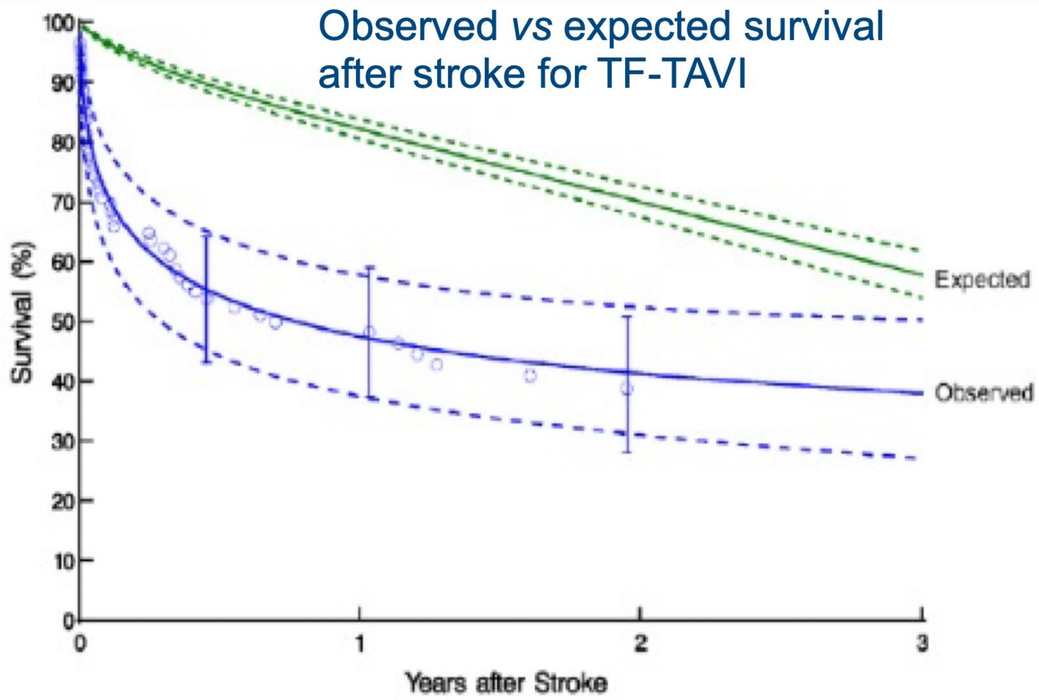
Sentinel Unveiled : Exploring Initial Experience, Purpose, and Application

THE CATHOLIC UNIVERSITY OF KOREA
SEOUL ST. MARY'S HOSPITAL

Byung-Hee Hwang

Mortality & Outcomes of Stroke : PARTNER Data

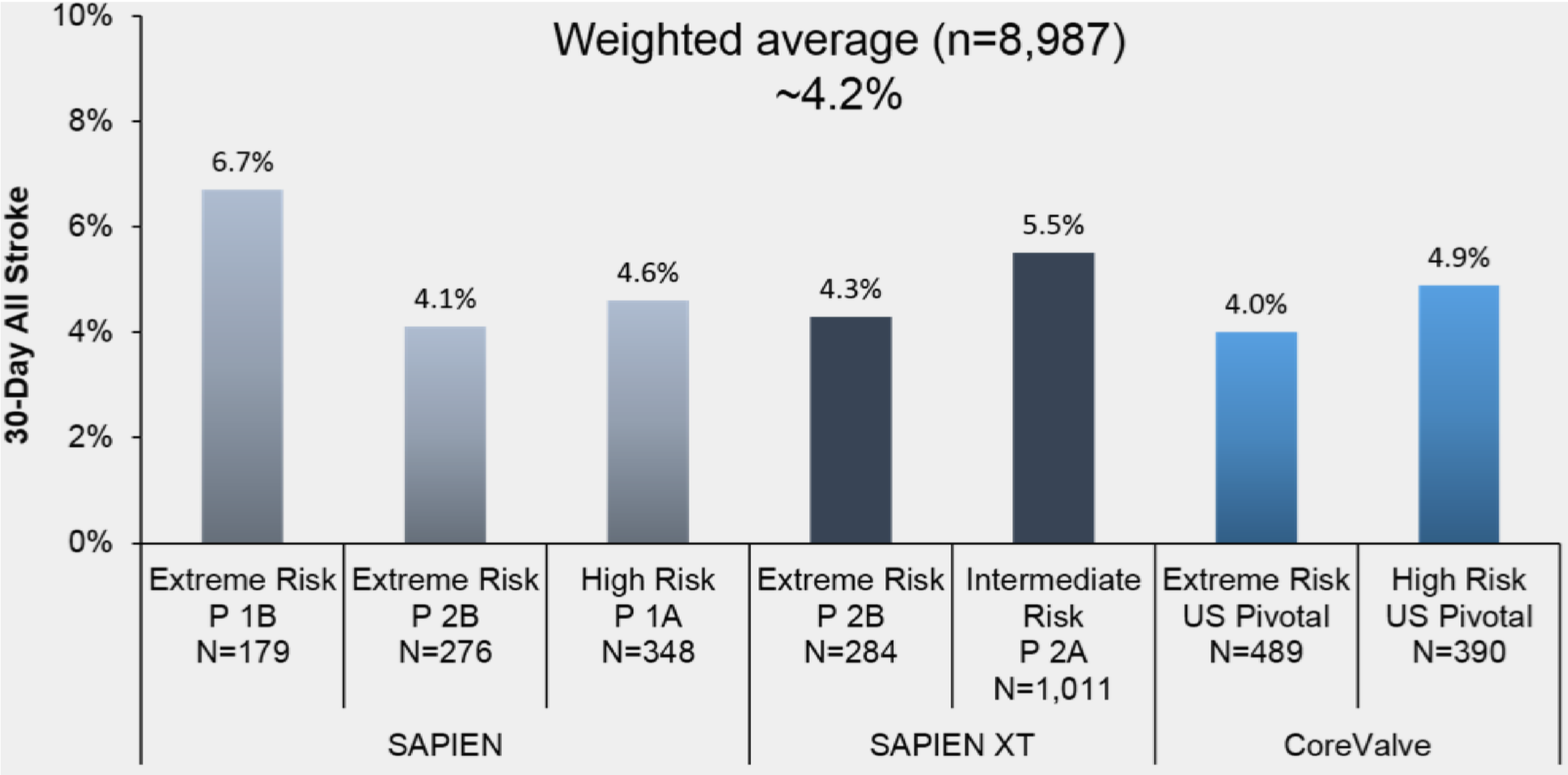
Stroke & TIA after TAVI are associated with an increased risk of 1-yr mortality



- **Patients experiencing a stroke or TIA had lower 1-year survival**
  - **With *stroke*: *47%* 1-yr survival vs 82% without for TF-TAVI**
  - **With *TIA*: *64%* 1-yr survival vs. 83% without for TF-TAVI**

