UB NS University at Buffalo Neurosurgery

JACOBS INSTITUTE

The Progress in Endovascular Management of Intracranial Aneurysms

Gates Vascular Institute

Adnan H. Siddiqui, MD, PhD

Professor & Vice-Chairman Neurosurgery,
SUNY University at Buffalo
Director Neurosurgical Stroke Service, Kaleida Health
Chief Medical Officer, Jacobs Institute

&

Aquilla Turk, DO

Professor of Neurosurgery & Radiology
Chief of Stroke Service
Chief of Neuroendovascular Program
Medical University of South Carolina

TOSHIBA STROKE & VASCULAR RESEARCH CENTER

Kaleida Health
Building a healthier future

University at Buffalo
State University of New York

UB University at Buffalo NEUROSURGERY

GDC Approved 510K September 1995

Device Name

Guglielmi Detachable Coil (GDC), Class III.

GDC (K951256)	for embolizing certain intracranial aneurysms that - because of their morphology, their location, or the patient's general medical condition - are considered by the treating neurosurgical team to be a)very high risk for management by traditional operative techniques, or b) inoperable

UB NS University at Buffalo Neurosurgery

We then did the trials

ISUIA 03

	Surgery	Endovascular
Procedural M&M* (Gr. I)	12.6% (Gr. I)	9.1%
(Gr. II)	10.1% (Gr. II)	9.5%

*Endo patients: Older
Larger aneurysms
More posterior circulation

UB NS University at Buffalo Neurosurgery

ISAT

N=2143 (AJ Molyneux)

- RPCT: coils vs. clips
- 44 NS centers
- 1994 start

UB NS University at Buffalo Neurosurgery

ISAT

1 Year Follow Up - 1491 Patients

- Relative risk reduction - coils 24.3%
- $p<0.001$
- Absolute risk reduction 7%

UB NS University at Buffalo Neurosurgery

Available Coil Shapes 510K

Mini Complex

Complex

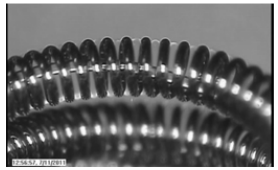
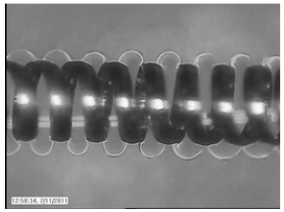
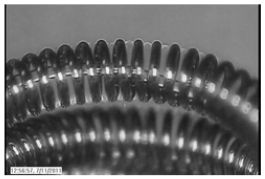
Helical

Available Coil Shapes 510K

Platinum Coils		
Framing		• Cosmos • HyperSoft 3D • Complex
Filling		• VFC • Cosmos • HyperSoft 3D • Helical
Finishing		• HyperSoft • HyperSoft 3D • VFC

New Coil types – Hydrogel 510K

- Hydrosoft and Hydroframe
  - Platinum with hydrogel core
  - Do not expand much, can be retrieved

Framing		HydroFrame
Filling		HydroFill
Finishing		HydroSoft

UB NS University at Buffalo Neurosurgery

Delivery System Comparison

Manufacturer	Coil Attachment Point	Delivery System Design
Codman Neurovascular		Soft Tube → Hydraulic
Micrus Endovascular		Wire → Electrolytic
Boston Scientific		Wire → Electrolytic
Microvention / Terumo		Wire → Electrolytic
eV3		Wire → Mechanical

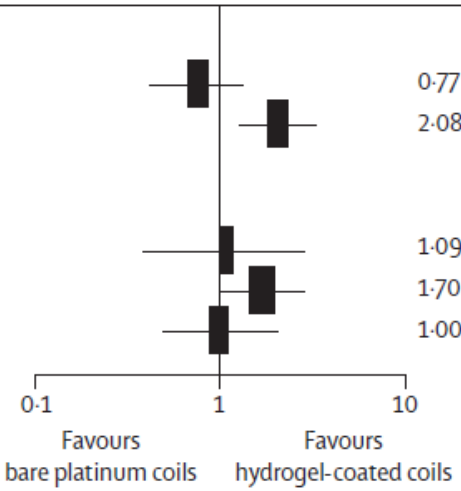
UB NS University at Buffalo Neurosurgery

We then did the trials

Hydrogel-coated coils versus bare platinum coils for the endovascular treatment of intracranial aneurysms (HELPS): a randomised controlled trial

*Philip M White, Stephanie C Lewis, Anil Gholkar, Robin J Sellar, Hans Nahser, Christophe Cognard, Lynn Forrester, Joanna M Wardlaw, for the HELPS trial collaborators**

	Hydrogel (n/N)	Bare platinum (n/N)	OR (95% CI)	p value
Rupture status				
Unruptured	75/105 (71%)	85/111 (77%)	0·77 (0·42–1·41)	0·014
Ruptured	83/123 (68%)	64/128 (50%)	2·08 (1·24–3·46)	
Aneurysm size (mm)				
2·0–4·9	27/38 (71%)	27/39 (69%)	1·09 (0·41–2·90)	
5·0–9·9	103/134 (77%)	90/136 (66%)	1·70 (0·99–2·90)	0·458
10·0–24·9	28/56 (50%)	32/64 (50%)	1·00 (0·49–2·05)	



Interpretation Whether use of hydrogel coils reduces late aneurysm rupture or improves long-term clinical outcome is not clear, but our results indicate that their use lowers major recurrence.

UB NS University at Buffalo Neurosurgery

AJNR
AMERICAN JOURNAL OF NEURORADIOLOGY

Review of 2 Decades of Aneurysm-Recurrence Literature, Part 1: Reducing Recurrence after Endovascular Coiling

E. Crobeddu, G. Lanzino, D.F. Kallmes, and H.J. Cloft

The most progress has come about from improvements in initial angiographic results through the use of balloon remodeling, adjunctive stent placement, and a wider selection of coils.

New Coil types – Bioactive Coils 510K

- Polyglycolic-Polylactic Acid (PGLA)
  - Incites inflammation and thrombosis
- Matrix Coils
  - Platinum coil with PGLA
  - Packing density decreases over time
- Cerecyte Coils
  - Platinum coils around polyglycolic acid (PGA) filament
- Nexus Coils
  - Platinum coils with PGLA filaments that extend out as small hairs

UB NS University at Buffalo Neurosurgery

We then did the trials

AJNR
AMERICAN JOURNAL OF NEURORADIOLOGY

ORIGINAL RESEARCH
INTERVENTIONAL

Bioactive versus Bare Platinum Coils in the Treatment of Intracranial Aneurysms: The MAPS (Matrix and Platinum Science) Trial

C.G. McDougall, S. Claiborne Johnston, A. Gholkar, S.L. Barnwell, J.C. Vazquez Suarez, J. Massó Romero, J.C. Chaloupka, A. Bonafe, A.K. Wakhloo, D. Tampieri, C.F. Dowd, A.J. Fox, S.J. Imm, K. Carroll, and A.S. Turk, for the MAPS Investigators

MATERIALS AND METHODS: This was a multicenter randomized noninferiority trial with blinded end point adjudication. We enrolled 626 patients, divided between Matrix^2 and bare metal coil groups. The primary outcome was target aneurysm recurrence at 12 $\pm$ 3 months.

CONCLUSIONS: Tested Matrix^2 coils were not inferior to bare metal coils. Endovascular coiling of intracranial aneurysms was safe, and the rate of technical success was high. Target aneurysm recurrence is a promising clinical outcome measure that correlates well with established angiographic measurements.

Cerecyte Coil Trial

Angiographic Outcomes of a Prospective Randomized Trial Comparing Endovascular Coiling of Cerebral Aneurysms With Either Cerecyte or Bare Platinum Coils

Andrew J. Molyneux, FRCR; Alison Clarke, BA; Mary Sneade, BA; Ziyah Mehta, DPhil; Stuart Coley, FRCR; Daniel Roy, MD; David F. Kallmes, MD; Allan J. Fox, MD

Results—Four hundred ninety-four patients were eligible for analysis. Four hundred eighty-one patients underwent coil treatment of their aneurysm, 227 patients with recently ruptured aneurysms and 254 with unruptured aneurysms. Four hundred thirty-three follow-up angiograms were assessed by the core laboratory; 127 of 215 (59%) and 118 of 218 (54%) in the Cerecyte and bare platinum groups, respectively, fulfilled the trial prespecified definition of success, namely that the treated aneurysm showed complete angiographic occlusion, had stable neck remnant, or improved in angiographic appearance compared with the end-of-treatment angiogram ($P=0.17$). Late retreatment was performed in 25 of 452 (5.5%) patients, 17 (7.7%) Cerecyte versus 8 (3.5%) bare platinum ($P=0.064$; range, 4–34 months). The clinical outcomes did not differ between the groups.

Conclusion—There was no significant difference at 6 months in the angiographic outcomes between Cerecyte coils and bare platinum coils when assessed by the core laboratory.

High Recanalization Rate was Observed in Published Coiling Studies Treating Wide-Necked and/or Large and Giant Aneurysms Outcomes

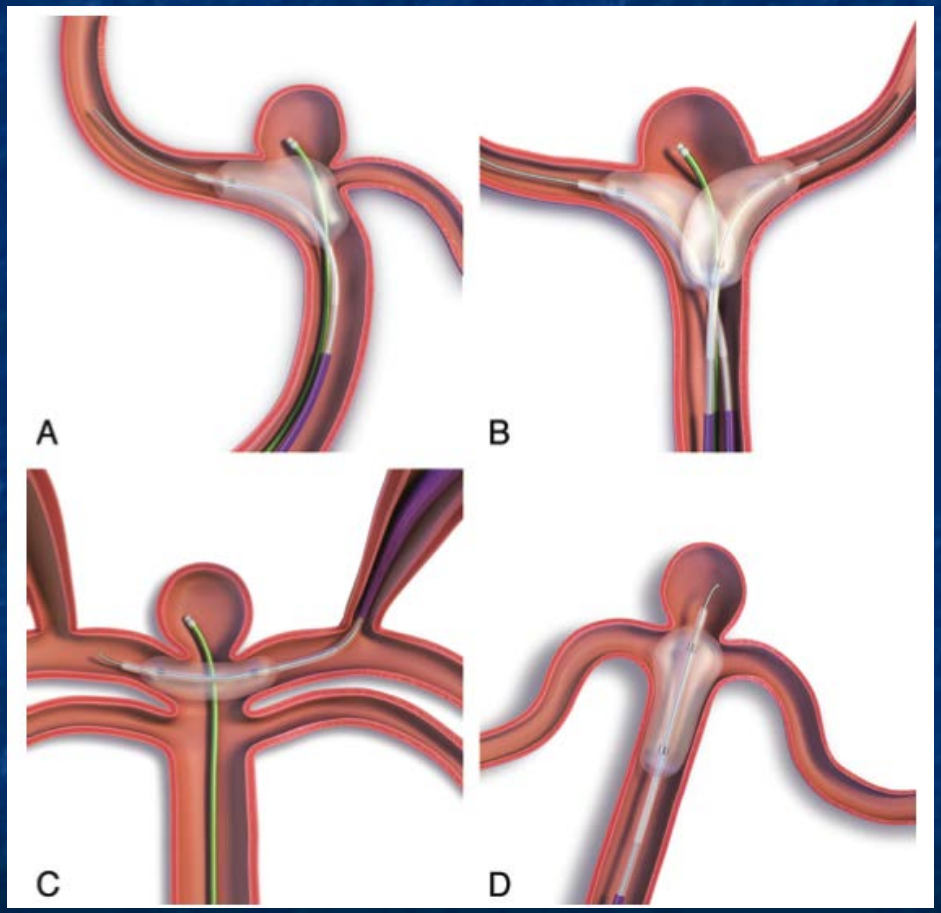
Author	Year	N	Size	100% Occlusion Rate	Neck Remnants	Morbidity	Mortality	Follow-Up Time	Recanal. Rate (# Follow ups)	% Retreat
ISAT[14]	2002	Endovascular Arm: 1073	Small	92.0%	Not Reported	125/801 (1 year) 15%	65/801 (1 year) 8%	1 year	N/A	N/A
			Large	8.0%						
Berenstein[17]	2006	27	Small Wide-Neck	33%	41%	5.8%	0%	5.3 Months (11/30)	57% (4/7)	12%
		32	Large	13%	38%				27% (6/22)	
		3	Giant	0%	67%				100% (1/1)	
Murayama[15]	2003	245	Small Wide-Neck	41%	46%	4.8%	5.7%	11 months (489 / 916)	20% (NR)	Not Reported
		198	Large Wide-Neck	40%	45%				35% (NR)	
		73	Giant	26%	64%				59% (NR)	
Sluzewski[18]	2003	31	Very Large and Giant	51%	48%	15%	0%	18 months (20/29)	69% (20/29)	58%
Gruber[19]	1999	19	Very Large	42%	Not Reported	20%	0%	30 months (14/25)	50% (8/16)	52%
		12	Giant	42%					67% (6/9)	

