.

Figure 9 Histological specimen of aneurysm wall showing thinned wall with microfissures.

Figure 10 Magnified histological specimen of aneurysm wall showing thinned wall with no evidence of inflammatory cells.

Flow diversion in the treatment of aneurysms: a randomized care trial and registry

Jean Raymond, MD,[1] Jean-Christophe Gentric, MD,[1,2] Tim E. Darsaut, MD,[3] Daniela Iancu, MD,[4] Miguel Chagnon, MSc,[5] Alain Weill, MD,[1] and Daniel Roy, MD[1]

- NCT01349582 (clinicaltrials.gov)
- the Steering Committee was notified of additional serious adverse events and that a prespecified safety boundary had been crossed
  - 10% of patients with mRS > 2

TABLE 1. Characteristics of the patients and aneurysms

Characteristic	Randomization: BSO (n = 39)	Randomization: Flow Diversion (n = 39)	Registry (n = 34)	Any Flow Diverter (n = 76)
Mean age ± SD (yrs)	57 ± 11	59 ± 12	58 ± 13	58 ± 13
No. of females (%)	34 (87.2)	32 (82.1)	25 (73.5)	59 (77.6)
Presentation (%)				
Asymptomatic	20 (51.3)	20 (51.3)	17 (50.0)	38 (50.0)
Mass effect	16 (41.0)	18 (46.2)	16 (47.1)	36 (47.4)
SAH	3 (7.7)	1 (2.6)	1 (2.9)	2 (2.6)
Aneurysm size (mm)				
Mean ± SD	16 ± 11	16 ± 12	19 ± 13	17 ± 12
Median (range)	12 (3–51)	12 (3–56)	15 (2–60)	15 (2–60)
>10 mm	24 (61.5%)	23 (59.0%)	26 (76.5%)	52 (68.4%)
Aneurysm neck (mm)				
Median (range)	5 (2–10)	5 (2–14)	6 (2–16)	5 (2–16)
Undefined	12 (30.8%)	15 (38.5%)	21 (61.8%)	39 (51.3%)
Location (%)				
Proximal carotid	28 (71.8)	26 (66.7)	22 (64.7)	50 (65.8)
Other anterior	4 (10.3)	6 (15.4)	7 (20.6)	13 (17.1)
Posterior circulation	7 (17.9)	7 (17.9)	5 (14.7)	13 (17.1)

TABLE 2. Primary safety and efficacy outcomes in all patients

	Randomization: BSO (n = 39)		Flow Diversion (n = 38)		Registry (n = 34)		Any Flow Diverter (n = 75)	
	n (%)	95% CI (%)	n (%)	95% CI (%)	n (%)	95% CI (%)	n (%)	95% CI (%)
Death								
Related	2 (5.1)	0.9–18.6	2 (5.3)	0.9–19.1	4 (11.8)	3.8–28.4	7 (9.3)	4.2–18.9
Unrelated	1 (2.6)	0.1–15.1	0 (0.0)	0–11.4	1 (2.9)	0.2–17.1	1 (1.3)	0.1–8.2
Total	3 (7.7)	2.0–22.0	2 (5.3)	0.9–19.1	5 (14.7)	5.5–31.8	8 (10.7)	5.1–20.5
mRS score 3–5	2 (5.1)	0.9–18.6	3 (7.9)	2.1–22.5	0 (0.0)	0–12.6	4 (5.3)	1.7–13.8
Primary safety outcome	5 (12.8)	4.8–28.2	5 (13.2)	5.0–28.9	5 (14.7)	5.5–31.8	12 (16.0)	8.9–26.7
Any stroke	4 (10.3)	3.3–25.2	5 (13.2)	5.0–28.9	2 (5.9)	1.0–21.1	7 (9.3)	4.2–18.9
Any other SAE or complication	4 (10.3)	3.3–25.2	11 (28.9)	16.0–46.1	6 (17.6)	7.4–35.2	17 (22.7)	14.1–34.1
No complications	26 (66.7)	49.7–80.4	17 (44.7)	29.0–61.5	21 (61.8)	43.6–77.3	39 (52.0)	40.2–63.6
Angiographic results								
Immediate failure	3 (7.7)	2.0–22.0	8 (21.1)	10.1–37.8	1 (2.9)	0.2–17.1	9 (12.0)	6.0–22.1
Residual aneurysm	8 (20.5)	9.9–36.9	7 (18.4)	8.3–34.9	10 (29.4)	15.7–47.7	17 (22.7)	14.1–34.1
Residual neck	7 (17.9)	8.1–34.1	1 (2.6)	0.1–15.4	0 (0.0)	0–12.6	1 (1.3)	0.1–8.2
Complete occlusion	20 (51.3)	35.0–67.3	21 (55.3)	38.5–71.0	21 (61.8)	43.6–77.3	44 (58.7)	46.7–69.7
Data not available	1 (2.6)	0.1–15.1	1 (2.6)	0.1–15.4	2 (5.9)	1.0–21.1	4 (5.3)	1.7–13.8
Primary efficacy endpoint								
Failed to reach primary endpoint	14 (35.9)	21.7–52.9	16 (42.1)	26.7–59.1	13 (38.2)	22.7–56.4	31 (41.3)	30.3–53.3
Reached primary endpoint	25 (64.1)	47.2–78.3	22 (57.9)	40.9–73.3	21 (61.8)	43.6–77.3	44 (58.7)	46.7–69.7

TABLE 5. Primary safety and efficacy outcomes in patients eligible for coil embolization or stent-coil embolization

Variable	Randomization: Coiling or Stent-Coiling (n = 26)	Flow Diversion (n = 25)
Deaths	0 (0.0)	1 (4.0)
mRS score 3–5	0 (0.0)	1 (4.0)
Primary safety outcome	0 (0.0)	2 (8.0)
Any stroke	1 (3.8)	2 (8.0)
Any other SAE or complication	3 (11.5)	8 (32.0)
No complication	22 (84.6)	13 (52.0)
Angiographic results		
Immediate failure	1 (3.8)	4 (16.0)
Residual aneurysm	6 (23.1)	4 (16.0)
Residual neck	7 (26.9)	0 (0.0)
Occlusion	12 (46.2)	16 (64.0)
Data not available	0 (0.0)	1 (4.0)
Primary efficacy endpoint		
Failed to reach primary endpoint	7 (26.9)	9 (36.0)
Reached primary endpoint	19 (73.1)	16 (64.0)

All data in the table given as value (%).