Kapadia, et al. Circ Cardiovasc Interv. 2016;9:e002981

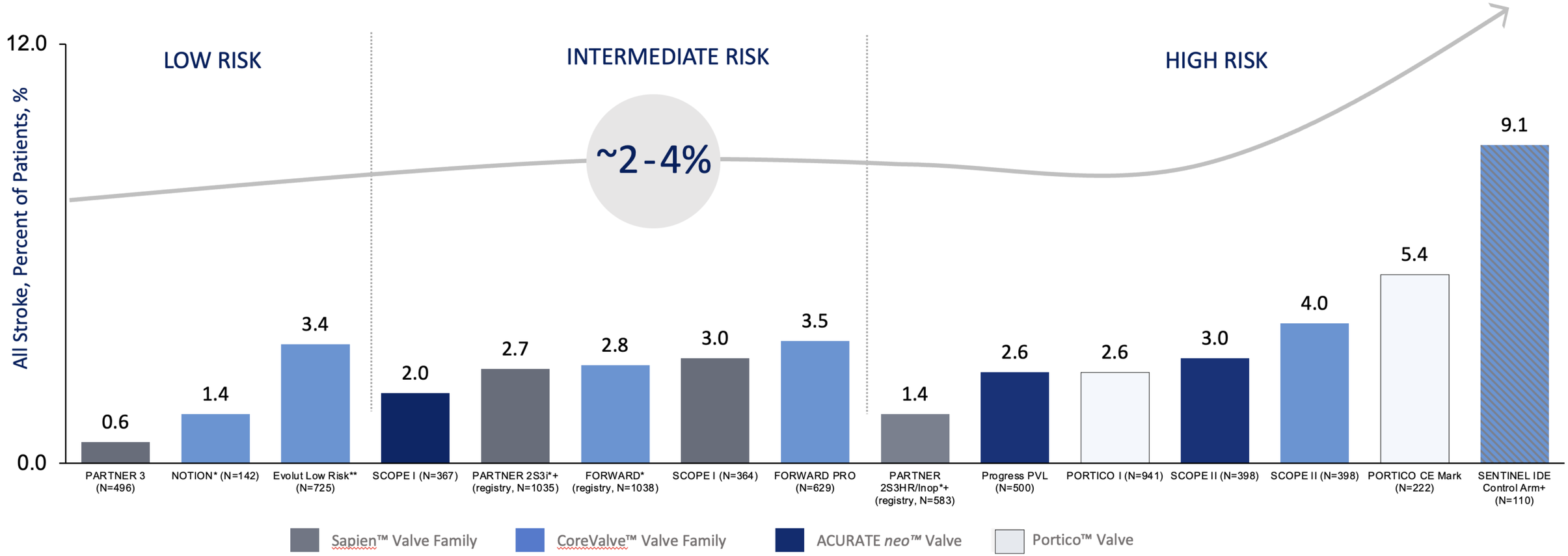
Stroke Incidence ; 1st gen.



Leon et al, NEJM 2010:363:1597-1607

30-day All-Stroke Rates with Contemporary TAVI Devices

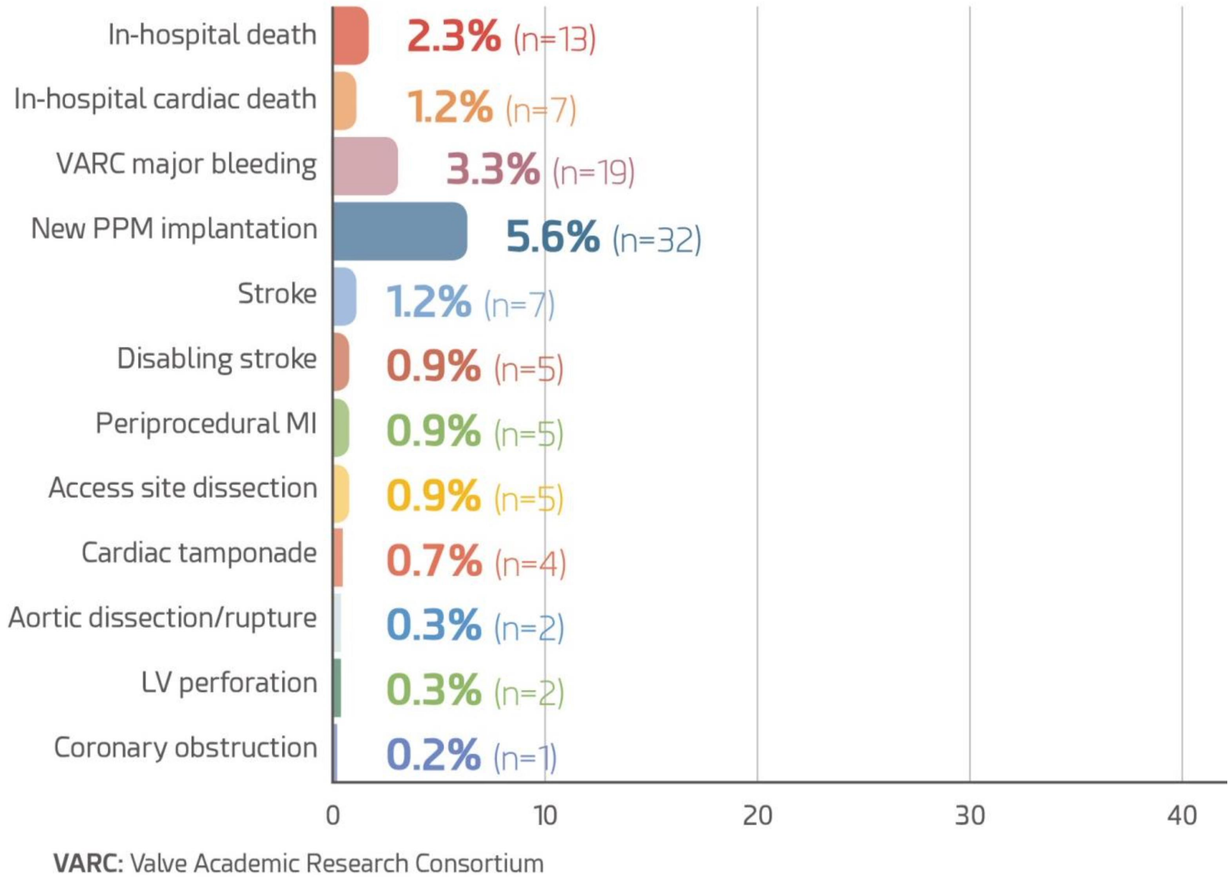
- Stroke remains an issue in contemporary studies (2-4% average rate)
- But, TAVI trials tend to emphasize only major/disabling stroke rates
- Recent minor stroke and TIA data show a 2-4 times mortality increase



Kapadia JACC 2017; Evolut Low Risk: Popma NEJM 2019; PARTNER 3: Mack NEJM 2019; PORTICO CE Mark: Linke, Circ Cardiovasc Interv 2018