M&M Range:
ISAT: 23%
Single Center: 5.8 – 20%

Recanalization Range: 20 – 100%
(5.3 – 24.3 month follow-up)

UB NS University at Buffalo Neurosurgery

Balloon-assisted Coiling 510K



UB NS University at Buffalo Neurosurgery

We then did the trials

Balloon assisted coiling

JNS JOURNAL OF NEUROSURGERY
OFFICIAL JOURNALS OF THE AANS SINCE 1944

CLINICAL ARTICLES

Balloon-assisted coil embolization of intracranial aneurysms: incidence, complications, and angiography results

Menno Sluzewski, M.D., Ph.D., Willem Jan Van Rooij, M.D., Ph.D., Guus N. Beute, M.D., and Peter C. Nijssen, M.D.

CONCLUSIONS

- Balloon-assisted coil embolization(BACE) of intracranial aneurysms is associated with a high complication rate
- The BACE procedure does not improve the occlusion rates of the aneurysms on follow-up evaluation.

Journal of Neurosurgery September 2006 / Vol. 105 / No. 3 / Pages 396-399

UB NS University at Buffalo Neurosurgery

AJNR AMERICAN JOURNAL OF NEURORADIOLOGY

Safety and Efficacy of Adjunctive Balloon Remodeling during Endovascular Treatment of Intracranial Aneurysms: A Literature Review

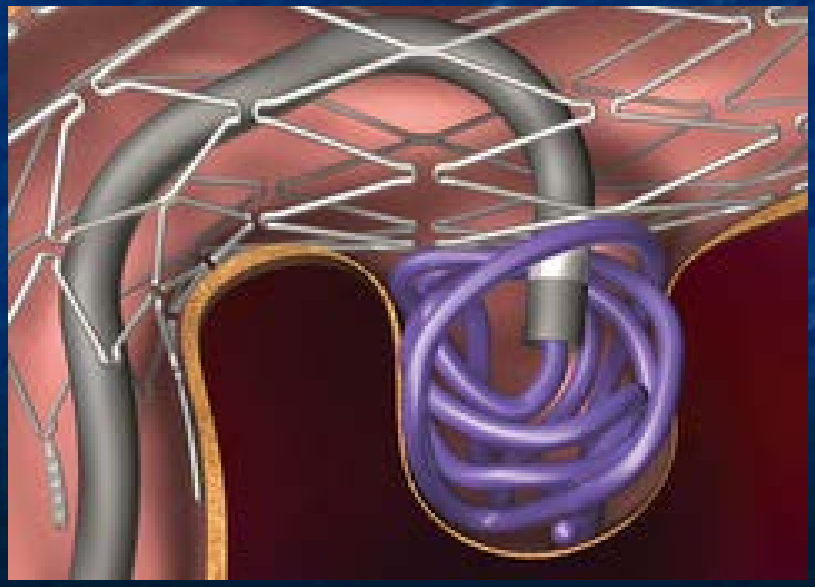
M. Shapiroa, J. Babba, T. Becskea and P.K. Nelsona

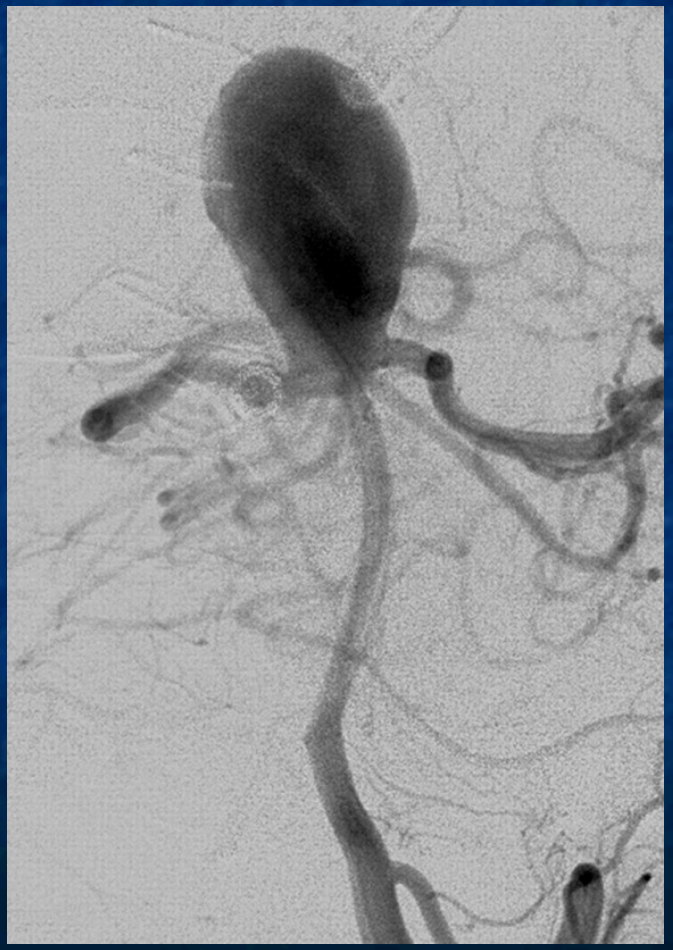
CONCLUSION: This largest-to-date literature review and meta-analysis did not demonstrate a higher incidence of thromboembolic events or iatrogenic rupture with the use of adjunctive balloon remodeling compared with unassisted coiling. Balloon remodeling appears to result in higher initial and follow-up aneurysm occlusion rates.

AJNR October 2008 29: 1777-1781

Self-Expanding Stents

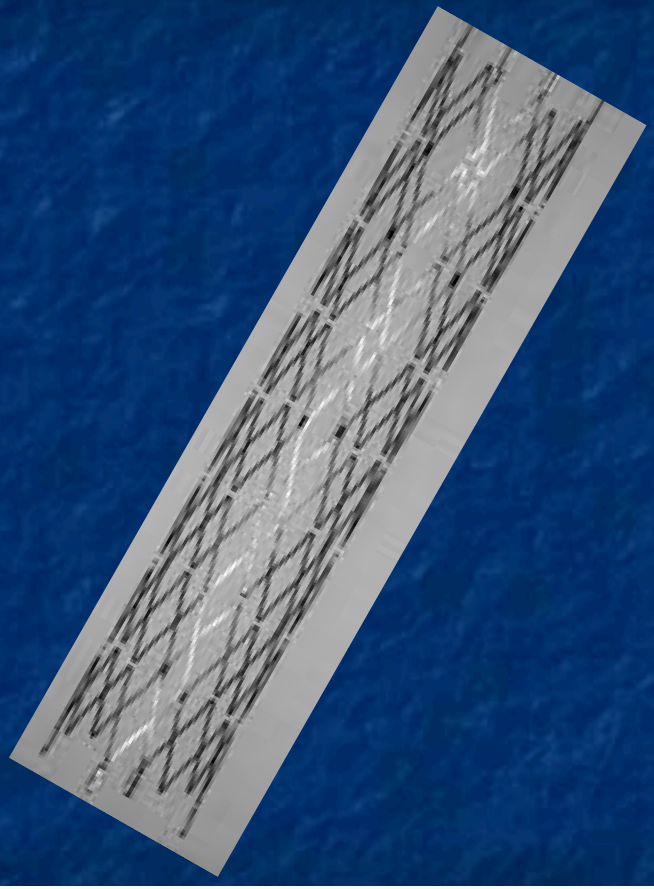
- First developed for the treatment of wide-necked intracranial aneurysms





Neuroform Stent HDE August 2000

- Nitinol
- Over-the-wire technique
- Open-cell design
  - Better conformability around turtuous vessels



The Neuroform™ Microdelivery Stent System is intended for use with embolic coils for the treatment of wide neck, intracranial, saccular aneurysms arising from a parent vessel with a diameter of ≥2mm and ≤4.5mm that are not amenable to treatment with surgical clipping. Wide neck aneurysms are defined as having a neck of ≥4mm or a dome-to-neck ratio of <2.

UB NS University at Buffalo Neurosurgery

29 patient study

Table 2: Serious Device or Procedure-Related Adverse Events

Serious Adverse Event[1]	n (%)
Death[2]	1 (3.4%)
Aneurysm Perforation[2,3]	2 (6.9%)
Arterial Perforation[4]	1 (3.4%)
Subarachnoid/Interventricular Hemorrhage[2,3]	2 (6.9%)
Thromboembolic Stroke[4]	1 (3.4%)
Intracerebral Hematoma[4]	1 (3.4%)
Left Hemiparesis[4]	1 (3.4%)
Intraparenchymal Bleeding[3]	1 (3.4%)
Retroperitoneal Hematoma[5]	1 (3.4%)
Confusion[6]	1 (3.4%)

We learnt from use

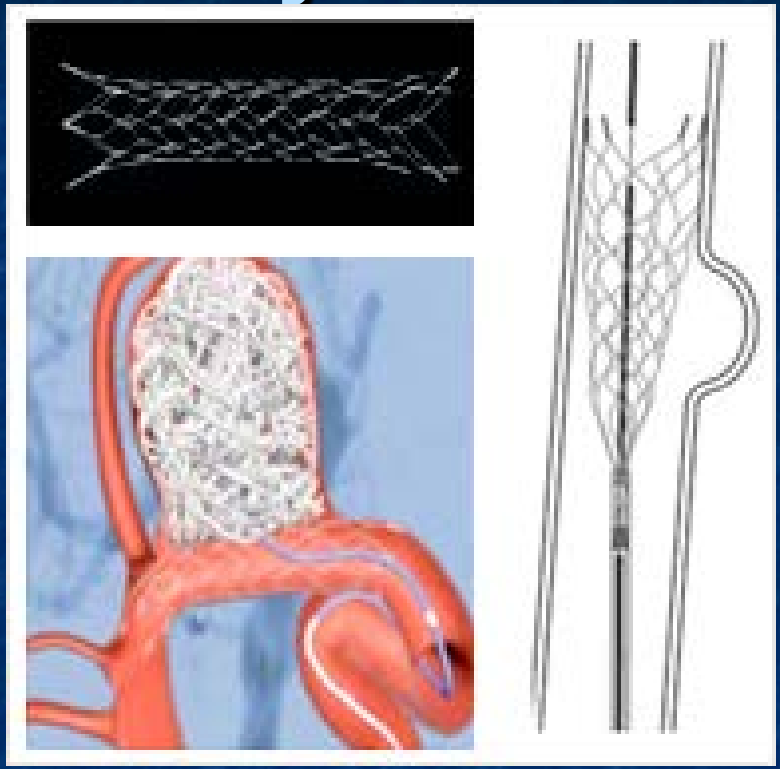
Drawbacks - Neuroform

- Open cell has limited support in large coil masses
  - Potentially allowing herniation into the parent vessel
- Early experience demonstrated increased thrombogenicity, requiring pre-treatment of patients with dual anti-platelet agents (aspirin, clopidogrel)
- Resulting in limited use in acute subarachnoid hemorrhage