- In the FIAT study, flow diversion was not as safe and effective as initially hypothesized.
- The criterion of "untreatability by other means" is vague and subjective; when examined in retrospect, few of the 34 patients of the registry were truly ineligible for other management options.

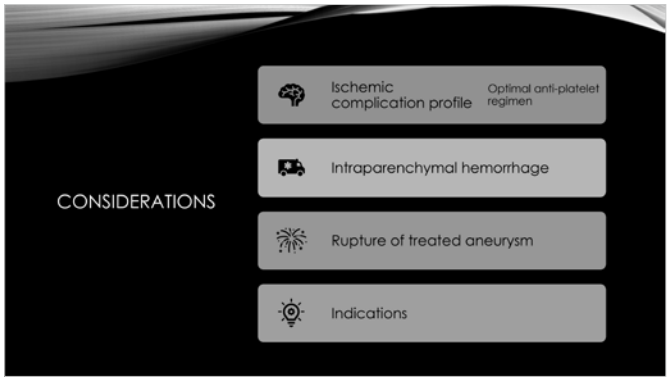
Table 2: Inter- and intraobserver agreement regarding question 4 (best final management choice)

	Categories[a]	All Cases (*n* = 35)	Patients in RCTs (*n* = 14)	Others (*n* = 21)
Interobserver agreement				
All raters (*n* = 22)	5	0.219 ± 0.017	0.225 ± 0.020	0.190 ± 0.025
	2	0.111 ± 0.018	0.151 ± 0.036	0.072 ± 0.020
Surgeons (*n* = 6)	5	0.252 ± 0.025	0.202 ± 0.043	0.271 ± 0.033
	2	0.114 ± 0.084	0.063 ± 0.131	0.148 ± 0.109
>10 years' experience (*n* = 13)	5	0.210 ± 0.019	0.203 ± 0.030	0.199 ± 0.025
	2	0.062 ± 0.030	0.120 ± 0.050	0.024 ± 0.038
>15 FD experiences (*n* = 9)	5	0.182 ± 0.029	0.258 ± 0.042	0.116 ± 0.040
	2	0.093 ± 0.032	0.201 ± 0.055	0.018 ± 0.040
Intraobserver agreement				
Rater 1	5	0.465 ± 0.115	0.432 ± 0.162	0.465 ± 0.163
	2	0.634 ± 0.109	0.340 ± 0.178	0.463 ± 0.195
Rater 2	5	0.387 ± 0.112	0.421 ± 0.175	0.333 ± 0.143
	2	0.243 ± 0.175	0.176 ± 0.272	0.271 ± 0.208
Rater 3	5	0.501 ± 0.104	0.246 ± 0.141	0.629 ± 0.124
	2	0.382 ± 0.114	0.263 ± 0.154	0.442 ± 0.160
Rater 4	5	0.634 ± 0.109	0.509 ± 0.178	0.707 ± 0.129
	2	0.651 ± 0.129	0.571 ± 0.198	0.712 ± 0.153

Table 2. Outcomes for Endovascular Treatment of Intracranial Aneurysms With Flow Diverters

Outcome	Rate	95% CI	I^2 (%)
Complete aneurysmal occlusion ≥6 months	76.0	70.0–81.0	69.0
Procedure-related morbidity	5.0	4.0–7.0	15.0
Procedure-related mortality	4.0	3.0–6.0	35.0
SAH ≤30 days	3.0	2.0–5.0	0.0
SAH >30 days	2.0	1.0–3.0	0.0
SAH total	4.0	3.0–5.0	4.0
Intraparenchymal hemorrhage ≤30 days	3.0	2.0–4.0	0.0
Intraparenchymal hemorrhage >30 days	2.0	1.0–2.0	0.0
Intraparenchymal hemorrhage total	3.0	2.0–4.0	0.0
Ischemic stroke ≤30 days	5.0	3.0–8.0	48.0
Ischemic stroke >30 days	3.0	2.0–4.0	0.0
Ischemic stroke total	6.0	4.0–9.0	56.0
Perforator infarction	3.0	1.0–5.0	60.0

CI indicates confidence interval; and SAH, subarachnoid hemorrhage.



2. Flow diversion beyond the circle of Willis

박석규 (순천향대)

At present, cerebral aneurysm embolization is being developed into various treatment methods according to the development of new device. The coil is more subdivided, and the product is suitable for each step of coil insertion, and a coil for a higher packing density has been used. The stent used with coil is softer than in the past, the profile becomes smaller, and it is possible to deploy it more easily in the small artery, and the variety of the stent becomes wider. The use of flow diverters (FD) is becoming increasingly widespread (although it is difficult to use of FD in Korea).

Endovascular flow diversion, with the ability to reconstruct the parent artery, has been suggested as an important addition to the endovascular treatment for the intracranial aneurysm and dissection. Several articles have reported on the safety and efficacy of the FD which showed promising results. The application of flow diversion with different flow-diverter stents for the treatment of intracranial aneurysms has gained increasing acceptance during the past several years. After its initial employment as a last resort strategy for wide-necked aneurysms, the field of application has expanded rapidly and nowadays even includes the first treatment for saccular and fusiform-shaped incidental aneurysms located within any of the proximal segments of the circle of Willis, as well as otherwise only inadequately treatable acutely ruptured aneurysms.