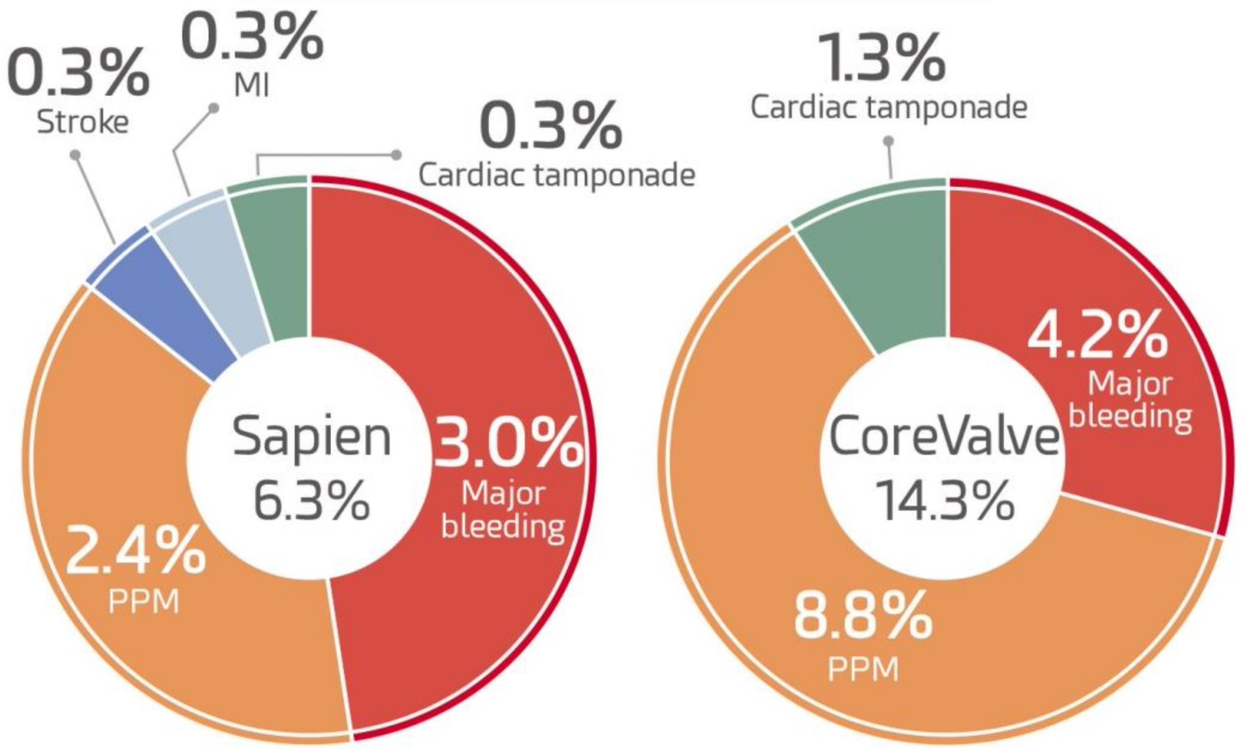
K-TAVI 1st cohort

Complications at discharge



VARC: Valve Academic Research Consortium

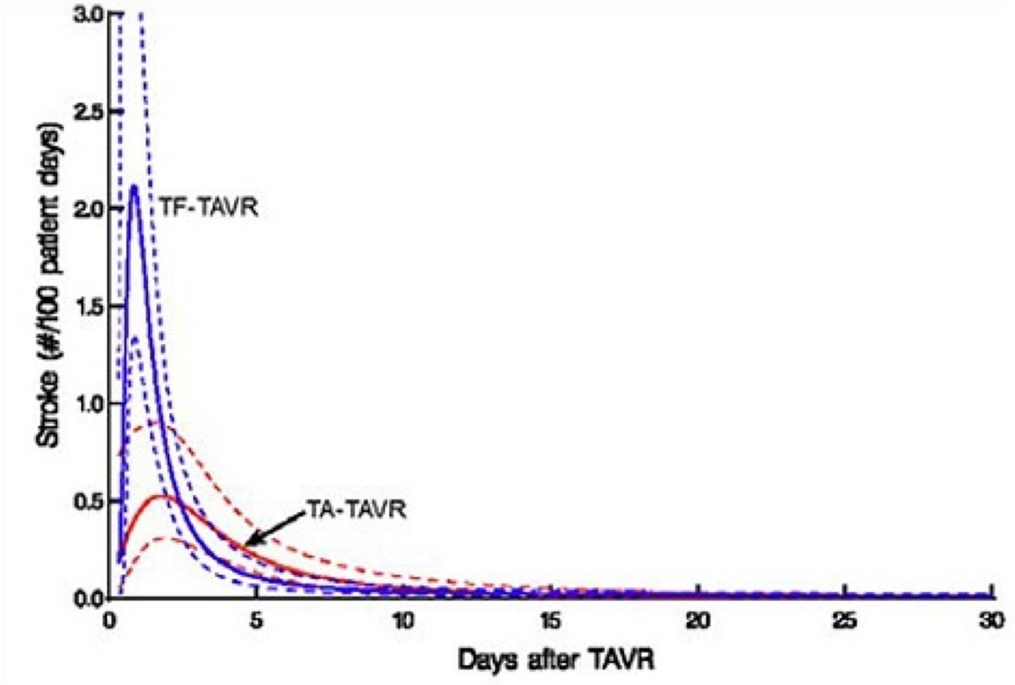
Complications by devices



Timing of Stroke : PARTNER Data

- Different pathophysiology by timing
- Early Stroke
  - 0-7 days
  - Broadly considered to be related d/t procedure
- Late Stroke
  - >1 wks.
  - Related to pt's atherosclerotic risk & frailty

Risk of stroke or TIA is highest early after TAVI (*85% occurring within 1 week, 34% in 1 day)*



TF-TAVI is transfemoral TAVI
TA-TAVI is transapical TAVI

Kapadia, et al. Circ Cardiovasc Interv. 2016;9:e002981

Predictors of Stroke

Pt. Related

Female gender
CKD
History of stroke
PVD
Low BMI
History of falls
NOAF

Procedure Related

AV annulus size
Pure AS
Total time in the Cathlab
Time of delivery catheter in patient's body
Rapid pacing
Balloon predilatation
Valve repositioning
Balloon postdilatation (?)

Kleiman et al. Circ Cardiovasc Interv. 2016;9:e003551

How to minimize Stroke ; Good procedure

- So what is a good procedure… ; Fast but accurate skill !!! -> ***minimize total time in cathlab & time of catheter movement in pt.'s body***
  - Accurate pre-procedural imaging for sizing & approach
  - Overcome aorta to iliac tortuosity with multiple techniques
  - Accurate & minimal Rapid pacing
  - Balloon predilatation only when needed (no routine predilatation)
  - Delicate & accurate LV wire manipulation (never let LV wire fall back to aorta!)
  - Harmony between 1st & 2nd operator is important
  - Final accurate access site closure !, more bleeding means increased possibility of stroke…

Procedure Related

AV annulus size
Pure AS
Total time in the Cathlab
Time of delivery catheter in patient's body
Rapid pacing
Balloon predilatation
Valve repositioning
Balloon postdilatation (debatable)

Risk of Stroke in TAVR with *Bicuspid Aortic Valve*

STS/ACC TVT Registry (between 2015-2018): 2691 propensity-score matched pairs out of N=81,822 patients (2726 bicuspid; 79,096 tricuspid) who underwent TAVR with Sapien 3™ valve at 552 US hospitals.

Bicuspid patients had an increased 30-day risk of stroke as compared to tricuspids

Table 3. Thirty-Day and 1-Year Clinical Outcomes[a]

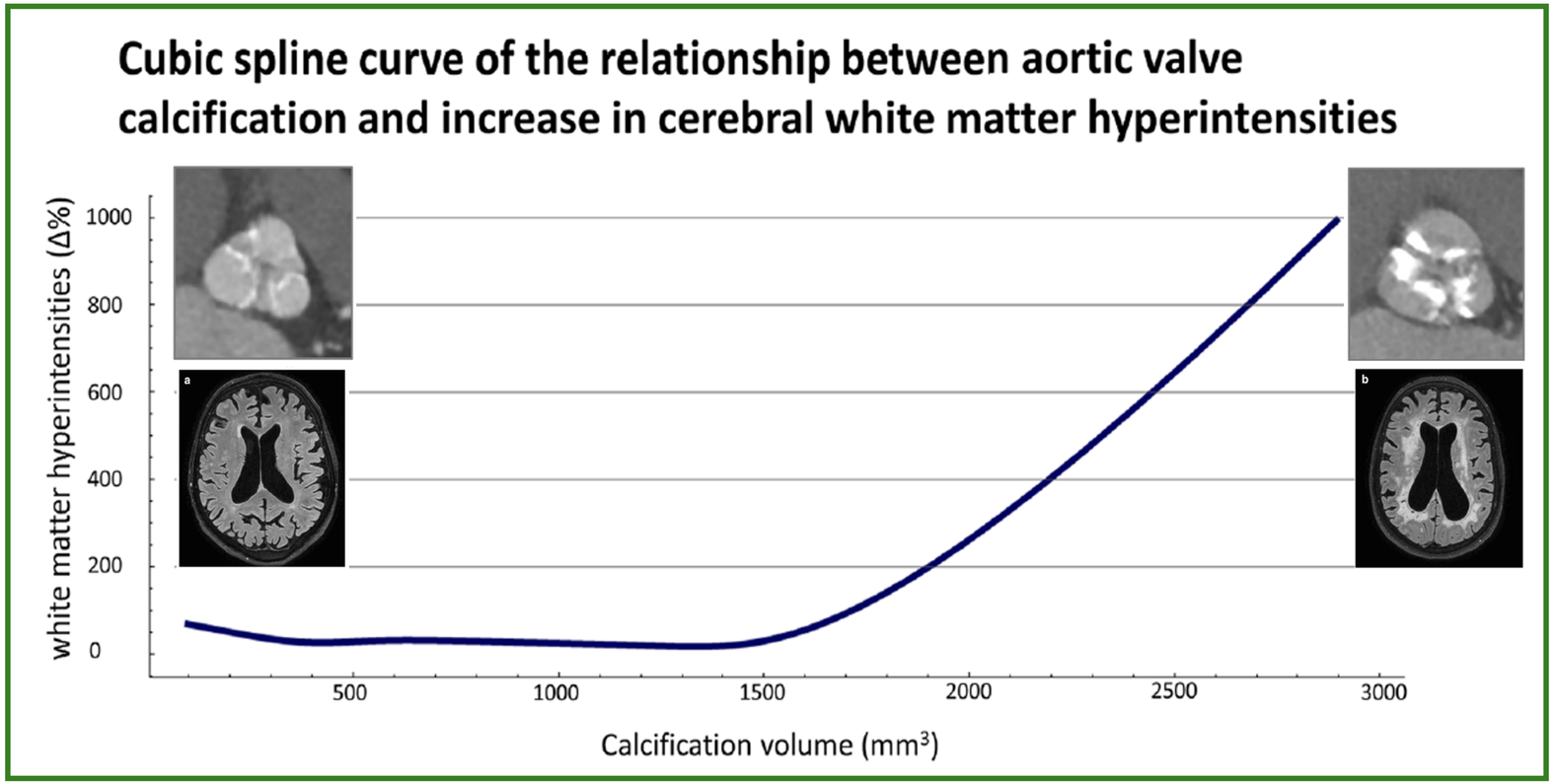
	No. (%) of Patients With Aortic Valve Stenosis				
	Bicuspid (n = 2691)	Tricuspid (n = 2691)	Absolute Difference (95% CI), %	Hazard Ratio (95% CI)	Log-Rank *P* Value
Primary Outcomes					
At 30 d					
Mortality	66 (2.6)	63 (2.5)	0.09 (0.08-0.1)	1.04 (0.74-1.47)	.82
Stroke	64 (2.5)	41 (1.6)	0.89 (0.88-0.90)	1.57 (1.06-2.33)	.02
At 1 y					
Mortality	171 (10.5)	200 (12.0)	1.48 (1.45-1.50)	0.90 (0.73-1.10)	.31
Stroke	76 (3.4)	61 (3.1)	0.34 (0.32-0.35)	1.28 (0.91-1.79)	.16