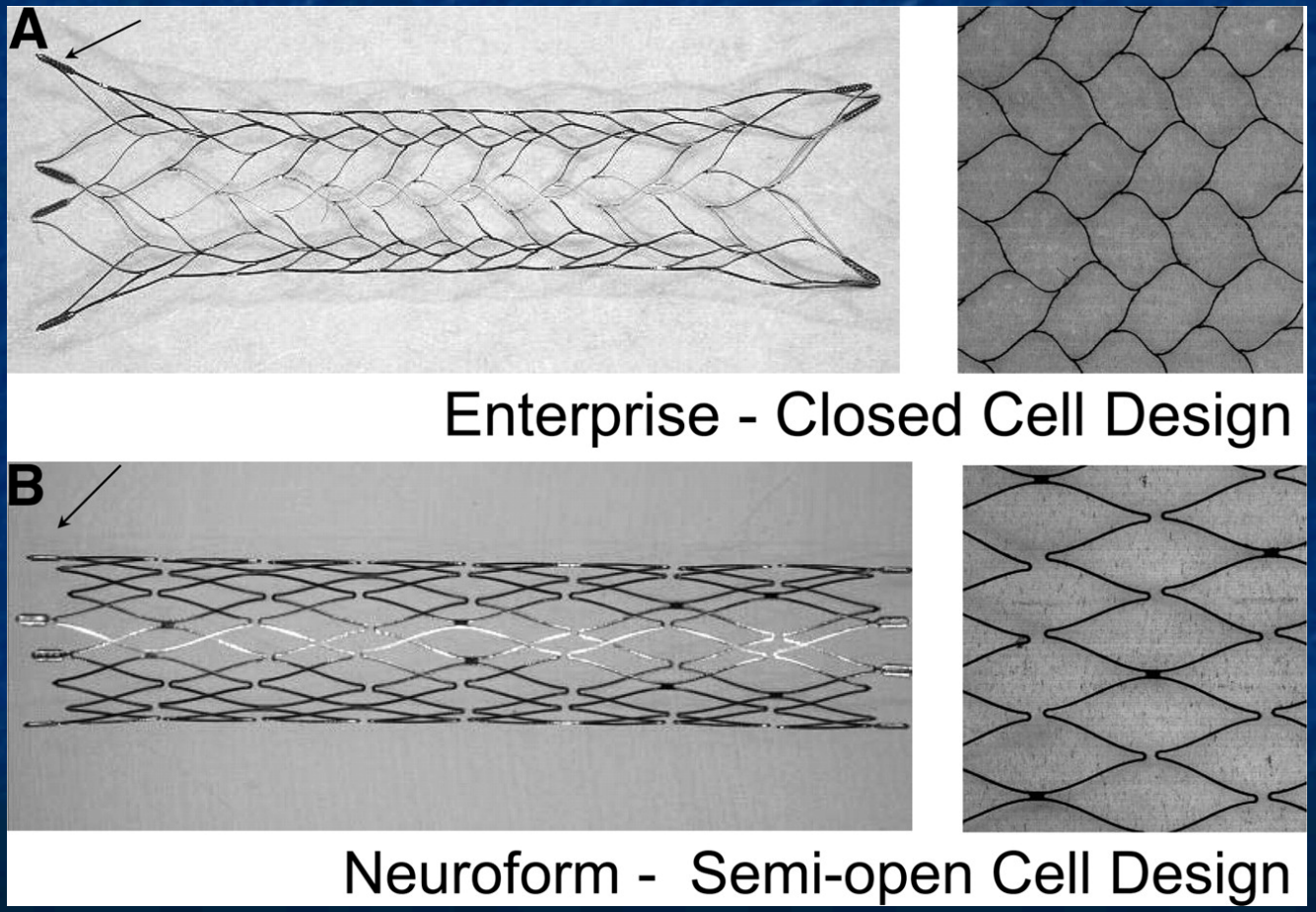
UB NS University at Buffalo Neurosurgery

Enterprise Stent HDE May 2005

- Designed to address the limitations of the open-cell design
- Further support provided to limit coil mass herniation
- Closed-cell design allows for retrieval of stent if necessary



The CORDIS ENTERPRISE™ Vascular Reconstruction Device and Delivery System is intended for use with embolic coils for the treatment of wide-neck, intracranial, saccular or fusiform aneurysms arising from a parent vessel with a diameter of ≥ 3 mm and ≤ 4 mm. Wide-neck is defined as having a neck width ≥ 4mm or a dome-to-neck ratio < 2.



Stroke. 2009; 40: e305-e312

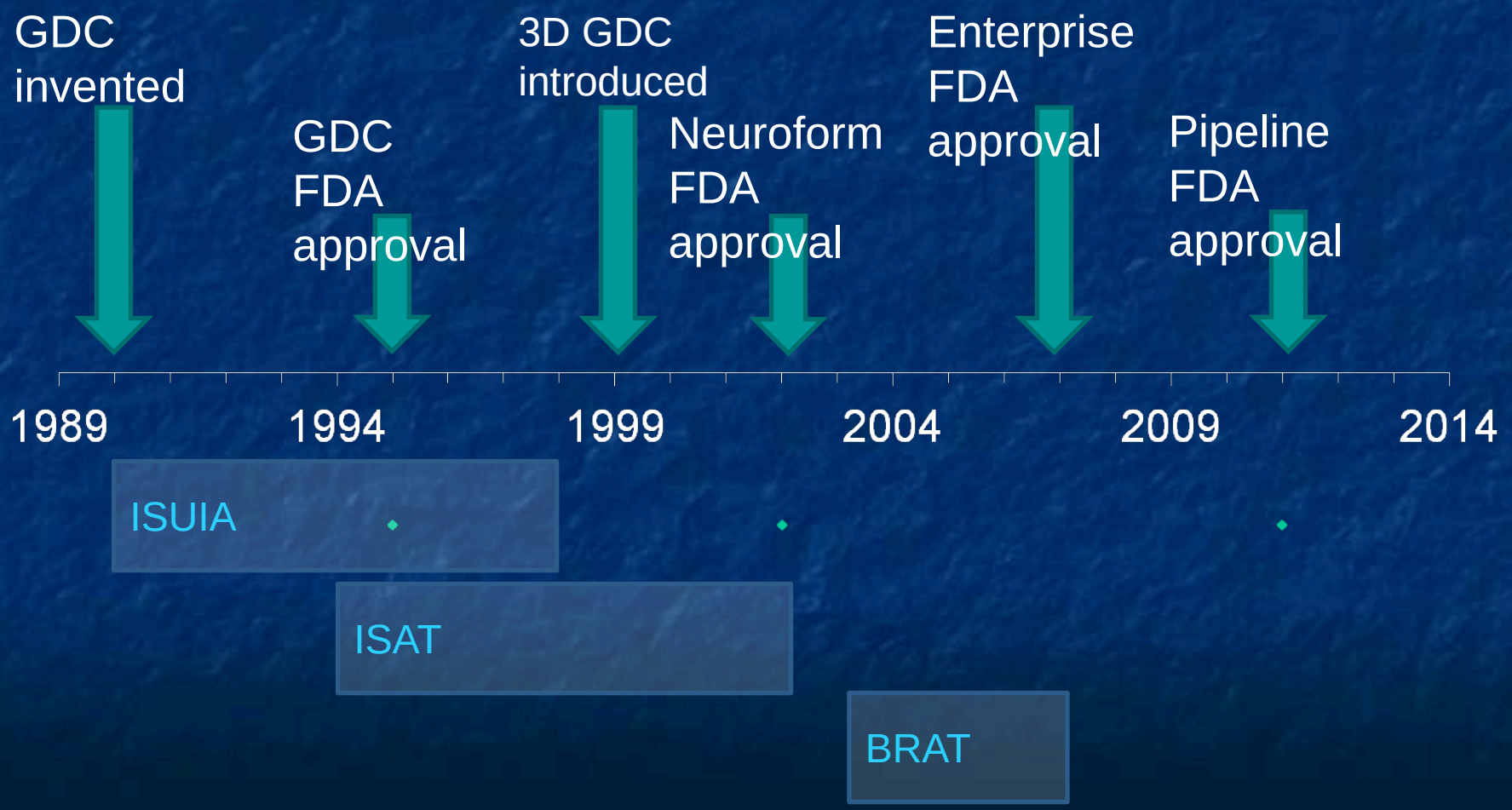
UB NS University at Buffalo Neurosurgery

We then did the trials

Treatment	Study	# ANs Treated	Mean AN Size (mm)	Immediate Complete Occlusion %	Follow-Up Occlusion %	Recurrence %	Recurrence% for LG Giant	Follow-Up %
Stent-Coiling	**Stent-Coiling Meta Analysis/ Shapiro et al, 2012[2]**	1517	65% <10	45%	61% (6 mo)	14%	Not Reported	48.5%
Stent-Coiling	**Mocco et al, 2009**	142	55 were <7, 48 were 7-12, 24 were 12-24, 4 were >25	25%	Not Reported	Not Reported	Not Reported	100.0%
Stent-Coiling	**Mocco et al, 2011**	219	46.6% <7, 31.1% 7-12, 16.9% 12-24, 4.6% >24, 0.9% n/a	Not Reported	40% (6 mo)	Not Reported	Not Reported	50.2%
Stent-Coiling	**Fiorella et al, 2009**	302	Of aneurysms with follow up: 97 small, 57 large, 12 Giant	Not Reported	33.1% (12.9 mo avg)	28%	54%	58.5%
Stent-Coiling	**Piotin et al, 2010**	216	9.7	44% (100/216)	Not Reported	15%	33%	52.7%
Stent-Coiling	**Colby et al, 2011**	41	7	43%	Not Reported	15%	Not Reported	86.7%

Treatment	Study	Avg AN Size (mm)	Patients/ ANs	Follow-up	Overall M&M	Intracranial Hemorrhages
Stent-Coiling	**Stent-Coiling Meta Analysis/ Shapiro et al, 2012[2]**	63% <10	1517/ Not Reported	Not reported	2.1% mortality, 3.2% delayed TIA/stroke	2.2%
Stent-Coiling	**Mocco et al, 2009[8]**	73%<12	141/142	Not reported	8.8% morbidity, 2.8% mortality	3.5%
Stent-Coiling	**Mocco et al, 2011[9]**	79%<12	213/219	110 (52%)	Not reported	Not reported
Stent-Coiling	**Fiorella et al, 2009[10]**	61%<10	284/302	62%	5.3% major stroke/ 3.2% mortality	4 IPH
Stent-Coiling	**Piotin et al, 2010[11]**	9.3	216 (with SAC)	53%	7.4% morbidity/ 6.0% mortality	2.8% -ruptured, 0.5% -unruptured
Stent-Coiling	**Colby et al, 2011[12]**	7.0	30	87%		3.3% -SAH peri procedural

Timeline of Endovascular Development



The problem with stent/coil

- Relatively complex procedures
  - 2 microcatheters, multiple devices
  - Configuration at bifurcations often leaves surgeon wanting for better devices
  - Complication rates on the order of 4-8%
- Recanalization rate is high for large aneurysms treated with coiling

Flow Diverters

- Stents with higher metal coverage and lower porosity than traditional intracranial stents
- Aim to
  - redirect flow through the parent vessel away from the aneurysm
  - provide a scaffold for neointimal growth and healing of the vessel wall

Pipeline for Uncoilable or Failed Aneurysms (PUFs)

- 107 patients treated
- Unruptured aneurysm in the ICA from petrous to superior hypophyseal segments
  - >=10 mm in size and neck >=4 mm
- 81.8% complete occlusion at 180 days with 5.6% of major complications
- 97.8% successful delivery

Based on PUFS…

- In April of 2011, the Pipeline embolization device gained FDA PMA approval for large or giant wide-necked intracranial aneurysms in the internal carotid artery from the petrous to the superior hypophyseal segments

UB NS University at Buffalo Neurosurgery

We then did the trials

Complications associated with Pipeline across different studies

Table 2. Reported Clinically Significant Complications, Morbidity, and Mortality Associated with Pipeline Embolization Device Treatment Across Various Studies

Complications	Lylyk et al., 2009 (21)	Szikora et al., 2010 (33)	Nelson et al., 2011 (27)	Lubicz et al., 2011 (19)	Fischer et al., 2012 (11)	Total
Mass effect	3	0	0	0	0	3
In-stent thrombosis	0	1	0	1*	2†	3
Perforator occlusion	0	0	1	0	0	1
Thromboemoblic event	0	2	0	0	0	2
Intracranial Hemorrhage	0	1†	1	2†	4†	8
Morbidity, n (%)	3 (5)	3 (16.6)	2 (6.4)	1 (5)	4 (4.5)	13 (5.7)
Mortality, n (%)	0	1 (5.5)	0	1 (5)	2 (2.2)	4 (1.9)
Morbidity and Mortality, n (%)	3 (5)	4 (22.2)	2 (6.4)	2 (10)	6 (6.8)	17 (8.1)

*Same patient with more than one complication.
†Mortality case.