Although numerous studies have already demonstrated that FD is an effective and safe therapy for a variety of cerebral aneurysms, the subgroup of aneurysms originating from distal segments of the circle of Willis has empirically not yet been sufficiently treatable with FD. More specifically, the delivery systems of currently available well-established FDS require microcatheters providing large inner diameters, which inherently constitute a significant stiffness and thus impede smooth atraumatic maneuverability in the

distal segments. As a consequence, only proximal elements of the circle of Willis such as the internal carotid arteries (ICAs), V4 segments, basilar artery, as well as the M1 and A1 segments have been treated regularly with FD.

However, smaller segments of the circle of Willis such as the anterior cerebral artery/anterior communicating artery complex, the middle cerebral artery (MCA) bifurcation, as well as the M2 branches and the pericallosal artery also frequently give rise to especially critical aneurysms with a high risk of rupture. As a consequence, endovascular treatment in these locations remains challenging and novel devices allowing the use of more flexible smaller delivery catheters are warranted.

In this presentation, we will discuss the use of low-profile FD for the treatment of aneurysm beyond the circle of Willis.

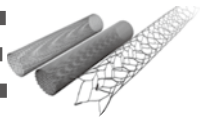
3. Evolving flow-diverters and its supporting devices

김대원 (원광대)

Stents and flow diverters have revolutionized the treatment of cerebral aneurysm. Guglielmi coils, flexible microcatheters, and first-generation intracranial stents, such as Neuroform (Stryker Neurovascular) and Enterprise stents (Codman/DePuy-Synthes), have paved the way for the development of the Pipeline Embolization Device (PED) (ev3/Covidien/Medtronic) and other endovascular approaches. Flow diversion has become a well-accepted option for the treatment of cerebral aneurysms. Given the significant treatment effect of flow diverters, numerous options have emerged since the initial Pipeline embolization device studies. In this review, the author describes the available flow diverters, both endoluminal and intrasaccular, addressing nuances of device design and function and presenting data on complications and outcomes, where available.

ENDOVASCULAR NERUOSURGICAL SYMPOSIUM UPDATE on CBF REDIRECTING ENDOPROSTHESIS

ENSURE



FLOW DIVERTERS FOR CEREBRAL ANEURYSM

뇌동맥류 혈류전환유도 스텐트 심포지엄 및
대한뇌혈관내수술학회 2019 추계보수교육

SESSION III. Practical tactics & pitfalls of cerebral flow-diverter

좌장: 김범태 (순천향대), 장철훈 (영남대)

1. Flow-diverter for anterior circulation aneurysm	신용삼 (가톨릭대)
2. Flow-diverter for posterior circulation aneurysm	강현승 (서울대)
3. How to prevent and get out of complications due to FD	김성림 (가톨릭대)
4. How to do? medication & imaging follow-up for FD	김태곤 (차의과학대)

1. Flow-diverter for anterior circulation aneurysm

신용삼 (가톨릭대)

2. Flow-diverter for posterior circulation aneurysm

강현승 (서울대)

ENSURE 2019

Flow Diverter for Posterior Circulation Aneurysms

Hyun-Seung Kang, MD, PhD
Professor, Department of Neurosurgery
Seoul National University Hospital
Seoul National University College of Medicine, Seoul, KOREA

Why Flow Diverters?

Vertebral artery dissecting aneurysm

Flow Diversion for Posterior Circulation
- SNUH experiences -

- From 2014.11. to 2019.9.
- 36 patients treated with **FDS**

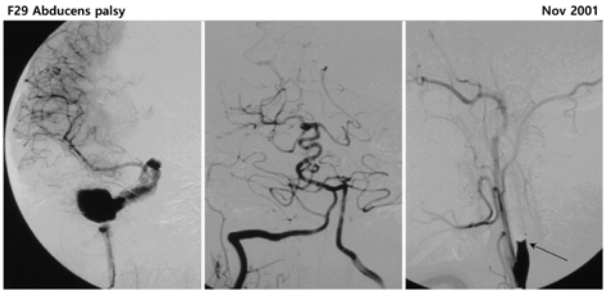
- **Posterior circulation, 17 patients**
  - **VA (13), VB junction (1), BA (1), PCA (1), PICA (1)**
  - **Previously treated, 8 patients**

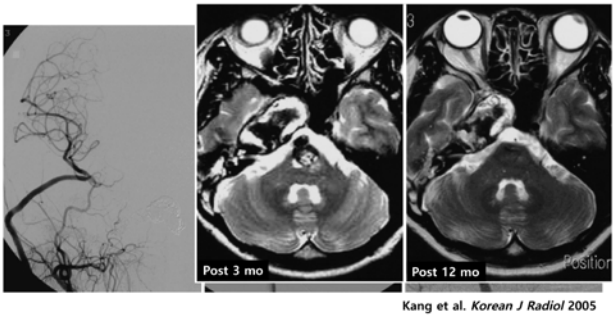
- **Sole stenting (*illustrative cases*)**

FDS for Posterior Circulation Disease
- SNUH experiences -

- **BA (1)** → retreatment, retreatment → stent thrombosis
- **PCA (1)** → small residual @6mo
- **VB junction (1)** → small residual @6mo
- **PICA (1),** no FU imaging yet
- **VA (13)**
  - **complete occlusion (8**; 1 stent thrombosis after other An. op.)
  - **small residual (2**; 1 after retreatment)
  - **spiral residual (1)**
  - no FU imaging yet (2)