Makkar, R. et al. JAMA. 2019 Jun 11;321(22):2193-2202. doi: 10.1001/jama.2019.7108

Aortic Valve Calcification as a Predictor of White Matter Hyperintensity Volume (WMHV)

Prospective, single center study of N=48 patients with severe AS who underwent TAVR (92% TF) with a Sapien 3™ (97%) in Amsterdam (Jun 2016-Nov 2017).

- **Aortic valve calcification** is associated with increase in WMHV ($p<0.001$), indicative of silent brain infarctions 3 months post-TAVR
- Calcification of the following did ***not predict*** relative increase in cerebral WMHV
  - **Aortic arch (*P*=0.42)**
  - **Landing zone (*P*=0.69)**
  - **Left ventricle (*P*=0.55)**

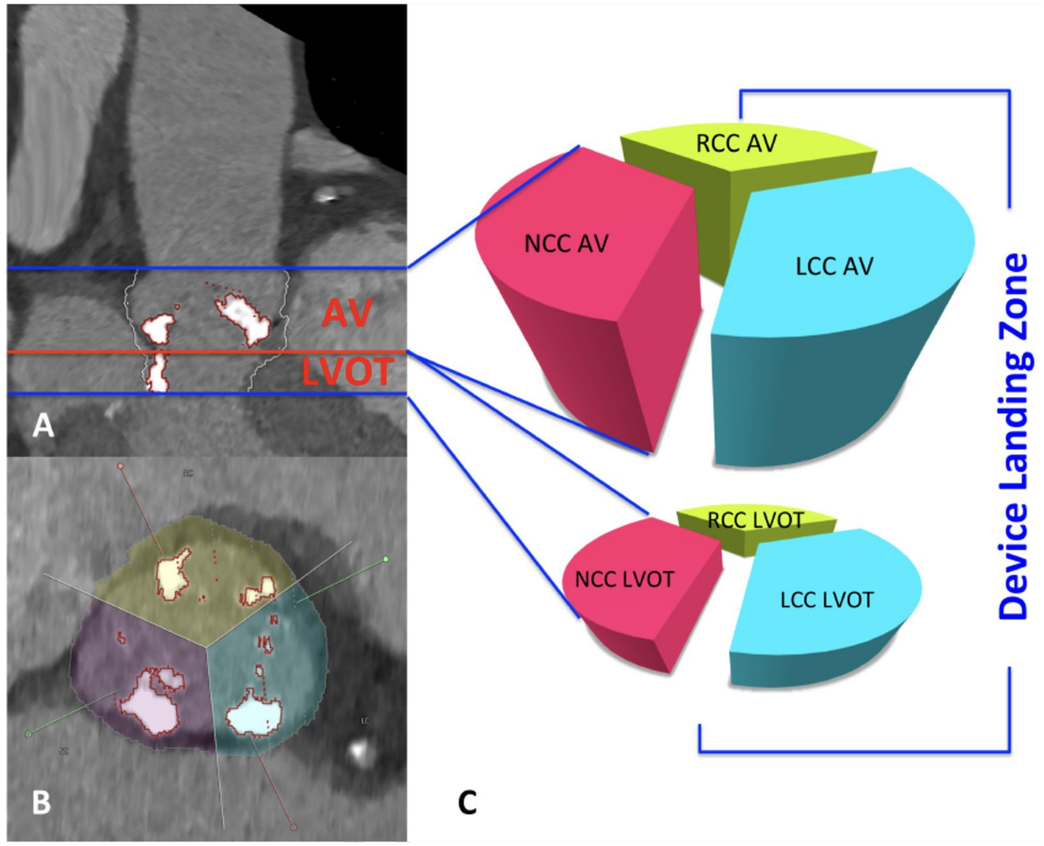


Final study population included N=36 TAVR patients, mean age 78.7 years, 61% female, median STS 2.8%. None of the patients experienced clinical overt stroke during the follow-up period, but in 72% of patients, white matter hyperintensity volume increased 27% (median) 3 months after TAVR.

Vlastra, W. et al. Int J Cardiovasc Imaging. 2019 Jul 16. doi: 10.1007/s10554-019-01663-0.

Aortic Valve Calcification As A Predictor of Stroke and Reduced Survival After TAVR

Retrospective analysis of pre-operative contrast enhanced MDCT scans of N=581 TAVR patients in Germany (between 2009-2017)



Calcium load in LVOT beneath the RCC significantly associated with stroke (OR: 1.2; 95% CI: 1.03-1.3; *P*=0.0019)
and in-hospital mortality
(OR 1.1: 95% CI: 1.004-1.2; *P*=0.04)

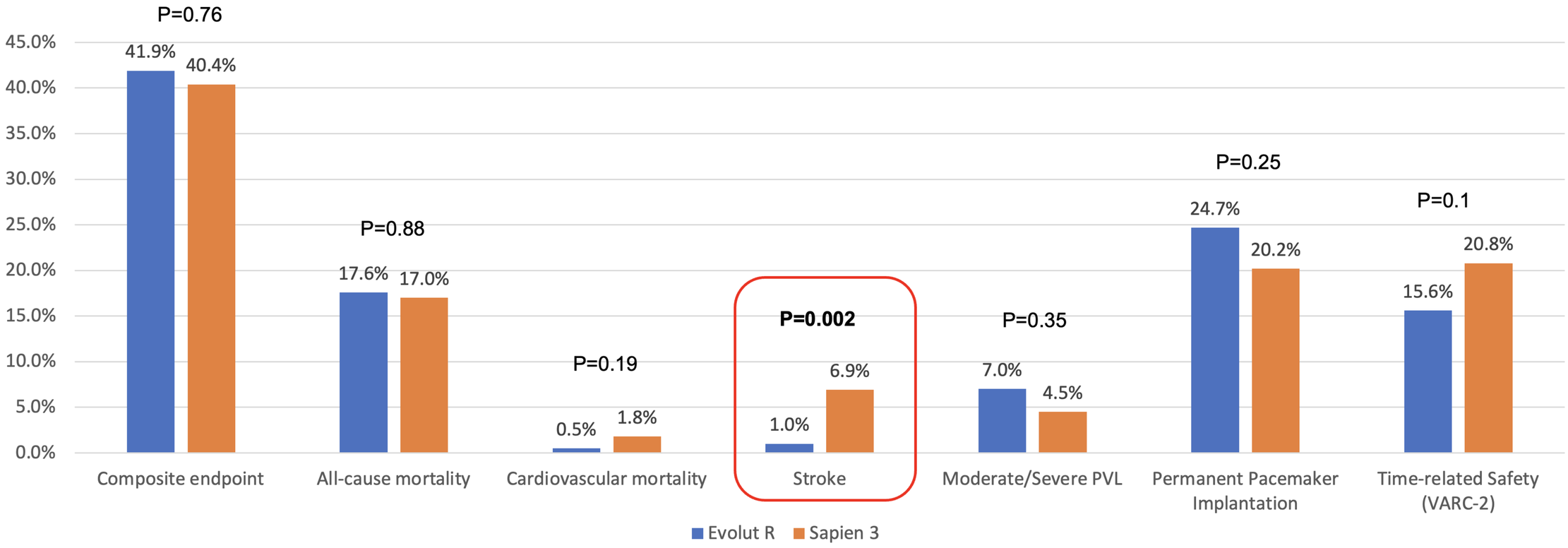
Total calcium load in LVOT associated with in-hospital mortality
(OR 1.2; 95% CI: 1.01-1.4, *P*=0.03)
and 30-day mortality
(OR 1.2; 95% CI 1.02-1.43; *P*=0.029)