Tse at al. WNS 2013

UB NS University at Buffalo Neurosurgery

NEUROSURGERY
THE REGISTER OF THE NEUROSURGICAL MEME

Post-market experience with Pipeline

Peter Kan, MD, MPH*§
Adnan H. Siddiqui, MD, PhD*‡§
Erol Veznedaroglu, MD¶
Kenneth M. Liebman, MD¶
Mandy J. Binning, MD¶
Travis M. Dumont, MD*§
Christopher S. Ogilvy, MD*§||
John R. Gaughen, Jr, MD#
J Mocco, MD**
Gregory J. Velat, MD‡‡
Andrew J. Ringer, MD§§
Babu G. Welch, MD¶¶
Michael B. Horowitz, MD|| ||
Kenneth V. Snyder, MD PhD*‡§
L. Nelson Hopkins, MD*‡§##
Elad I. Levy, MD*‡§

*Department of Neurosurgery and Toshiba Stroke and Vascular Research Center and ‡Department of Radiology, School of Medicine and Biomedical Sciences, University at Buffalo, State University of New York, Buffalo, New York; §Department of Neurosurgery, Gates Vascular Institute, Kaleida Health, Buffalo, New York; ¶Department of Neurosciences, Stroke and Cerebrovascular Center of New Jersey, Capital Health, Trenton, New Jersey; ||Neurovascular Service, Massachusetts General Hospital, Boston, Massachusetts; #University of South Florida, Department of Neurosurgery, Tampa, Florida; **Department of Neurological Surgery, Vanderbilt University Medical Center, Nashville, Tennessee; ‡‡Department of Neurosurgery, University of Florida, Gainesville, Florida; §§Mayfield Clinic, Department of Neurosurgery, University of Cincinnati, Cincinnati, Ohio; ¶¶Departments of Neurosurgery and Neuroradiology, University of Texas South-

Early Postmarket Results After Treatment of Intracranial Aneurysms With the Pipeline Embolization Device: A US Multicenter Experience

BACKGROUND: The Pipeline embolization device (PED) is the latest technology available for intracranial aneurysm treatment.

OBJECTIVE: To report early postmarket results with the PED.

METHODS: This study was a prospective registry of patients treated with PEDs at 7 American neurosurgical centers subsequent to Food and Drug Administration approval of this device. Data collected included clinical presentation, aneurysm characteristics, treatment details, and periprocedural events. Follow-up data included degree of aneurysm occlusion and delayed (> 30 days after the procedure) complications.

RESULTS: Sixty-two PED procedures were performed to treat 58 aneurysms in 56 patients. Thirty-seven of the aneurysms (64%) treated were located from the cavernous to the superior hypophyseal artery segment of the internal carotid artery; 22% were distal to that segment, and 14% were in the vertebrobasilar system. A total of 123 PEDs were deployed with an average of 2 implanted per aneurysm treated. Six devices were incompletely deployed; in these cases, rescue balloon angioplasty was required. Six periprocedural (during the procedure/within 30 days after the procedure) thromboembolic events occurred, of which 5 were in patients with vertebrobasilar aneurysms. There were 4 fatal postprocedural hemorrhages (from 2 giant basilar trunk and 2 large ophthalmic artery aneurysms). The major complication rate (permanent disability/death resulting from perioperative/delayed complication) was 8.5%. Among 19 patients with 3-month follow-up angiography, 68% (13 patients) had complete aneurysm occlusion. Two patients presented with delayed flow-limiting in-stent stenosis that was successfully treated with angioplasty.

CONCLUSION: Unlike conventional coil embolization, aneurysm occlusion with PED is not immediate. Early complications include both thromboembolic and hemorrhagic events and appear to be significantly more frequent in association with treatment of vertebrobasilar aneurysms.

KEY WORDS: Endovascular treatment, Flow diversion, Intracranial aneurysm, Pipeline device

Neurosurgery 71:1080–1088, 2012 DOI: 10.1227/NEU.0b013e3182706089 www.neurosurgery-online.com

Post-market experience with PED

- Prospective registry at 7 American hospitals
- 58 aneurysms in 56 patients
  - 8 posterior circulation aneurysms
- Complications:
  - Overall: 6 thromboembolic events, 4 post-procedural hemorrhage , 2 delayed in-stent stenosis
  - For posterior circulation aneurysms only: 5 thromboembolic events, 2 fetal hemorrhage

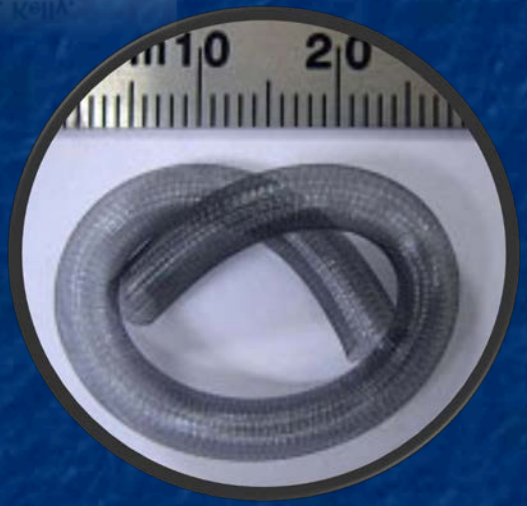
Complication rates higher in posterior circulations!

UB NS University at Buffalo Neurosurgery

International Retrospective Study of the Pipeline Embolization Device: A Multicenter Aneurysm Treatment Study

D.F. Kallmes, R. Hanel, D. Lopes, E. Boccardi, A. Bonafé, S. Cekirge, D. Fiorella, P. Jabbour, E. Levy, C. McDougall, A. Siddiqui, I. Szikora, H. Woo, F. Albuquerque, H. Bozorgchami, S.R. Dashti, J.D. Almandoz, M.E. Kelly, R. Turner IV, B.K. Woodward, W. Brinjikji, G. Lanzino and P. Lylyk

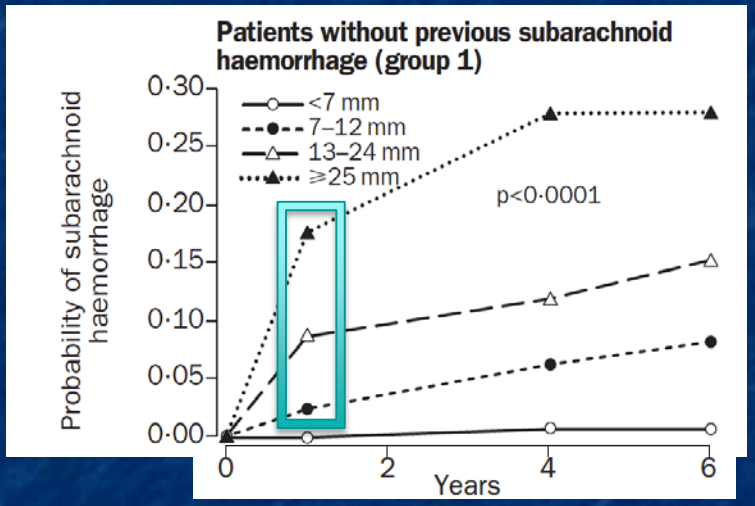
- Retrospective study
- Included all patients treated with PED 7/2008 – 2/2013
- 6 countries, 13 centers
- Required minimum 10 PED cases experience per center
  - Included initial experiences of other investigators
- 793 patients with 906 aneurysms enrolled



Incidence of delayed aneurysm ruptures in relation to aneurysm size

Total	large & giant	large	giant
5/793	5/423	2/357	3/66
0,6%	1,1%	0,5%	4,5%

Natural history



Wiebers et al., ISUIA II., THE LANCET • Vol 362 • July 12, 2003

Safety outcomes: Intracranial hemorrhage

Study	F/u	Total incidence	Clinical significance: Major	Clinical significance: Minor
IntrePED	19.3 months	24/793 (3.0%)	19/793 (2.4%)	5/793 (0.6%)
PUFS	6 months	5/107 (4.6%)	2/107 (1.9%)	3/107 (2.8%)

p = 0.74

2 non PUFS eligible aneurysms

Major Events: symptoms present after 7 days

Minor Events: resolved within 7 days

Safety Outcomes: Ischemic stroke

Cohorts	F/u	Total incidence	Clinical significance	
			Major	Minor
IntrePED	19.3 months	51/793 (6.5%)	36/793 (4.5%)	15/793 (1.9%)
PUFs	6 months	5/107 (4.6%)	3/107 (2.8%)	2/107 (1.9%)

p = 0.41

Major Events: symptoms present after 7 days

Minor Events: resolved within 7 days

9 non PUFS eligible aneurysms

Safety profile compared to stent assisted coiling

Treatment	Study	% F/u & Duration	Pts	Overall M&M	Intracranial Hemorrhages
Pipeline	PUFs	96% / 1 year	107	5.6%	1.9%
Pipeline	IntrePED	19.3 mo median	793	8.2%	2.3%
Meta - analysis Pipeline / Silk	Brinjikji W et al 2013	6 mo avg	1651 pts	9%	3%
Stent-Coiling	Fiorella et al, 2009	62% 13 mo	284	8.1%	1,4%
Stent-Coiling	Piotin et al, 2010	53% 14 mo	216 aneurysms	13.4%	3.3%
Meta- analysis Stent-Coiling	Shapiro et al, 2012	13 mo avg	1517 pts (763 pts reported M&M)	5.3%	2.2%

Pipeline Embolization Device for Small Intracranial Aneurysms: Evaluation of Safety and Efficacy in a Multicenter Cohort

Christoph J. Griessenauer, MD*
Christopher S. Ogilvy, MD*
Paul M. Foreman, MD‡
Michelle H. Chua, BS§
Mark R. Harrigan, MD‡
Lucy He, MD¶
Matthew R. Fusco, MD¶
J.D. Mocco, MD, MS||
Christopher J. Stapleton, MD#
Aman B. Patel, MD#
Ashish Sonig, MD**
Adnan H. Siddiqui, MD**
Ajith J. Thomas, MD*

*Neurosurgical Service, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts ‡Department of Neurosurgery, University of Alabama at Birmingham, Birmingham, Alabama §Harvard Medical School, Boston, Massachusetts ¶Department of Neurosurgery, Vanderbilt University, Nashville, Tennessee ||Department of Neurosurgery, Mount Sinai Hospital, New York, New York #Department of Neurosurgery, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts **Department of

BACKGROUND: To date, the use of the flow-diverting Pipeline Embolization Device (PED) for small intracranial aneurysms (≤ 7 mm) has been reported only in single-center series.