FD for Basilar Trunk Giant Aneurysm





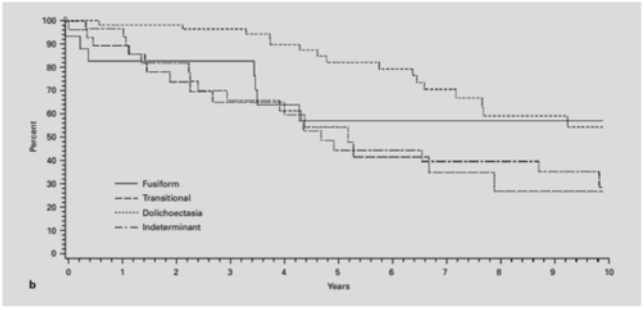


Table 3. Comparison of outcome in VBNIA subtypes

	Dolichoectasia	Fusiform	Transition	Indeterminate	p value
Total of subtype in cohort, n	72	23	31	33	–
Initial symptoms due to NIA	24 (33)	15 (65)	25 (81)	20 (60)	<0.0001
Functional status at last follow-up[1]					0.08
No disability	18 (25)	10 (43)	7 (23)	8 (24)	
Slight disability	15 (21)	2 (9)	4 (13)	6 (18)	
Moderate-severe disability	10 (14)	1 (4)	3 (10)	0	
Dead	22 (31)	8 (35)	16 (52)	19 (58)	
Median survival, years	11.0	NA	5.3	4.8	0.02

Endovascular treatment of **intracranial VBA DA: Parent artery occlusion vs. Flow diverter**

- n=25
- Immediate total occlusion rate after initial treatment (PAO:FD)
→ 62.5% vs. 9.1%, p = .018

- Complete occlusion on follow-up at 18 mo. **81.8%** vs. 55.6%
- Procedure related complication: 28% vs. 24%
- Excellent outcome at discharge: 40% vs. **77.8%**

Fang et al. ***Eur J Radiol*** 2018

Deconstructive and **Reconstructive** Techniques in Treatment of **Vertebrobasilar Dissecting Aneurysms: A Systematic Review and Meta-Analysis**

- n=478

- Deconstructive techniques, higher rates of long-term complete occlusion compared with reconstructive techniques (**88.0%** vs. 81.0%; P < .0001).
- Deconstructive and reconstructive techniques, high rates of good neurologic outcome (86.0% vs. **92.0%**)

Sonmez et al. ***AJNR*** 2015

Impact of aneurysm morphology on safety and effectiveness of FD treatment of VB aneurysms

	Saccular (n=25)	Fusiform (n=64)
Location	BA (15), VB junction (5), VA (5)	BA (26), VBA (27), VA (11)
Age; Sex (m:f)	51.1yrs; 24%:**76% [F]**	53.8yrs; **61%**:39% **[M]**
Treatment [No. of FD]	**[1]** PED (15), Silk (10); Coil (12); one VA sacrifice (4)	**[3]** PED (54), Silk (9), Surpass (1); Coil (18); one VA sacrifice (12)
Neurologic complication	**36%** - stroke, IPH, in-stent thrombosis	**35%** - stroke, TIA, IPH, aneurysm rupture
Complete occlusion	**71%**	**52%**
Complete or Near-complete occlusion	88%	71%
Good clinical outcome	**82%**	**60%**

Wallace et al. ***J Neuroradiol*** (in press)

●Complication

	Aneurysm location			
Aneurysm Size	**BA**	**VA**	**VB**	**Total**
Small (< 6 mm)	0	0	1/1	100% (1/1)
Medium (7–15 mm)	2/7	0/8	2/7	18% (4/22)
Large (16–25 mm)	2/7	1/3	1/4	29% (4/14)
Giant (> 25 mm)	6/12	0	4/6	56% (10/18)
Total	38% (10/26)	9.1% (1/11)	44% (8/18)	35% (19/55)

Wallace et al. ***J Neuroradiol*** (in press)

●Angiographic occlusion

	Aneurysm location			
Aneurysm size	**BA**	**VA**	**VB**	**Total**
Small (< 6 mm)	0	0	0/1	0% (0/1)
Medium (7–15 mm)	3/5	8/8	11/14	82% (22/27)
Large (16–25 mm)	4/5	2/2	3/5	75% (9/12)
Giant (> 25 mm)	5/10	0	4/6	56% (9/16)
Total	60% (12/20)	100% (10/10)	69% (18/26)	71% (40/56)

Wallace et al. ***J Neuroradiol*** (in press)

Impact of aneurysm morphology on safety and effectiveness of **FD treatment of VB aneurysms**

- Flow diversion is an option for the treatment of saccular posterior circulation aneurysms that cannot be treated with conventional strategies.
- Flow diversion of **fusiform basilar** aneurysms, particularly those that are **giant or symptomatic**, is likely less effective and higher risk than flow diversion of fusiform vertebral artery aneurysms.

Wallace et al. ***J Neuroradiol*** (in press)

Treatment of **posterior circulation non-saccular** aneurysms with **flow diverters**

- n=56; 338 FDS (175 PED, 163 p64)
- Dolichoectasia (10.3%), fusiform (41.3%), **transitional** (48.2%)
- **VB** (44.8%), VA (29.3%), BA (18.9%)

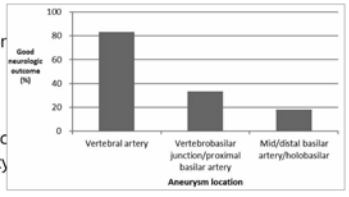
- Angiographic occlusion, 57.4%
- Complication, 15.5% (ischemic, traumatic IVH, cerebellar hemorrh.)
- 9 pts (15.5%) died during FU (in-stent thrombosis, SAH, mass effect, ischemic)

- **Early treatment** prior to the development of symptoms, ***fusiform*** and ***transitional*** subtypes
- **Regular imaging follow-up,** for **asymptomatic** ***dolichoectasia***.