Implanted prostheses were: SAPIEN XT, SAPIEN 3, CoreValve, Evolut R, Engager, and ACURATE neo.
MDCT=multidetector computed tomography

Pollari, F. et al. Journal of Cardiovascular Computed Tomograph (2020), doi: https://doi.org/10.1016/j.jcct.2019.12.001

Stroke Rate with Balloon-Expandable Valve

SURTAVI trial sub-analysis: Patients were randomized to receive either a CoreValve Evolut R™ valve (n=219) or Sapien 3™ valve (n=219) valve and then further stratified to receive local or general anesthesia.



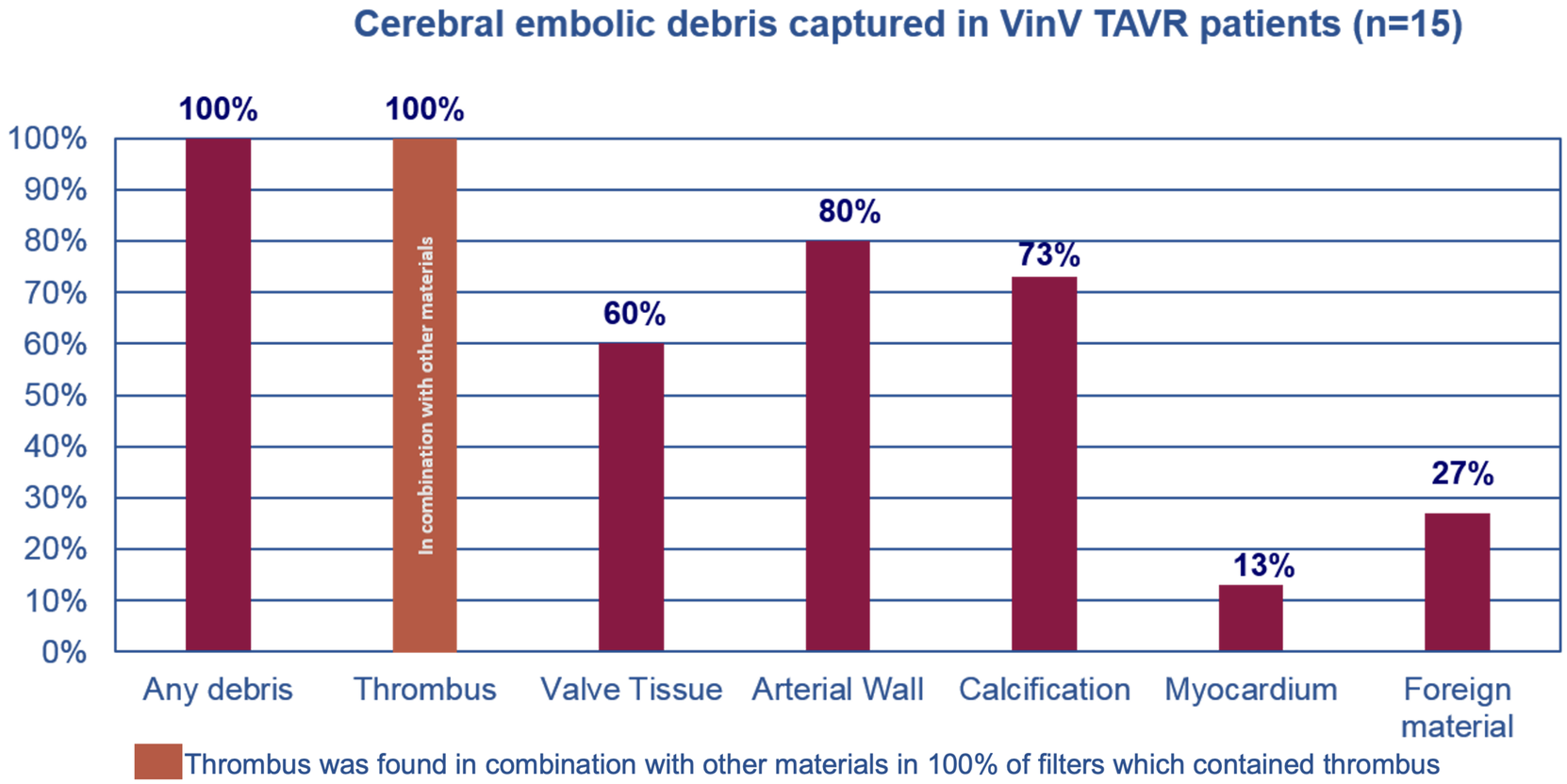
- The self-expanding Evolut R™ valve was equivalent to the S3 with respect to composite all-cause mortality, stroke, moderate or severe prosthetic valve regurgitation and permanent pacemaker implant at 1 year.
- The patients who received Evolut R™ valve had a lower stroke rate compared to the balloon expandable Sapien 3.

Feistritzer H. presented at TCT 2020

Embolic Debris Captured During *Transcatheter Valve-in-Valve (ViV)* Procedures with SENTINEL™ CPS

N=15 ViV TAVR patients implanted with EvolutR, Portico, Sapien XT or Lotus. CEP used successfully in all cases.

- Debris captured in 100% of patients
- Median of 123 particles were captured per patient
  - Median of 20 particles per patient being >150 mm



Schmidt T, et al. Heart 2016;0:1–7

Silent Brain Infarct (SBI)

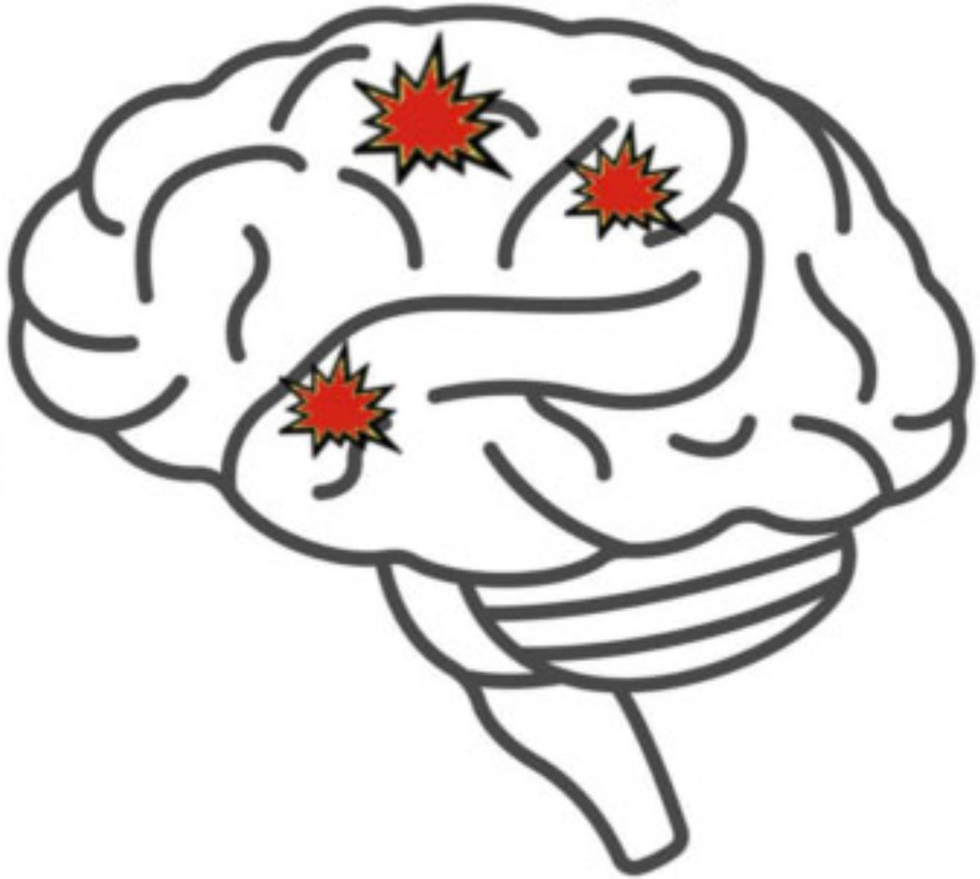
>70% of patients had evidence of silent brain infarct (SBI) after TAVI