OBJECTIVE: To evaluate the safety and efficacy of the PED in a multicenter cohort.

METHODS: Five major academic institutions in the United States provided data on patient demographics, aneurysm features, and treatment characteristics of consecutive patients with aneurysms ≤ 7 mm treated with a PED between 2009 and 2015. Radiographic outcome was assessed with digital subtraction angiography. Clinical outcome was measured with the modified Rankin Scale.

RESULTS: The cumulative number of aneurysms ≤ 7 mm treated with PED at the 5 institutions was 149 in 117 patients (age, 54 years [range, 29-87 years]; male to female, 1-5.9). Aneurysms were most commonly located in the paraophthalmic segment (67.1%) of the internal carotid artery. Radiographic outcome at last follow-up was available for 123 aneurysms (82.6%), with a complete occlusion rate of 87%. Thromboembolic and symptomatic procedural complications occurred in 8.7% and 6% of the aneurysms treated, respectively. There was 1 mortality (0.9%) unrelated to the PED procedure. Multivariable logistic regression identified size < 4 mm, balloon angioplasty to open the device, and simultaneous treatment of multiple aneurysms as predictors of procedural complications. Good clinical outcome was achieved in 96% of electively treated patients.

CONCLUSION: In the largest series on PED for small aneurysms to date, data suggest that treatment with the flow-diverting PED is safe and efficacious, with complication rates comparable to those for traditional endovascular techniques.

KEY WORDS: Pipeline embolization device, Small, Aneurysm, Intracranial, Endovascular, Embolization

Neurosurgery 0:1–9, 2016 DOI: 10.1227/NEU.0000000000001377 www.neurosurgery-online.com

Ning Lin, MD*‡
Giuseppe Lanzino, MD§
Demetrius K. Lopes, MD¶
Adam S. Arthur, MD‖
Christopher S. Ogilvy, MD#
Robert D. Ecker, MD**
Travis M. Dumont, MD‡‡
Raymond D. Turner IV, MD§§
M. Reid Gooch, MD¶¶
Alan S. Boulos, MD¶¶
Peter Kan, MD, MPH‖‖
Kenneth V. Snyder, MD, PhD*##*‡‡‡**
Elad I. Levy, MD, MBA*##‡‡‡
Adnan H. Siddiqui, MD, PhD*##‡‡‡§§§

*Department of Neurosurgery, School of Medicine and Biomedical Sciences, University at Buffalo, State University of New York, Buffalo, New York; ‡Current affiliation: Department of Neurosurgery, Weill Cornell Medical College, New York City, New York; §Department of Neurosurgery, Mayo Clinic, Rochester, Minnesota; ¶Department of Neurosurgery, Rush University Medical Center, Chicago, Illinois; ‖Semmes-Murphey Neurologic and Spine Institute, University of Tennessee, Memphis, Tennessee; #Department of Neurosurgery, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, Massachusetts; **Neuroscience Institute, Maine Medical Center, Portland, Maine; ‡‡Division of Neurosurgery, Department of Surgery, University of Arizona, Tucson, Arizona; §§Division of Neurosurgery, Medical University of South Carolina, Charleston, South Carolina; ¶¶Department of Neurosurgery, Albany Medical Center, Albany, New York; ‖‖Department of Neurosurgery, Baylor College of Medicine, Houston, Texas; ##Department of Radiology, University at Buffalo, State University of New York, Buffalo, New York; ***Department of Neurology, University at Buffalo, State University of New York, Buffalo, New York; ‡‡‡School of Medicine and Biomedical Sciences and Toshiba Stroke and Vascular Research Center, University at Buffalo, State University of New York, Buffalo, New York; §§§Jacobs Institute, Buffalo, New York

Presented in part as a poster at the Annual Meeting of the Congress of Neurological Surgeons, Boston, MA, October 18 to 22, 2014.

Treatment of Distal Anterior Circulation Aneurysms With the Pipeline Embolization Device: A US Multicenter Experience

BACKGROUND: Utilization of the Pipeline embolization device (PED) to treat distal carotid circulation aneurysms has not been well studied.

OBJECTIVE: To report the collective experience of using PED to treat distal anterior circulation aneurysms.

METHODS: We retrospectively reviewed clinical and radiographic records of all patients who underwent Pipeline embolization of distal anterior circulation aneurysms at 10 US neurosurgical centers between 2011 and 2013.

RESULTS: Twenty-eight patients (mean age 51.7 years; 18 women) with 28 aneurysms were included in the analyses. Fifteen aneurysms were fusiform, 5 dissecting, and 8 saccular. Average aneurysm size was 12.3 mm; 7 were giant. Twenty aneurysms were located along the middle cerebral artery, 6 along the anterior cerebral artery, and 2 along the anterior communicating artery. PED deployment was successful in 27 patients, with coils utilized in 6 cases. Clinical follow-up was available for an average of 10.7 months (range 3-26). Twenty-seven patients had follow-up neurovascular imaging: 21 aneurysms had complete occlusion, 4 had residual neck filling, and 2 had residual dome filling. Periprocedural complications (<30 days) occurred in 3 patients (10.7%), including 1 case of device failure resulting in stroke. Outcomes were good (modified Rankin Scale score 0 to 2) in 27 patients (96.4%) and fair (modified Rankin Scale 3) in 1.

CONCLUSION: PED can be utilized in the treatment of distal anterior circulation aneurysms with difficult anatomy for conventional surgical or endovascular techniques. Larger-scale studies with long-term follow-up are needed to further elucidate the durability of PED treatment and its effect on perforator-rich vascular segments.

KEY WORDS: Flow diverter, Intracranial aneurysm, Pipeline embolization device

Neurosurgery 0:1–9, 2015 DOI: 10.1227/NEU.0000000000001117 www.neurosurgery-online.com

CASE SERIES

Treatment failure of fetal posterior communicating artery aneurysms with the pipeline embolization device

Peter Kan,[1] Edward Duckworth,[1] Ajit Puri,[2] Greg Velat,[1] Ajay Wakhloo[2]

[1]Department of Neurosurgery, Baylor College of Medicine, Houston, Texas, USA
[2]Department of Radiology, University of Massachusetts Medical School, Worcester, Massachusetts, USA

Correspondence to
Dr P Kan, Department of Neurosurgery, Baylor College of Medicine, 7200 Cambridge St, Suite 9A, Houston, Texas 77030; peter.kan@bcm.edu

Received 10 July 2015
Revised 14 August 2015
Accepted 20 August 2015

ABSTRACT

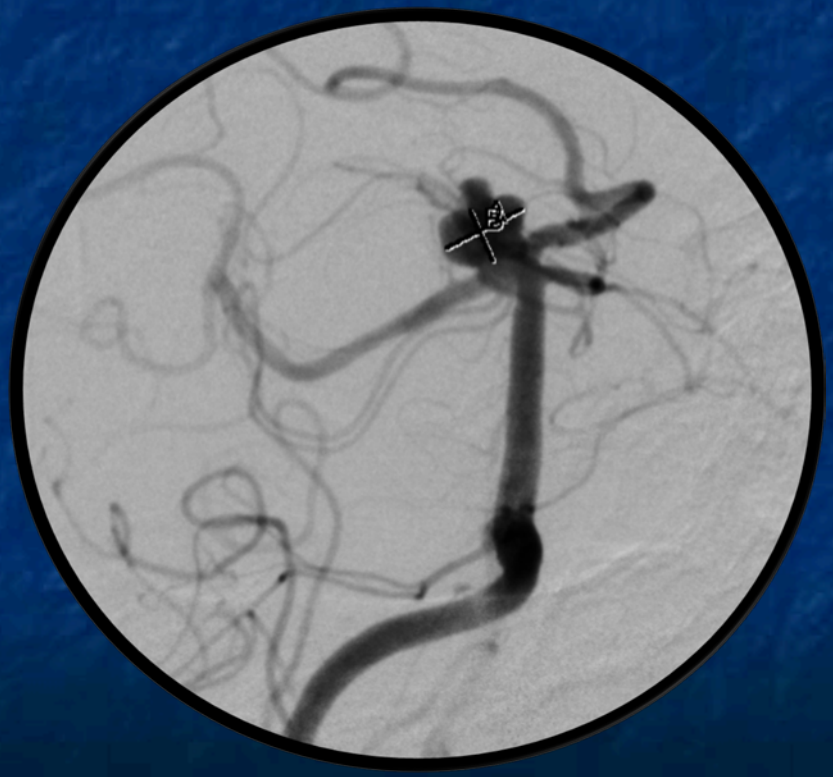
Aneurysms that involve the internal carotid artery and posterior communicating artery junction and incorporate a fetal posterior cerebral artery are known as fetal posterior communicating artery aneurysms. We report the outcomes of four patients with fetal posterior communicating artery aneurysms who underwent treatment with the pipeline embolization device with or without adjunctive coil embolization. In our study, all four patients failed to achieve aneurysm occlusion at the last follow-up evaluation. Based on our results, we currently do not recommend the use of the flow diverter for the treatment of fetal posterior communicating artery aneurysms.

METHODS

We report the cases of four patients with fetal PCOMA aneurysms who underwent treatment with a PED. Each of the patients had a PCOMA aneurysm incorporating a fetal PCA (fetal PCOMA aneurysm) treated with a PED, and had at least 12 months of angiographic follow-up. A fetal PCA was defined as one with a primary supply from the ICA on angiography, with an absent P1 segment. Patients with PCOMA aneurysms occurring on the ICA separate from the fetal PCA were excluded. The study was approved by the local institutional

Aneurysm treatment Options have evolved….

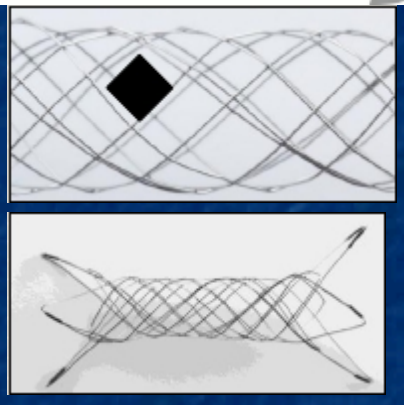
1. Clipping
2. Coiling
3. Balloon-assisted coiling
4. Stent-assisted coiling
5. Flow Diverters
6. Second generation microstents
7. Second generation flow diverters
8. Bifurcation stents/devices



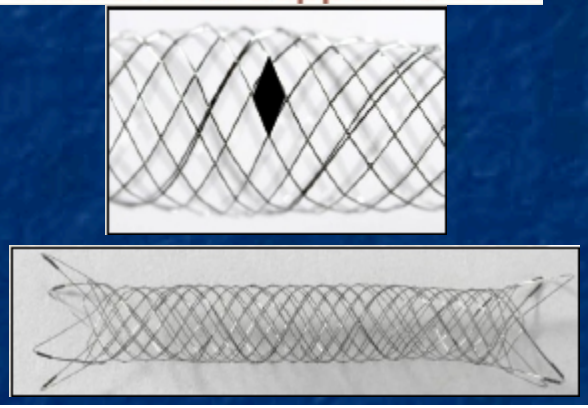
UB NS University at Buffalo Neurosurgery

LVIS stent HDE July 2014

LVIS™ Jr. Intraluminal Support Device



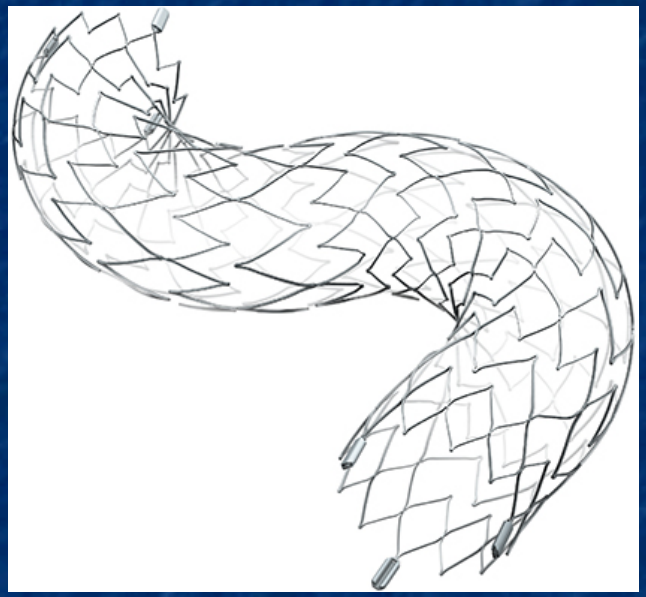
LVIS™ Intraluminal Support Device



The LVIS Device is intended for use with bare platinum embolic coils for the treatment of unruptured, wide neck (neck ≥ 4 mm or dome to neck ratio < 2), intracranial, saccular aneurysms arising from a parent vessel with a diameter ≥ 2.5 mm and ≤ 4.5 mm.