Bhogal et al. ***J Neurointervent Surg*** 2017

Meta-analysis of treatment outcomes of **posterior circulation non-saccular aneurysms by flow diverters**

- n=129; No. of FD, 4.33
- Immediate complete or near cor
- Long-term occlusion, **52%**



- Periprocedural stroke, 23%
- Good long-term neurologic outc
- Overall mortality, 21%; Morbidity
- Retreatment, 5%
- Good neurologic outcome rate, higher in VA aneurysms (**83%**) than other locations (18-33%)

Kiyofuji et al. ***J Neurointervent Surg*** 2018

Flow Diversion for Posterior Circulation Aneurysms (large/giant/dissection/fusiform) – My Impression

- **FD seems to be effective for patients with VADA.**
- **FD can be especially preferred in patients with bilateral VAD.**
- **Response to FD seems to be better in young age patients.**
- **Clinical patients' condition seems to be an important prognostic indicator.**

- **Other treatment options should be kept in mind all the time, which include surgery (w/ or w/o bypass), segmental occlusion, and flow reversal.**

3. How to prevent and get out of complications due to FD

김성림 (가톨릭대)

4. How to do? medication & imaging follow-up for FD

김태곤 (차의과학대)

How to do? medication & imaging follow-up for FD

Tae Gon Kim, M.D
Department of Neurosurgery,
CHA Bundang Medical Center,
CHA University School of Medicine

Preprocedural Antiplatelet Therapy

Dual antiplatelet therapy(DAT) must be initiated prior to implantation of FD.

Although these regimens have not been standardized or compared head-to-head in randomized controlled trials,

→ most studies pretreated patients

: for 5–7 days with aspirin 81–325 mg and clopidogrel 75 mg daily,

: in some cases, a loading dose of aspirin 325–600 mg and clopidogrel 300–600 mg is administered hours prior to the procedure

Preprocedural Antiplatelet Therapy

Some individuals show genetic variation resulting in failure to respond to commonly used antithrombotic agents such as clopidogrel.

There is no consensus on the best method to determine adequate preprocedure drug response

Point of service testing devices can be imprecise or inaccurate, and there has been temporal variation in test results.

For this reason, some experts have advocated genetic testing. Some operators do not test for drug effect on platelet aggregation.

may be related medications such as Proton Pump Inhibitors

Procedural Antithrombotics

Using effective heparinization during the case

Having glycoprotein (GP) IIb/IIIa receptor antagonist medications readily available is critical.

Follow-up angiographic runs should be performed frequently to assess for filling defects in the parent artery and stent, and for disappearance of perforator side branches, especially during complex cases.

GP IIb/IIIa inhibitor

Hyperacute and acute thrombi are platelet-rich (so-called "white thrombus")

→ intravenous antiplatelet medications are a first-line approach

The three FDA-approved GP IIb/IIIa receptor antagonists

– abciximab (ReoPro, Eli Lilly Inc.), tirofiban (Aggrastat, Medicure International Inc.), and eptifibatide (Integrilin, Millenium Pharmaceuticals Inc.)

– are potent inhibitors of both platelet cross-linking and aggregation and are well-suited for periprocedural clot disruption

GP IIb/IIIa inhibitors carry a risk of ICH

Abciximab

Abciximab has the most widely used

be administered intravenously (IV) or IA bolus with a rapid bolus at a weight-based dose of 0.25 mg/kg, followed by a continuous maintenance infusion of 125 μg/kg/min (to a maximum of 10 mg/min) for 12 h

an intra-arterial bolus, with the catheter tip directed at or within the obstructing thrombus, often using smaller doses than IV

has a prolonged platelet inhibitory effect which can persist for 8–15 days after infusion of the drug has been discontinued → may be overcome with platelet transfusion

paradoxical drug-induced platelet activation or thrombocytopenia

Eptifibatide

is also administered as either an IA or IV bolus at a dose of 180 μg/kg

may be followed with a maintenance infusion rate of 2 μg/kg/min for 20–24 h at the discretion of the operator

relatively short action durations, with biological half lives of 2–4 h

Clearance is predominantly renal → In cases of renal insufficiency, the doses should be adjusted

While some authors mention platelet transfusion as a potential reversal mechanism for eptifibatide and tirofiban, such measures are ineffective as the circulating drug will simply inactivate the transfused platelets.

Tirofiban

1. is infused at an initial rate of 0.4 μg/min/kg over 30 min and followed by infusion at a rate of 0.1 μg/min/kg over 48 hours

2. an IV loading dose of 25 μg/kg for 3–5 minutes followed by an IV maintenance dose of 0.15 μg/min/kg for more than 48 hours

→ It should be mentioned at this point that these doses have been extrapolated from the cardiology literature, and formal studies in patients with FDS are currently lacking.

Tirofiban

3. Recently, repeatedly given in a loading dose (~4–8 μg/kg or 300 μg) via the IA route of administration for several minutes until the thromboemboli were dissolved, as confirmed on repeated cerebral angiography.

relatively short action durations, with biological half lives of 1.5-2 h

Clearance is predominantly renal → In cases of renal insufficiency, the doses should be adjusted

While some authors mention platelet transfusion as a potential reversal mechanism for eptifibatide and tirofiban, such measures are ineffective as the circulating drug will simply inactivate the transfused platelets.

Fibrinolytics

recombinant tissue plasminogen activator(Actylase) and urokinase

their short half-lives make them well-suited for this application

However, in theory, these drugs may not be as effective as antiplatelet agents such as the GP IIb/IIIa inhibitors

thrombolytics carry a risk of ICH

Postprocedural Antiplatelet Therapy

Dual antiplatelet therapy is typically continued for 6 months after the procedure, at which time clopidogrel may be stopped depending on angiographic and clinical results, while aspirin is typically continued indefinitely

In published series, thromboembolic complications, including in-stent thrombosis, have occurred upon stopping clopidogrel even after 3 months of follow-up (De Vries J et al. Stroke 2013;44:1567–1577), even may be encountered when clopidogrel is discontinued at 6 months

Patients with stenosis after device implantation seem to be at a high risk of in-stent thrombosis upon discontinuation of clopidogrel.