Factors ↑ SBI Incidence

Diabetes

Renal impairment

Aortic valve predilation



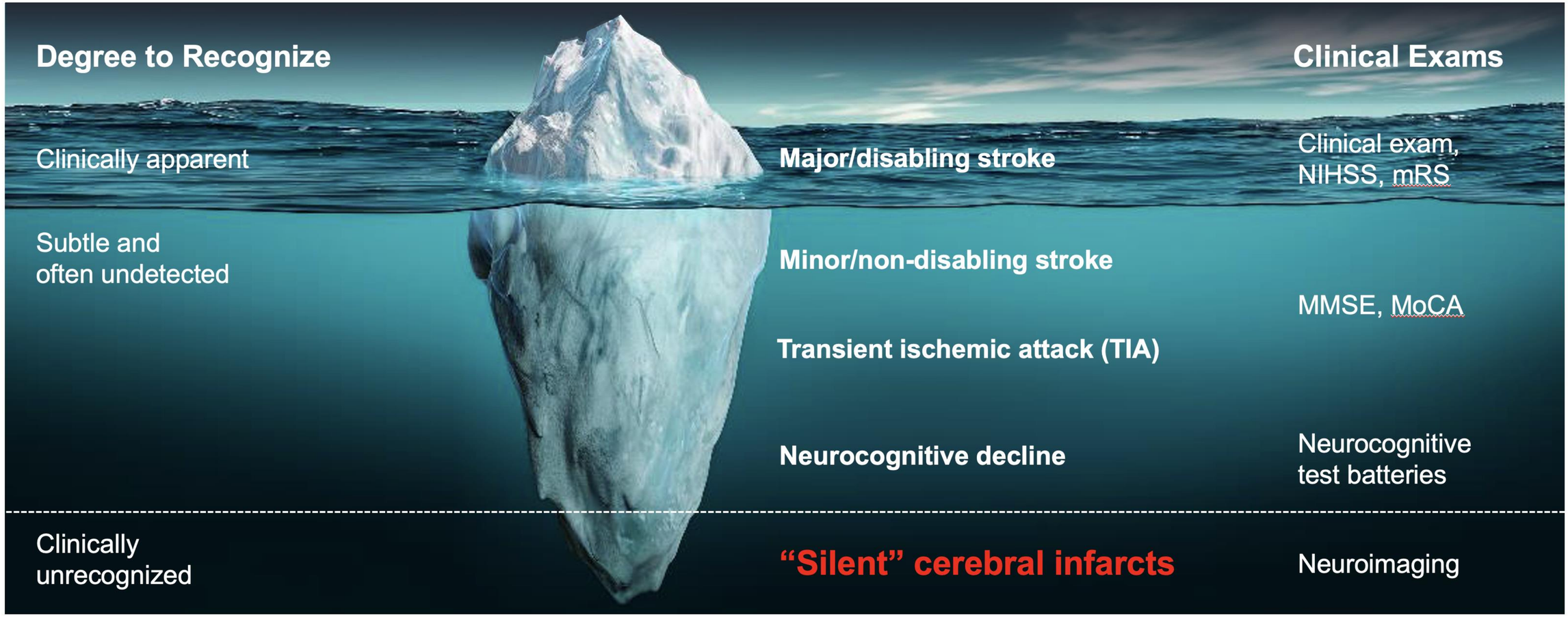
↑ number of SBIs was associated with a greater incidence of **postoperative cognitive dysfunction**

Cerebral embolic protection devices ↓ the volume of SBIs but did not affect the incidence or mean number of SBIs per patient

Woldendorp et al, EHJ 2021

Silent Brain Infarct (SBI)

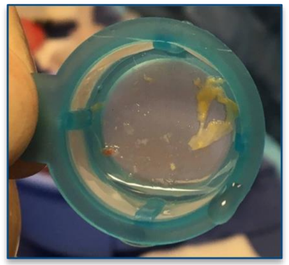
Post-TAVR Stroke and Other Neurological Events May Not Be Acutely Apparent

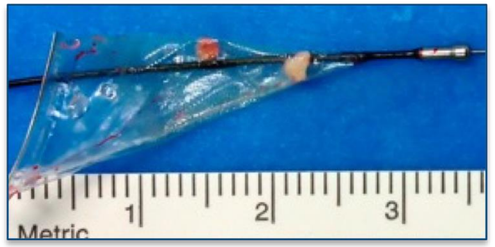


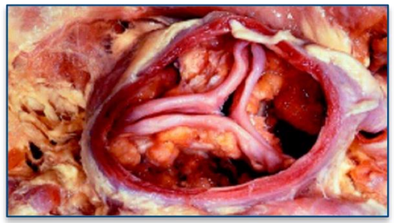
Woldendorp et al, EHJ 2021

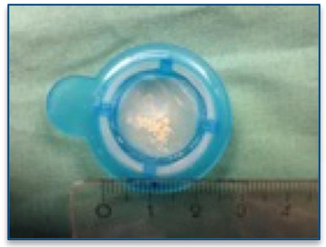
How to minimize Stroke

There are various sources of embolic debris that can result from TAVI



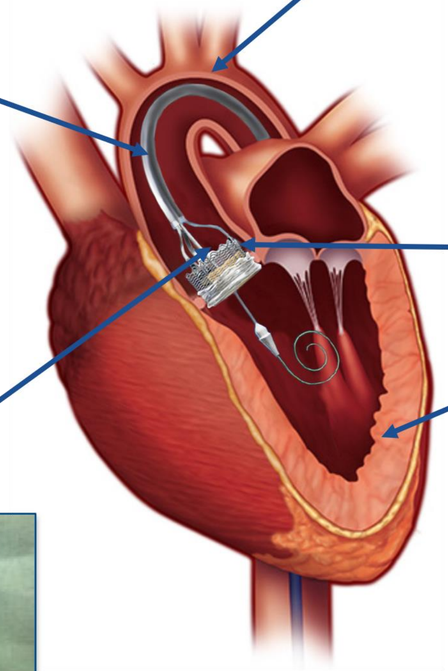




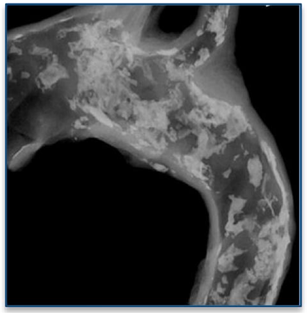


ASCENDING ARCH
Arterial wall, calcific and atherosclerotic material

STENOTIC VALVE
Leaflet tissue and calcific deposits

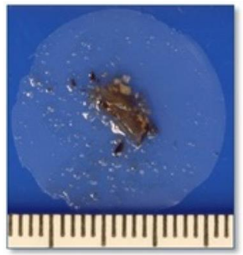


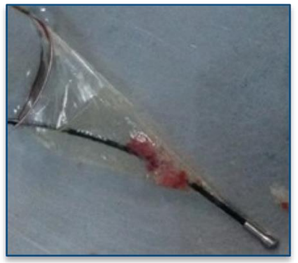
TRANSVERSE ARCH
Arterial wall, calcific and atherosclerotic material



TAVI DEVICES
Foreign material

NATIVE HEART
Myocardium





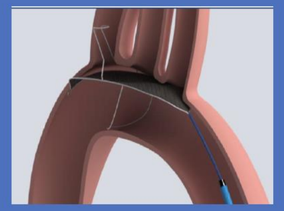
Kapadia, S. et al. JACC 2017;69(4): 367-77; Seeger, J. et al. JACC Cardiovasc Interv 2018;11(17):1683-1693.