UB NS University at Buffalo Neurosurgery

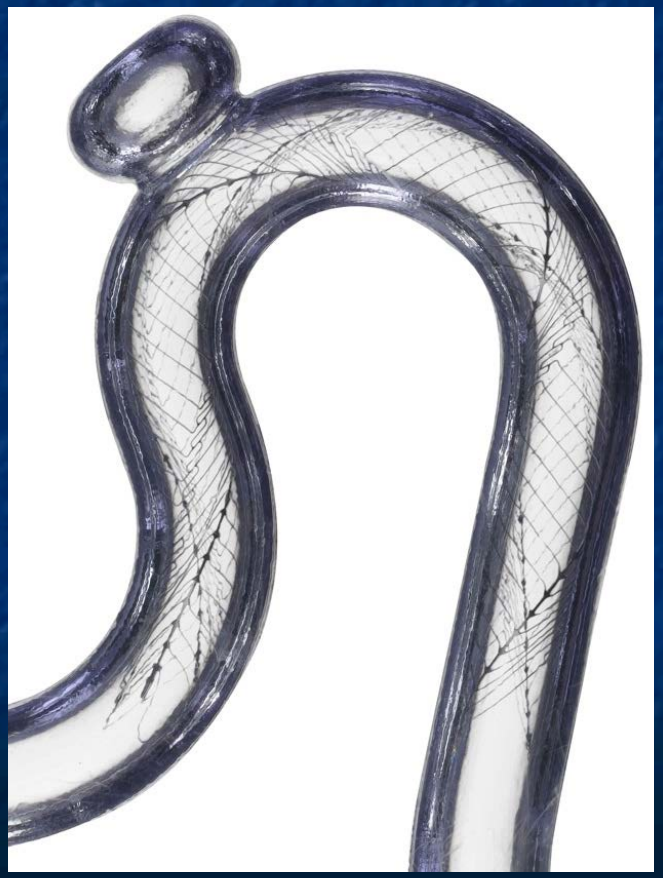
ATLAS stent HDE November 2017

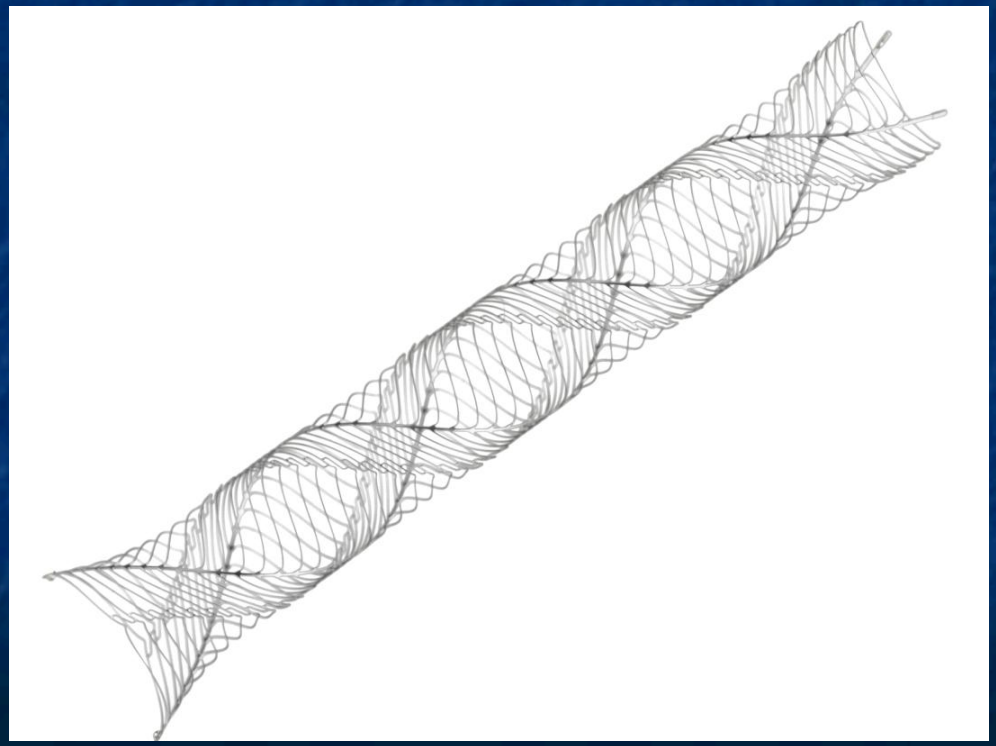


The Neuroform Atlas Stent System is indicated for use with neurovascular embolic coils in patients who are ≥ 18 years of age for the treatment of wide neck, intracranial, saccular aneurysms arising from a parent vessel with a diameter of ≥ 2 mm and ≤ 4.5 mm that are not amenable to treatment with surgical clipping. Wide neck aneurysms are defined as having a neck ≥ 4 mm or a dome-to-neck ratio of < 2.

Liberty

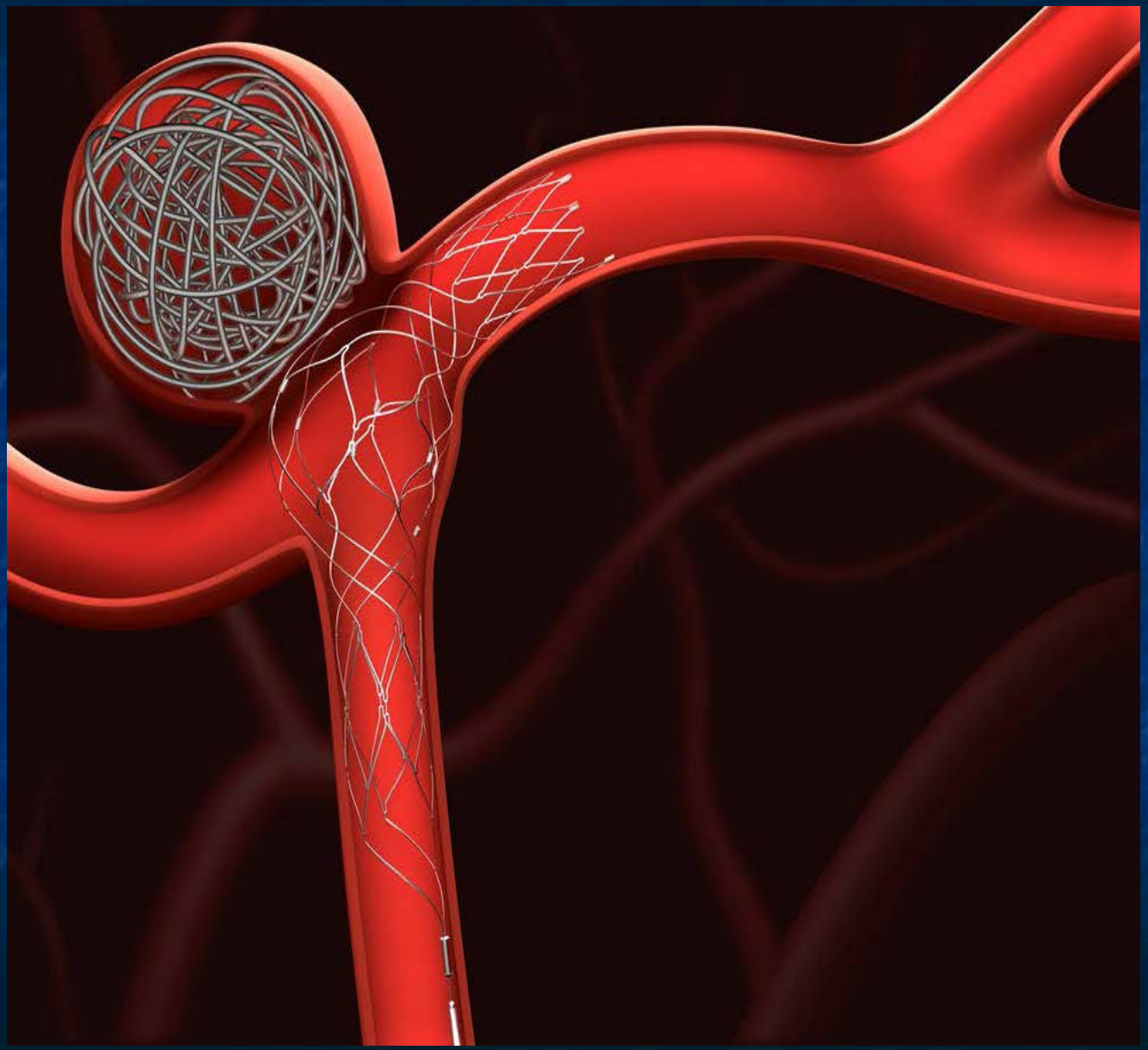
Hybrid approach laser cut- Nitinol Technology





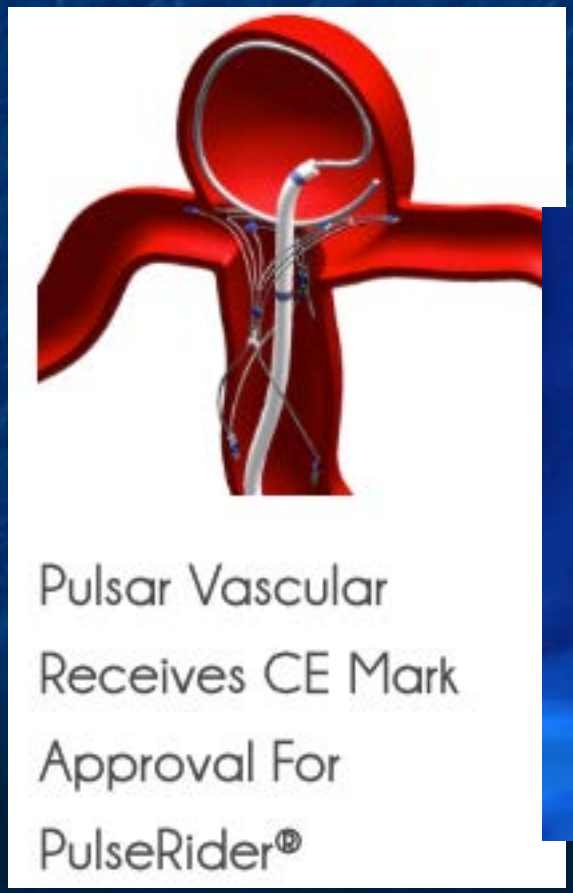
UB NS University at Buffalo Neurosurgery