Postprocedural Antiplatelet Therapy

The use of platelet aggregation tests and thromboelastography to measure medication resistance is controversial.

The decision to use ticagrelor, ticlopidine, cilostazol, or other antiplatelet medications in patients resistant to clopidogrel undergoing flow diverter implantation is based on data that have primarily been extrapolated from the cardiology literature.

The need for antiplatelet therapy also complicates the use of flow diverters for the treatment of ruptured aneurysms in the acute period.

Postprocedural Complications
- Perianeurysmal Edema -

Symptomatic improvement has been noted following administration of corticosteroids,

However, steroids have not been systematically studied in this setting and their response has been variable and no guidelines exist on which patients should receive such therapy.

Associated pathology, which may need treatment

: hydrocephalus, aseptic or chemical meningitis, and seizures

Delayed Complications
- Delayed Hemorrhage -

Usually beyond 48 h after procedure – ICH and SAH

may be critical, and develop in 3 and 4% of cases

To date, there is no consensus on the management of such delayed hemorrhages.

Risks should be weighed between discontinuing antiplatelet therapy to prevent hematoma expansion, and the potential to develop in-stent thrombosis

Platelet transfusion or Desmopressin (DDAVP, arginine vasopressin) for preventing hematoma expansion -- unclear.

The time of restarting DAPT should be made on a case by case basis.

Delayed Complications
- Delayed Aneurysm Rupture -

Delayed aneurysmal rupture is observed primarily in very large and giant symptomatic aneurysms and may be related to intra-aneurysmal thrombosis.

Despite successful FDS placement, aneurysm rupture occurred in 3.2% - 4% of cases (O'Kelly et al, AJNR 2013; 34: 381–387; Brinjikji W, Stroke 2013;44:442–447)

To date, there is no consensus on the management

Ikeda et al. (Interv Neuroradiol 2015; 21: 674–683) suggest that a hemodynamically unstable period may exist during the process of complete aneurysm thrombosis after flow diversion. During this time, blood pressure management and appropriate antiplatelet therapy may be important.

Delayed Complications
- Delayed Parent Vessel Occlusion -

In a case series of 29 patients with 34 aneurysms treated with FDS at 6-month follow-up, 8 (33%) patients had parent vessel stenosis that mostly occurred (5 of 8) when the distal end of the stent was placed within an artery that had a significantly smaller diameter than the proximal artery (Interv Neuroradiol 2013; 19: 432–437)

The degree of antiplatelet effectiveness was not routinely evaluated in these cases, but such monitoring could be useful to reduce this complication.

Endoluminal stenosis of a flow-diverting device may be treated with angioplasty

Follow-up Imaging

No data exist on the long-term (>10 years) stability of aneurysms treated by means of flow diverters.

Late recurrences should be unlikely in these cases because of neointimal coverage of the aneurysm neck along the metal surface; however, the longest published follow-up results are ≤56 months and 41 months for flow diverters (Chiu AH et al, AJNR 2015;36:1728–1734)

→ Data on long-term stability are needed for these treatment modalities.

Follow-up Imaging

1. Digital subtraction angiography
   -- the gold-standard test
   -- high temporal and spatial resolution,
   -- existing risk due to invasive character although it is low.

Table 2. Imaging Modalities Accuracies for Follow-Up in Regard to the Device Used

	DSA	CE-MRA	TOF-MRA	Radiographs	CTA
Coils	+++	+++	+++	+	?
Stent	+++	++	+	?	+
Flow diverter	+++	++	+	?	+
Flow disrupter	+++	++	+	?	?

+++ indicates excellent accuracy, recommended modality for routine follow-up; ++, moderate accuracy, can be used in specific cases; +, low accuracy, limited place in routine actually; ? not evaluated; CE-MRA, contrast-enhanced magnetic resonance angiography; CTA, computed tomographic angiography; DSA, digital subtraction angiography; and TOF, time-of-flight.

Follow-up Imaging

Several grading systems have been proposed to evaluate the success of the endovascular intervention

: Raymond–Roy occlusion classification (RROC) → it was not designed to predict recurrence (Roy D, Stroke 2001;32:1998–2004)

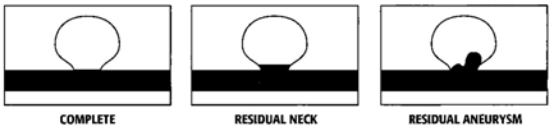
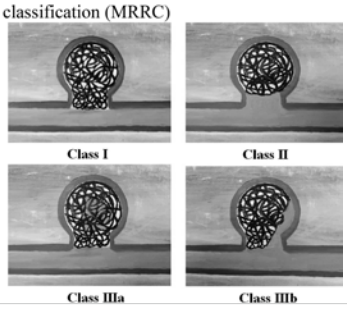


Figure 2. Classification of angiographic results: class 1, complete obliteration; class 2, residual neck; and class 3, residual aneurysm. See Subjects and Methods for details.

Follow-up Imaging

Modified Raymond–Roy classification (MRRC)

Figure 1 Modified Raymond–Roy Classification (MRRC). Class I: complete obliteration; Class II: residual neck; Class IIIa: residual aneurysm with contrast within coil interstices; Class IIIb: residual aneurysm with contrast along aneurysm wall.



Follow-up Imaging

In clinical practice, imaging follow-up of patients

: Aneurysm occlusion may take up to 6–12 months after a FD is placed as endothelialization occurs.

: at least 1 DSA examination, often performed between 6 and 12 months after the embolization, when stopping 1 antiplatelet therapeutic is considered.

: An MRA is simultaneously performed for further comparison in follow-up imaging.

: In case of in-stent stenosis or no good flow through the stent seen on MRA, a new DSA will be necessary to confirm or refute MRA findings.