Cerebral Embolization Protection Device

Boston Scientific SENTINEL™ Cerebral Protection System

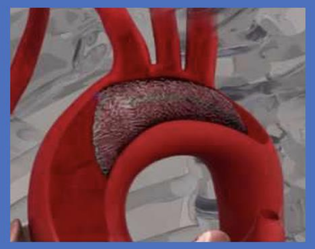
FDA-Cleared

TriGuard™ CPS[1]

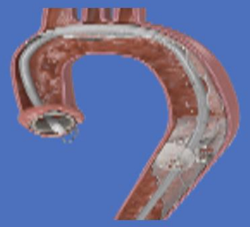


Protembis ProtEmbo™ CPS

ICS Emblok™ CPS[2]



Filterlex Medical Filterlex™

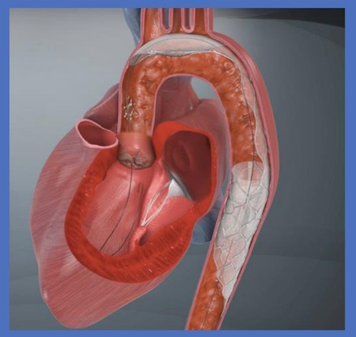


Emboline Emboliner™ Embolic Protection Catheter

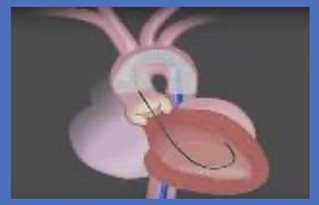
Under Development; Not Available for Sale in the US

Transverse Medical PointGuard™ Dynamic Cerebral Protection Device

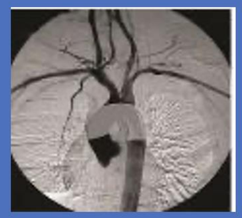
Captis™ [3]



CardiOptis Embolisher™



Capricorn™

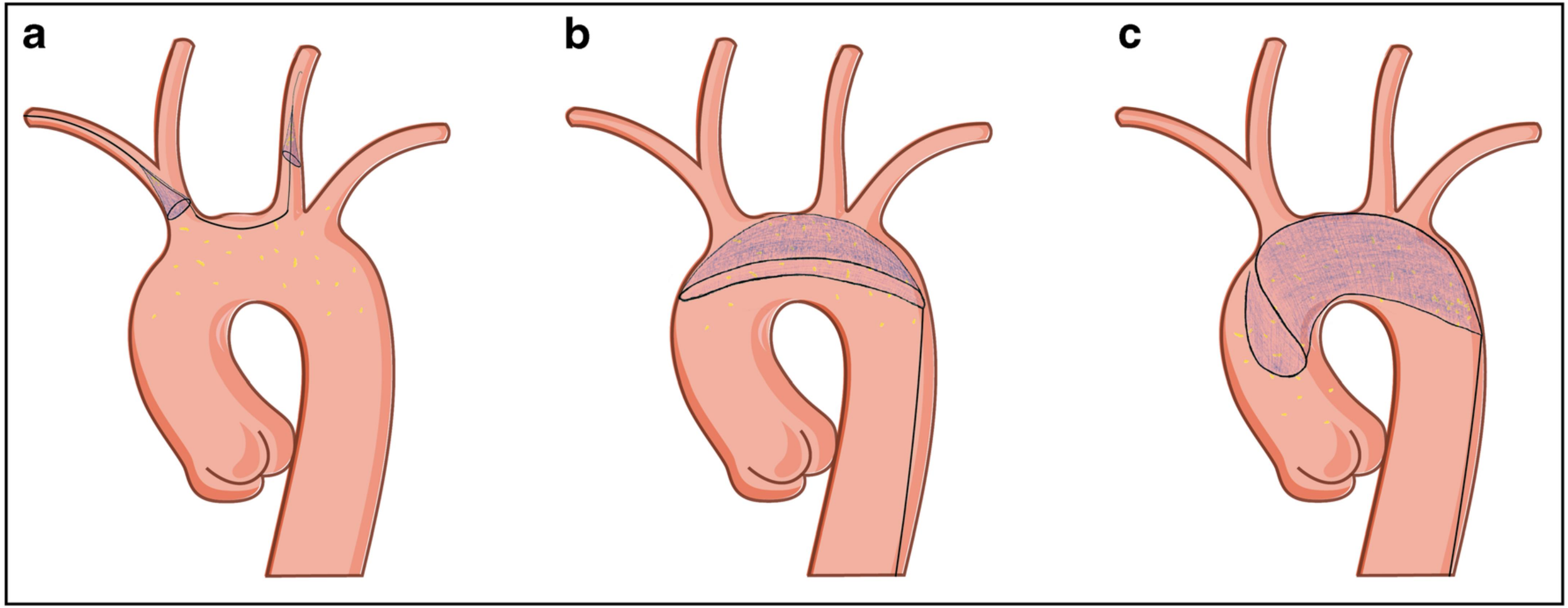


TransAortic Capture System™

1. TriGuard: not FDA approved.
2. Emblok: Pivotal Trial underway (May 2022)
3. Captis: Early Feasibility Study (EFS) completed.

In Courtesy of Boston Scientific Corporation

Cerebral Embolization Protection Device



Schematic draw of a filter-based capture (**a**), deflection (**b**), and complete protection device (**c**)

CEPD ; SENTINEL™

In Courtesy of Boston Scientific Corporation

CEPD ; SENTINEL™

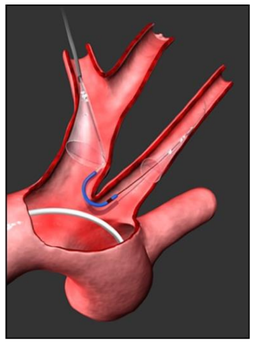
SENTINEL CPS does not adversely impact Cath lab workflow or timing

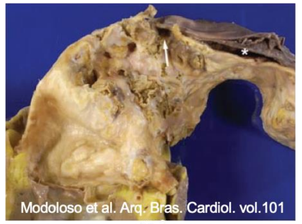
99.4% procedural success with at least 1 filter deployed (94.4% with both filters) per SENTINEL IDE Trial