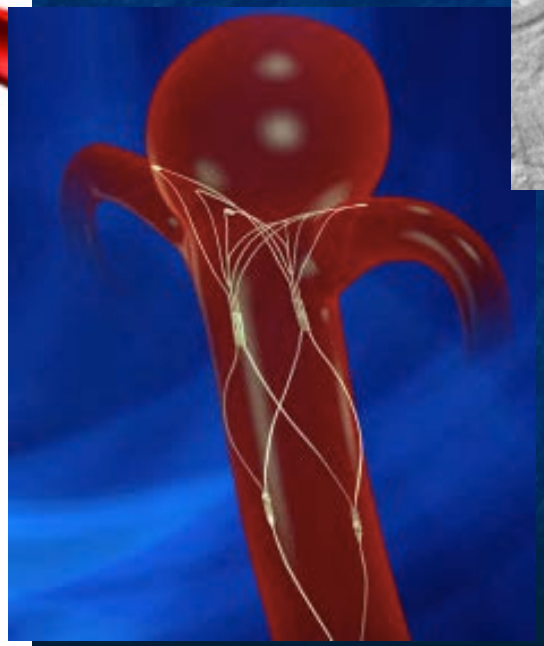
Medtronic Barrel Stent

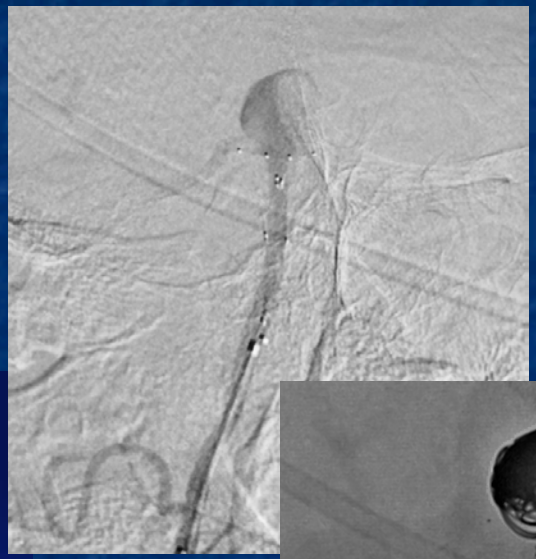


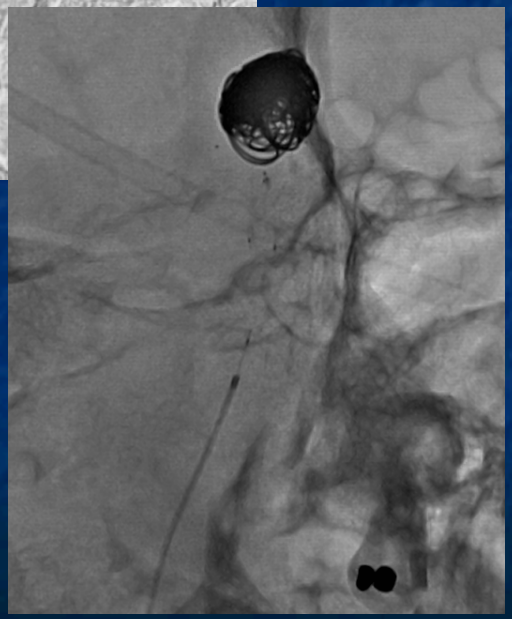
UB NS University at Buffalo Neurosurgery

PulseRider: Neck Reconstruction









Pulserider HDE June 2017

PulseRider® is indicated for use with neurovascular embolic coils in patients ≥ 18 years of age for the treatment of unruptured wide-necked intracranial aneurysms with neck widths ≥ 4 mm or dome to neck ratio < 2 originating on or near a vessel bifurcation of the basilar tip or carotid terminus with at least a portion of the aneurysm neck overlapping the lumen of the parent artery. The inflow vessels should have diameters from 2.7 mm to 4.5 mm.

Table 18: Aneurysm Occlusion

Report of Raymond Score			
Score	**Day Zero** n/N (%)	**180 Days**[1] n/N (%)	**365 Days** n/N (%)
Raymond I	18/34 (52.9%)	20/33 (60.6%)	6/8 (75%)
Raymond II	9/34 (26.5%)	9/33(27.3%)	2/8 (25%)
Raymond III	7/34 (20.6%)	4/33 (12.1%)	0/8 (0%)

[1]One enrolled subject had MRA performed instead of an angiogram and is excluded from this analysis.

Table 19: Blinded Core Lab Adjudicated Raymond I and II at 180-Days Follow-Up

Raymond Score	**180 Days % (n/N)**	**Lower 80% Confidence Limit**
I/II	87.9% (29/33[1])	80.5%

[1]One enrolled subject had MRA performed instead of an angiogram and is excluded from this analysis.

Table 16: Safety Outcome Assessed Based on Neurological Death and Stroke Resulting in mRS ≥ 3 at 180 ± 45 Days Follow-Up*

	% (n/N)
Neurological Death	0% (0/34)
Stroke resulting in mRS ≥ 3	2.9% (1/34)

*The 90-day mRS was not conducted and only 180-day long-term follow-up was available. The 180-day mRS was assessed by office visit by a non-blinded assessor to the treatment.

WEB (Sequent) Concept

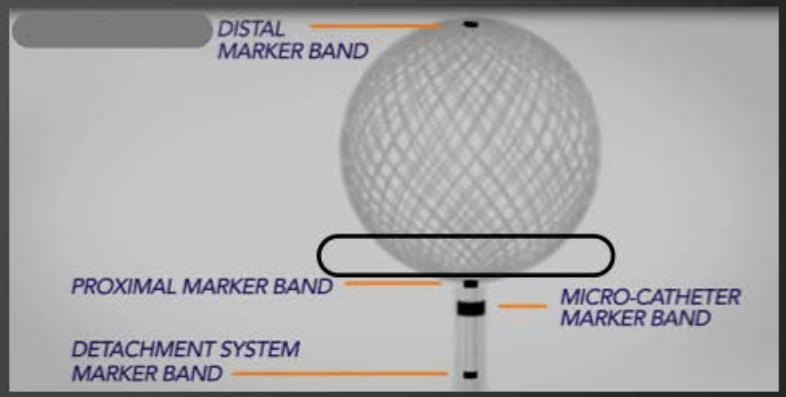
- Intrasaccular
- Microcatheters 0.027 for device ≤ 7 mm to 0.032 compatible for device > 7 mm
- Two layers of Nitinol mesh (216 or 288 wires)
- 3 platinum markers
- Retrievable and detachable
- CE marked

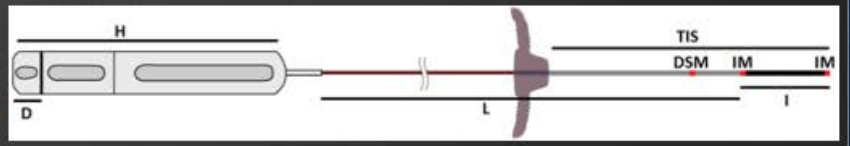
UB NS University at Buffalo Neurosurgery

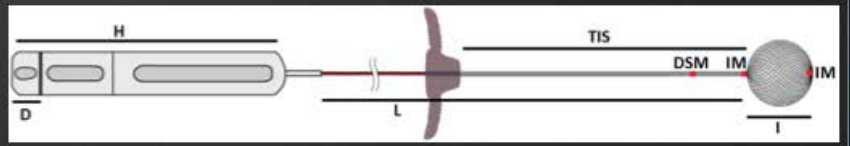
ARTISSE

LUNA (Nfocus/Covidien) AES Concept

- The LUNA Aneurysm Embolization System (AES) is a self-expandable, round-ovoid implant with delivery system
- The implant is made from a double layer of 72 Nitinol wire 25µ. Mesh (144 wires) secured at both proximal and distal ends and clearly marked with radiopaque markers
- Available size 4.5mm (B) - 8.5mm (G)
- The delivery system provides for distal navigation through a commercially available (0.027 compatible) microcatheter
- Microcatheter shaft with detachment controlled by operator activation of delivery handle
- CE marked February 2011

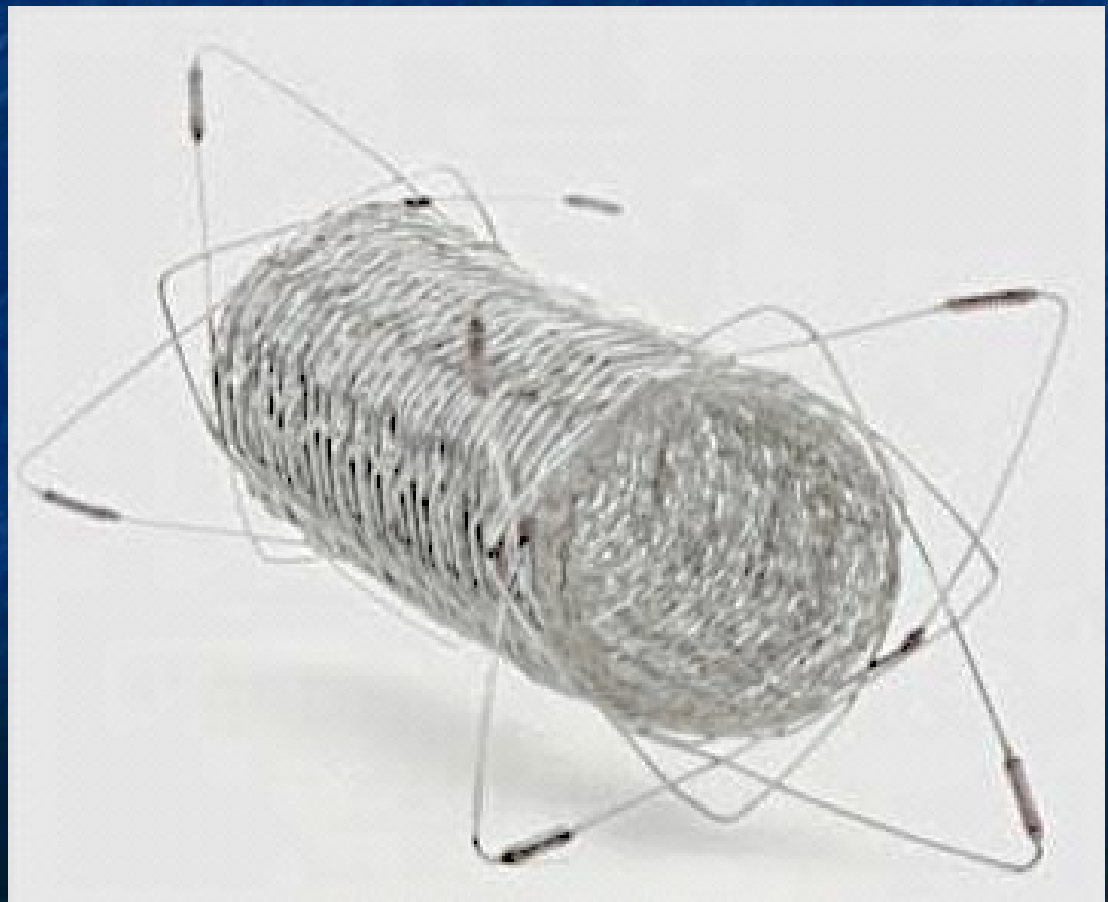






Flow Re-Direction Endoluminal Device (FRED)