Follow-up Imaging

In clinical practice, imaging follow-up of patients

: If the diagnosis of in-stent stenosis pattern is confirmed, a close follow-up with a yearly DSA (or more in case of neurological symptoms) will monitor potential modifications.

: Different evolution depending on the pathomechanism of the stenosis can be observed and will determine further monitoring.

: Clot deposits into the stent mesh will quickly disappear after the addition of a supplementary antiaggregant (leading to space the follow-up), whereas in the case of endothelial hyperplasia, the stenosis will continue to increase (leading to pursue the close follow-up).

Follow-up Imaging

2. Magnetic resonance imaging (MRI)

-- to assess aneurysm thrombosis, cerebral edema, and mass effect

-- sometimes, hyperintense signals on Flair MRI with circumferential contrast enhancement may indicate aneurysmal inflammation as a local response to flow-diverter therapy

-- In a recent study, Attali et al found that at 3T, aneurysm recurrence can be detected using CE-MRA with a sensitivity of 83% and a specificity of 100% when compared with TOF-MRA with sensitivity and specificity values of 50% and 100%, respectively

-- However, both techniques performed poorly with regard to the evaluation of the vessel lumen.

Follow-up Imaging

2. Magnetic resonance imaging (MRI)

-- Time resolved CE-MRA also showed better results than TOF-MRA (sensitivity of 96% and specificity of 85%) for aneurysm occlusion confirmation but overestimated luminal stenosis and demonstrated lower quality vessel reconstruction images when compared with DSA.

Follow-up Imaging

3. Computed tomography angiography (CTA)

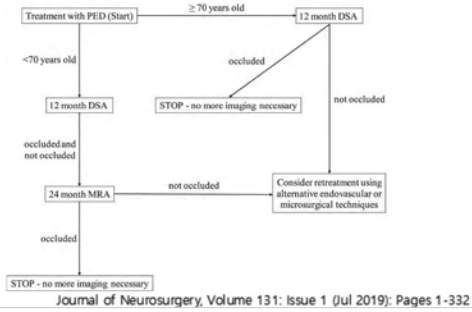
-- lower spatial resolution and beam hardening artifact caused by metallic implants, which leads to degradation of image quality and limited utility

-- Flat panel detector CTA with intravenous contrast injection allows imaging of cerebrovascular anatomy with decreased contrast quantity and osmolarity, and less radiation exposure time → the resolution of the image remains a limiting factor.

HARVARD MEDICAL SCHOOL

Beth Israel Deaconess Medical Center

Proposed follow-up imaging strategy for patients treated with the Pipeline flow diversion



Journal of Neurosurgery, Volume 131: Issue 1 (Jul 2019): Pages 1-332

Summary

1. The periprocedural antiplatelets and anticoagulants therapy is basically similar to that of conventional stent-assisted coiling.
2. Dual antiplatelet therapy is typically continued for 6 months after the procedure, at which time clopidogrel may be stopped depending on angiographic and clinical results, while aspirin is typically continued indefinitely.
3. At least 1 DSA examination, often performed between 6 and 12 months after the embolization, when stopping 1 antiplatelet therapeutic is considered.
4. An MRA is simultaneously performed for further comparison in follow-up imaging.

SESSION IV. Round table panel discussion, How I do it?

좌장: 윤석만 (순천향대), 임용철 (아주대)

Panel: 이창영 (계명대), 신용삼 (가톨릭대), 권오기 (서울대), 김성림 (가톨릭대), 강현승 (서울대)

1. Unruptured basilar fusiform aneurysm, How I do it?	임종국 (제주대)
2. A giant aneurysm on vertebrobasilar junction: How I do it?	신희섭 (경희대)
3. Endovascular treatment using coil versus flow diverter stent for vertebrobasilar aneurysm	이종영 (한림대)
4. Parent artery occlusion for giant intracranial aneurysm in a 11–year–old girl	김영우 (가톨릭대)
5. Endovascular treatment of ruptured fusiform aneurysm of the basilar artery	김대원 (원광대)
6. Multi–session endovascular treatment of ruptured recurrent M1 dissecting aneurysm	이재일 (부산대)

1. Unruptured basilar fusiform aneurysm, How I do it?

임종국 (제주대)

Objective: Although flow diverter is another choice of treatment in giant aneurysms, there is a lot of risk during procedure as well as periprocedural period. The fantastic rationale attracts the choice of treatment modalities and many interventionists try to treat giant aneurysms. The purpose of this case report is to describe rapid progression on giant basilar trunk aneurysm after FRED stenting.

Methods: A 72-years-old male visited neurosurgical department. The main complaint was gait disturbance that started one month ago. That was the traditional symptom of hydrocephalus. He has not heard hear anything and spoken well since 18 years ago due to cerebral infarction. After the first contact to regional clinics, further evaluation and treatment were recommended.

Results: Ventriculoperitoneal shunt was performed for hydrocephalus and GCS was decreased from 14 to 13 postoperatively. Antiplatelet medication was started for flow diversion and the aneurysm was treated with FRED flow-diverter after 6 days. GCS was E1VeM3 postprocedurally and left 5th and 7th nerves palsy were presented. Follow up magnetic resonance image was showed intraluminal thrombus formation and compressed brainstem was relieved slightly. On 4th postprocedural day, mentality was comatose and computed tomography was presented subarachnoid hemorrhage and intraventricular hemorrhage. Flow diversion was showed well in follow up TFCA. Despite of further medical management, patient was expired.

Conclusions: Alternative management for giant aneurysms is flow diversion and other papers may be presented good results. However, we consider giant aneurysms that locate in posterior circulation. Sometimes the disaster will be encountered after flow diversion. Further experiences and devices may be needed.