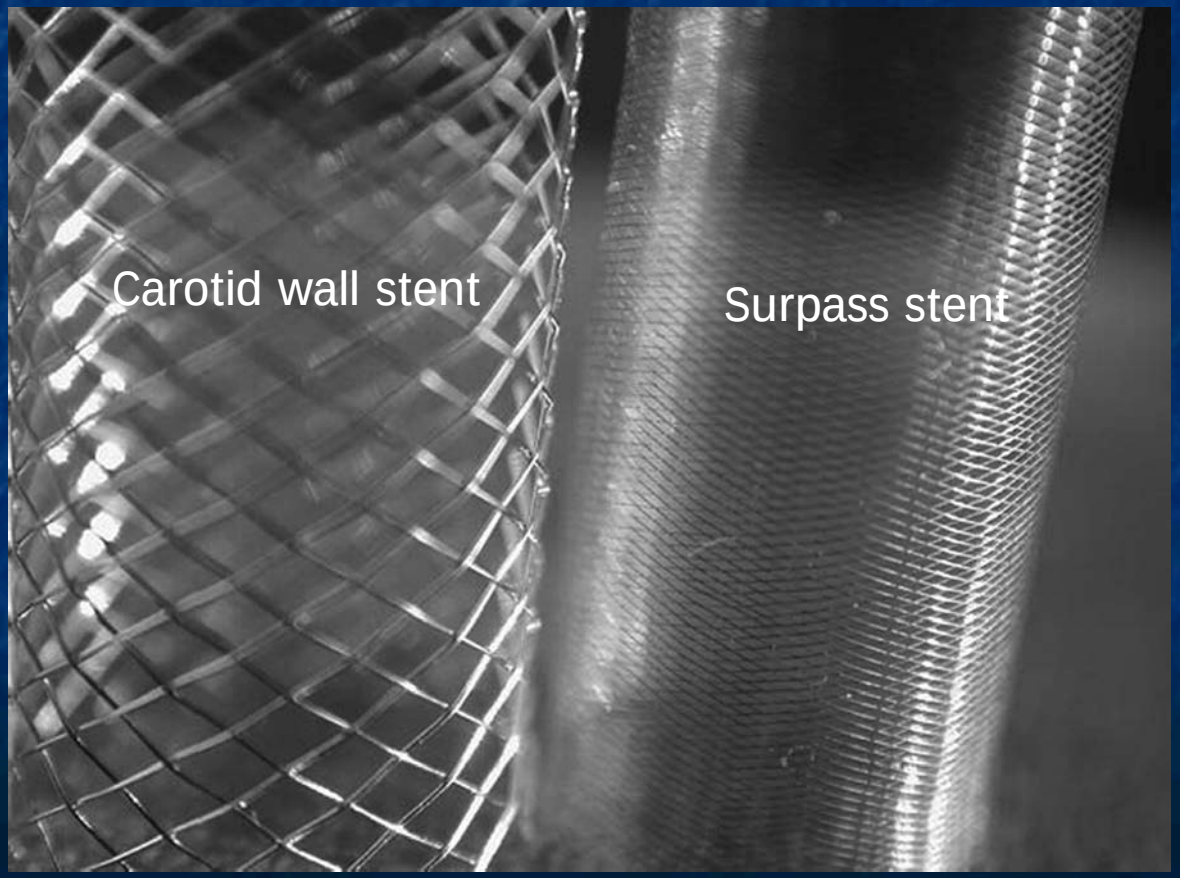
- Outer layer:
  - 1 mm cell size
  - 16-wire weave design
- Inner layer:
  - 48-wire braid design
  - Attached to outer layer in helix pattern



UB NS University at Buffalo Neurosurgery

SURPASS -Safety and Effectiveness of an Intracranial Aneurysm Embolization System for Treating Large or Giant Wide Neck Aneurysms (SCENT)

Surpass is a cobalt–chromium, low porosity (metal surface area coverage 30%), self-expanding tubular-shaped mesh structure with a high pore density (21–32 pores/mm2)

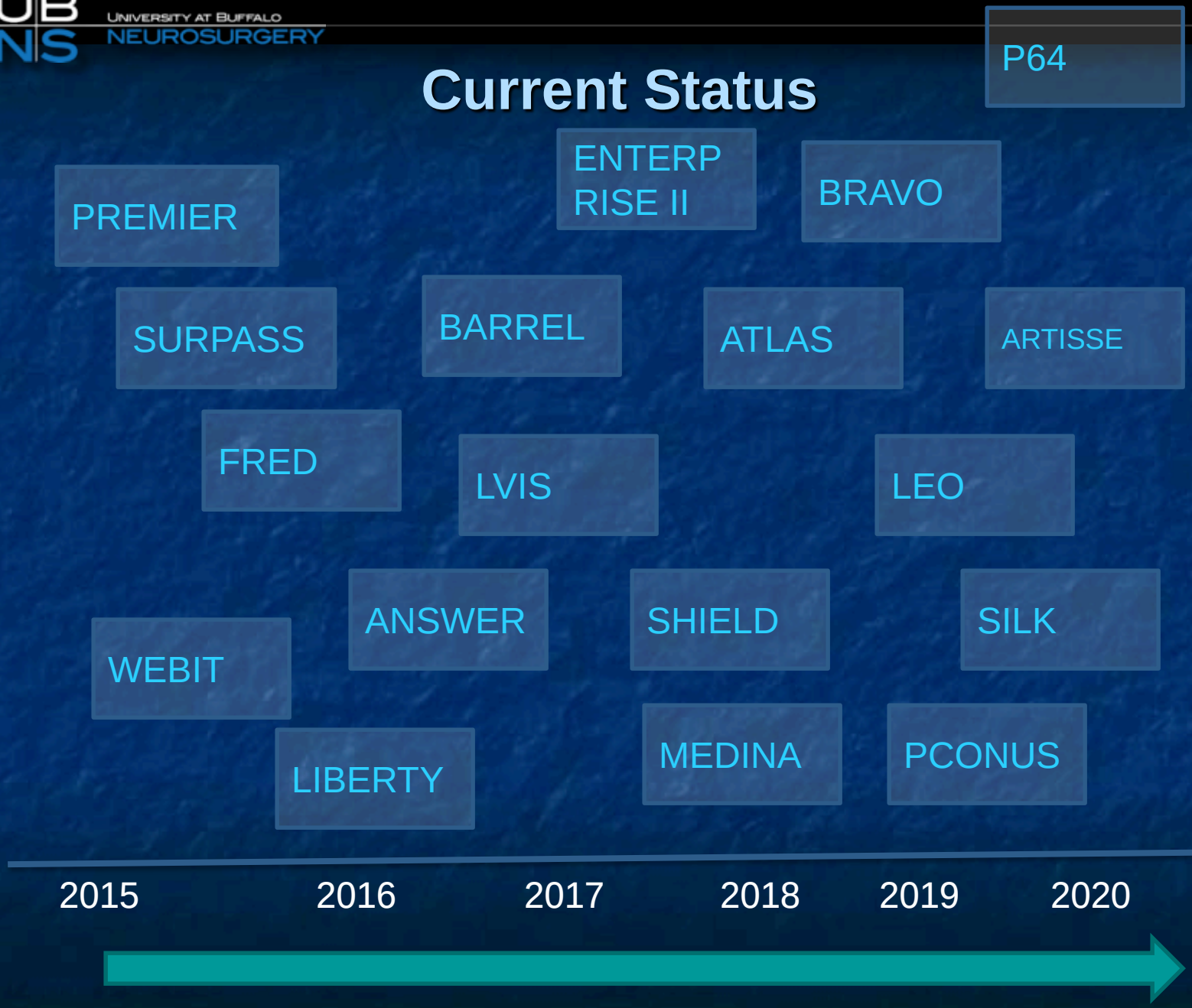


PIPELINE SHIELD

- Pipeline™ device with next generation delivery & Surface modification

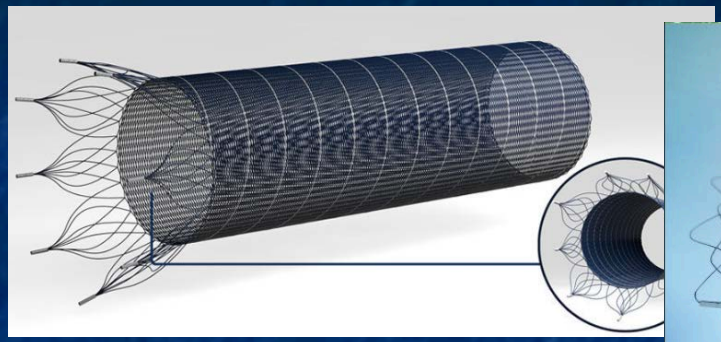
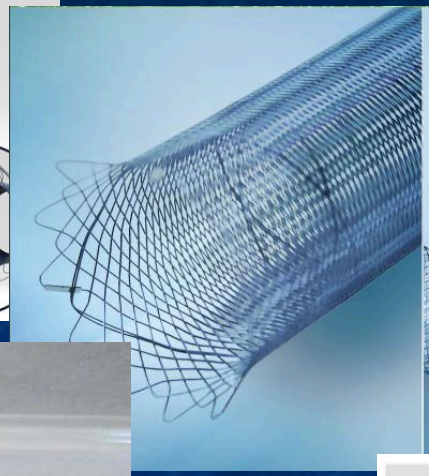
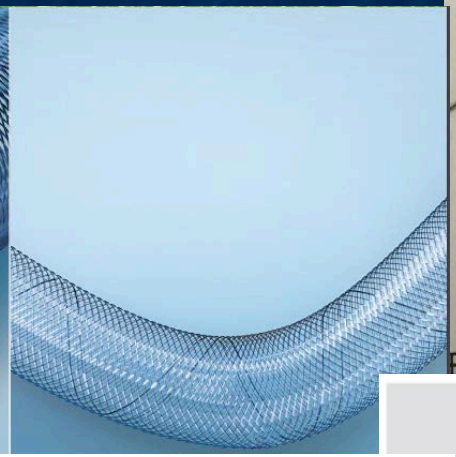
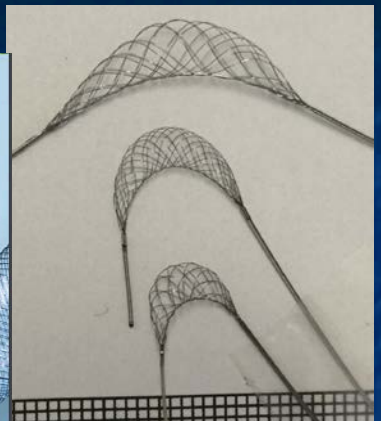
UB NS University at Buffalo Neurosurgery

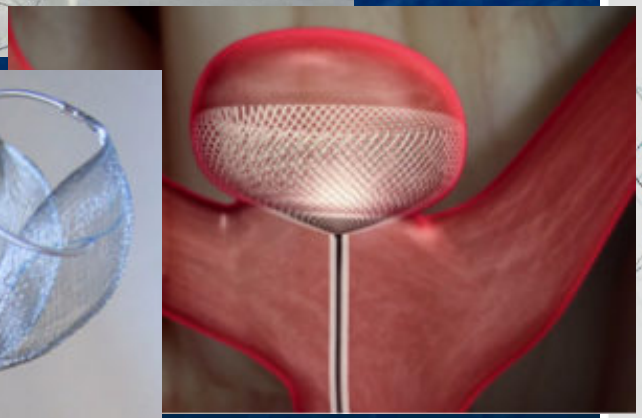
Current Status



Commercially available technologies not available in US

UB NS University at Buffalo Neurosurgery




UB NS University at Buffalo Neurosurgery

Continued progress towards higher safety and efficacy

- FDA has carefully approved iterative and transformational technologies based on a narrow focus on safety and efficacy
- The clinicians have refined their tool kits based on pragmatic trials and shared learning
- Rigorous post-market data collection can further strengthen this relationship and allow continued delivery of effective and safe therapies for our patients