KEY WORDS: unruptured intracranial aneurysm, giant, flow diverter, basilar artery

2. A giant aneurysm on vertebrobasilar junction: How I do it?

Hee Sup Shin, Jun Seok Koh, Chang Woo Ryu

Division of Endovascular Neurointervention, Kyung Hee University Hospital at Gangdong
Kyung Hee University School of Medicine, Seoul, Korea

Safety of traditional EVT Vs efficacy & durability of flow diverter ???

A 65-year-old female patient presenting dizziness and swallowing difficulty showed a giant aneurysm at the vertebrobasilar junction that compressing the brain stem on her CT and MR exam.

First EVT was done with double stent assisted coiling via the Lt. VA to BA followed by trapping of the Rt. VA for reducing blood flow to aneurysm sac. The 6-month follow-up TFCA showed recanalization of the upper part of aneurysm, and thus second EVT was performed with booster coiling. During the follow-up her dizziness and swallowing difficulty were disappeared. Repeated recurrence was observed on 2-year follow-up MRA and thus third coil insertion procedure was done with no complications.

The 4-year follow-up TFCA after third EVT showed no further recanalization. The patient lives well nowadays except intermittent dizziness.

3. Endovascular treatment using coil versus flow diverter stent for vertebrobasilar aneurysm

Jong Young Lee[1], Hong Jun Jeon[1], In-Ho Oh[2], Sun Ju Lee[2]

1 Department of Neurosurgery, Kangdong Sacred Heart Hospital, Hallym University College of Medicine, Seoul, Korea 2 Department of Neurosurgery,4 Veterans Health Service Medical Center, Seoul, Korea

Purpose: To discuss cases of vertebrobasilar aneurysms treated by using flow diverter or conventional endovascular techniques.

Cases

We present 2 cases of vertebral dissecting aneurysm. One case was treated using endovascular internal trapping of the dissecting segment using coils, and the other case was treated using flow diverter. All of two procedures were done without periprocedural complications. The patient of the first case was recovered without any neurologic deficits. The patient of the second case has been suffered from quadriplegia, fecal and urinary incontinence due to cervical cord infarction.

We present the other 2 cases of large vertebrobasilar aneurysm. One case was treated using stent assisted coil embolization, and the other case was treated using flow diverter. All of two procedures were done without periprocedural complications. The patients treated using stent assisted coil embolization has been followed-up for 5 years without retreatment. The patient treated using flow diverter suffered from subarachnoid hemorrhage due to stent migration into the aneurysm sac. Additional interventional procedure was tried, however, it was impossible to occlude aneurysm sac and parent artery.

Discussion: All 2 case of flow diverter stent showed fatal complications. Even though the flow diverter procedures could be done without any procedural complications, unexpected complications could be developed. Furthermore, there are few ways to resolve them in cases complications were recognized. Considering these unsolvable unexpected fatal complications, we should be discreet to use flow diverter stent in cases of vertebrobailar aneurysms.

4. Parent artery occlusion for giant intracranial aneurysm in a 11-year-old girl

김영우 (가톨릭대)

A 11-year-old girl with lipodystrophy was admitted with Rt. side 3rd, 6th N. palsy and severe headache. She also presented with Lt. side subjective weakness.

Magnetic resonance imaging (MRI) demonstrated a round mass causing a flow void in the right cavernous sinus, which had expanded laterally and displaced the right temporal lobe.
Cerebral angiography demonstrated giant aneurysm on the ant. genu of cavernous ICA, measuring 25 x 24.1mm and fusiform dilatation on the post. genu of cavernous ICA.
Collateral flow via the anterior communicating artery (ACoA) from the contralateral ICA and the posterior communicating artery (PCoA) from the post. circulation was noted through an ipsilateral ICA compression test. A manual ICA compression test showed a about 1.5-second venous drainage delay in the ipsilateral ICA

Proximal and distal ICA occlusion (like surgical trapping) was planned in order to reduce the space-occupying effect of the aneurysm. Cavernous ICA, just proximal to giant aneurysm, was occluded by detachable coils, and then, distal ICA, between PCoA and giant aneurysm, was occluded by detachable coils.

She gradually recovered from cranial N. palsy, and MRI 6 months later showed that the space-occupying effect had disappeared and that the right cavernous ICA aneurysm had decreased in size.

5. Endovascular treatment of ruptured fusiform aneurysm of the basilar artery

Dae-Won Kim, Sung-Don Kang
Department of Neurosurgery, Wonkwang University Hospital

Fusiform aneurysms present a unique challenge to traditional microsurgical and endovascular treatment because of the lack of a discernible neck and the involvement of parent vessel. Flow diversion has increasingly become the treatment of choice for fusiform aneurysms in the anterior circulation, but its results in the posterior circulation are variable. We report successful treatment of ruptured fusiform basilar aneurysms with the flow diversion following coiling, and discuss the treatment of fusiform basilar aneurysms.

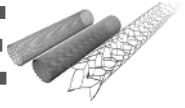
6. Multi-session endovascular treatment of ruptured recurrent M1 dissecting aneurysm

이재일 (부산대)

Middle cerebral artery first segment (M1) dissecting rupture is extremely rare and challenge to treat because of numerous perforators. We reported successful multi-session (5 sessions) endovascular treatment of ruptured M1 dissection in young female.

ENDOVASCULAR NERUOSURGICAL SYMPOSIUM UPDATE on CBF REDIRECTING ENDOPROSTHESIS

ENSURE



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  [J Med Pharma Sci 1992;28(1):178~85]
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  [CURRENT THERAPEUTIC RESEARCH® VOL.61,NO.7,JULY 2000]
- 야간에 과도한 강압을 하지 않으며 새벽의 혈압 상승을 억제합니다.
  [Blood Press Monit 2002;7(1):63~5]
- 지질대사와 동맥경화지수를 개선합니다.
  [Suzuki S.: Rinsho to Kenkyu, 67(11),303,1990]
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  [Kitajima K.,et al.: Jin to toseki, 29(5),89,1990]
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  [Prog Med 1995;15(11):2378~82]

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