4 minutes median procedural time to place both filters in SENTINEL IDE

~90% of anatomies accommodated

SENTINEL™ CPS – One Size to Fit ~90% of Anatomies

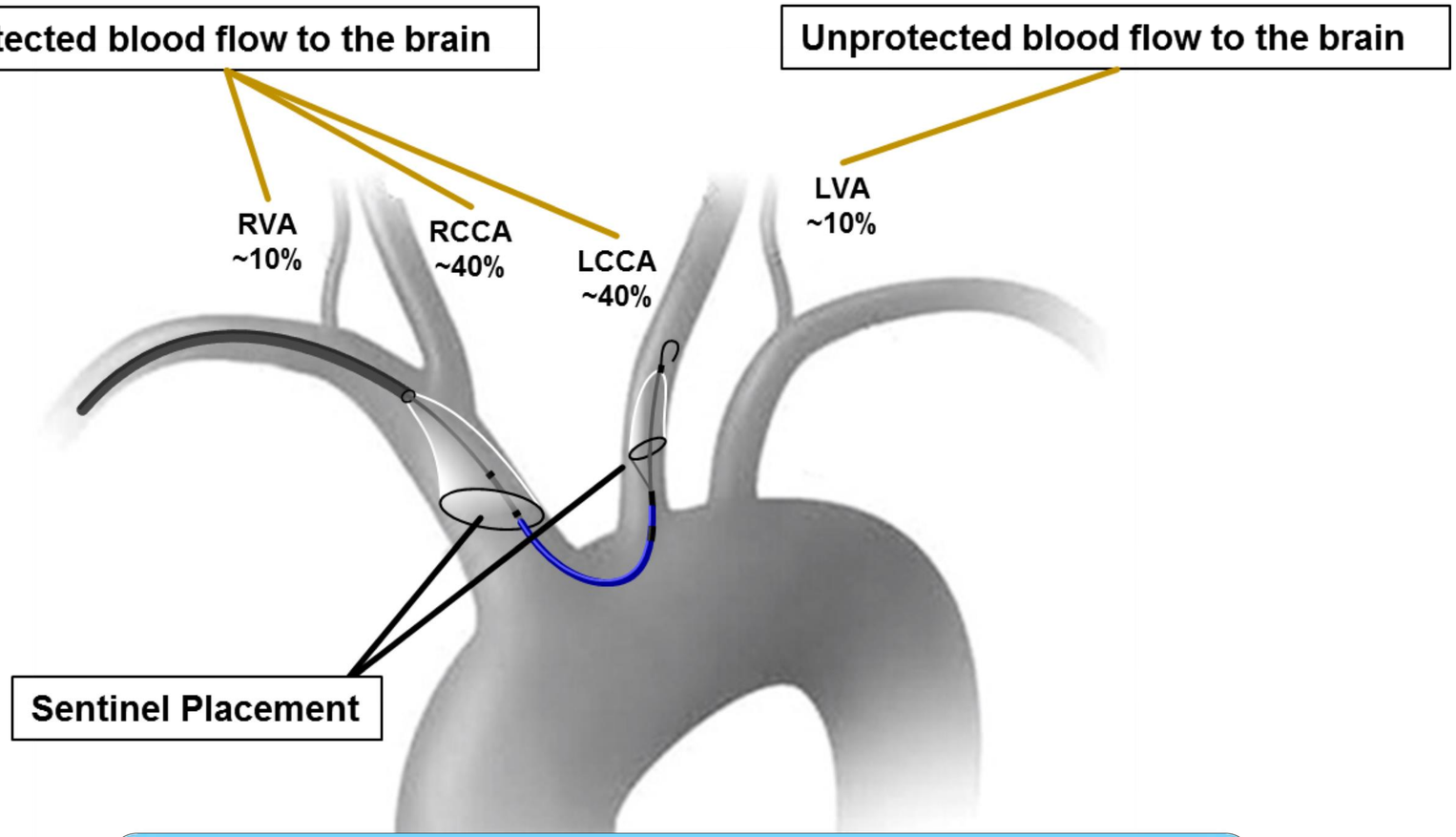




- Positioned in the carotids, outside aortic arch
- SENTINEL CPS leaves arch free for TAVI device passage
- Deflectors and other embolic protection designs which are placed in the aortic arch have the potential to interfere with TAVI devices, scrape the aortic wall, and have not proven ability to seal and remain stable in a wide variety of anatomies

In Courtesy of Boston Scientific Corporation

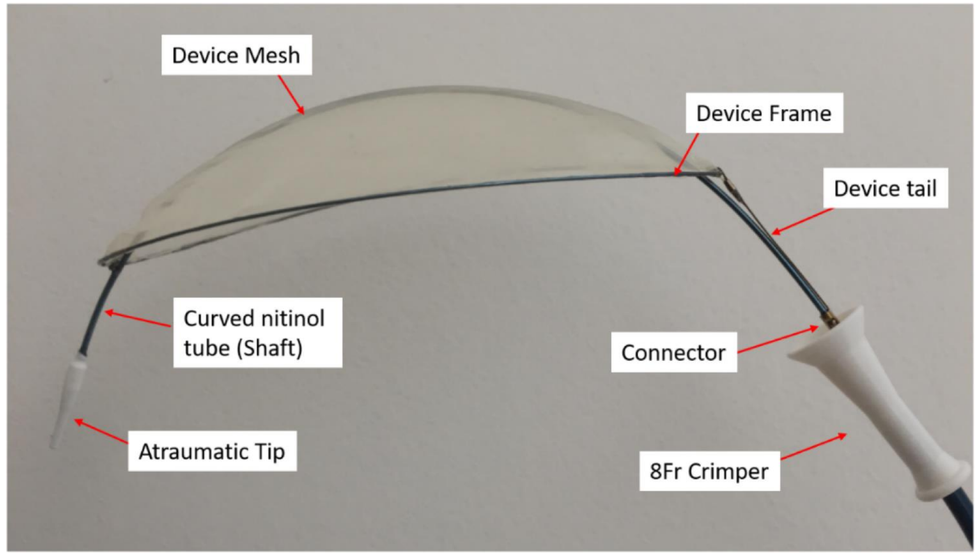
CEPD ; SENTINEL™

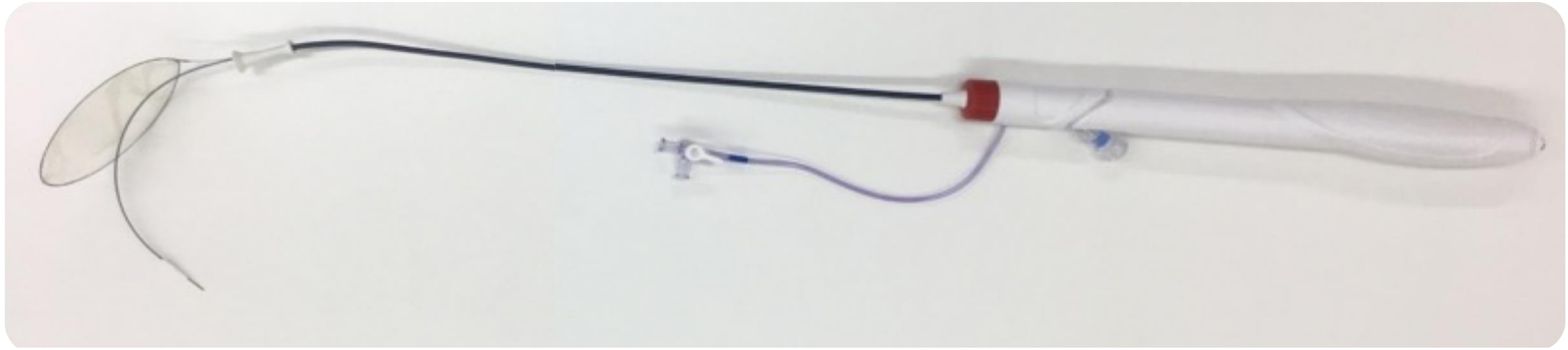


SENTINEL protects 90% of blood flow to the brain

Zhao M, et al. AJNR 2007

CEPD ; TriGuard 3™





TriGUARD 3 Deflection Filter

- Self-positioning, self-stabilizing, radiopaque nitinol frame
- Dome-shaped PEEK mesh
- 3X the Filter Area
- Decreased pore size (115 x 145 µm); 60% open area
- Heparin coated (same as to TriGuard HDH)

TriGUARD 3 Delivery System

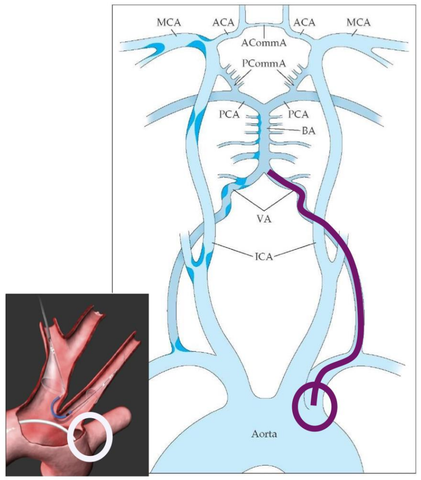
- 8 Fr integrated delivery sheath – pre-assembled for rapid prep
- Nitinol shaft – designed to provide stability after deployment
- Atraumatic tip – accommodates guidewire for OTW delivery
- Integrated pigtail entry port – improved hemostasis
- Ergonomic handle – consistent deployment and retrieval

In Courtesy of Venus Medtech, Inc

CEPD ; TriGuard 3™

In Courtesy of Venus Medtech, Inc

How about systemic embolization?



Don’t Ignore the Lt Vertebral Artery!

- Dominant in 34%
- Circle of Willis may have Lt to Rt flow

AKI after TAVR is Common

Study, Year	Incidence Rate of AKI, %	Criteria Used
Strauch et al, 2010[15]	57	RIFLE
Barbash et al, 2012[16]	15	RIFLE
Sinning et al, 2010[17]	26	AKIN
Khawaja et al, 2012[18]	36	VARC
Yamamoto et al, 2013[19]	15	VARC

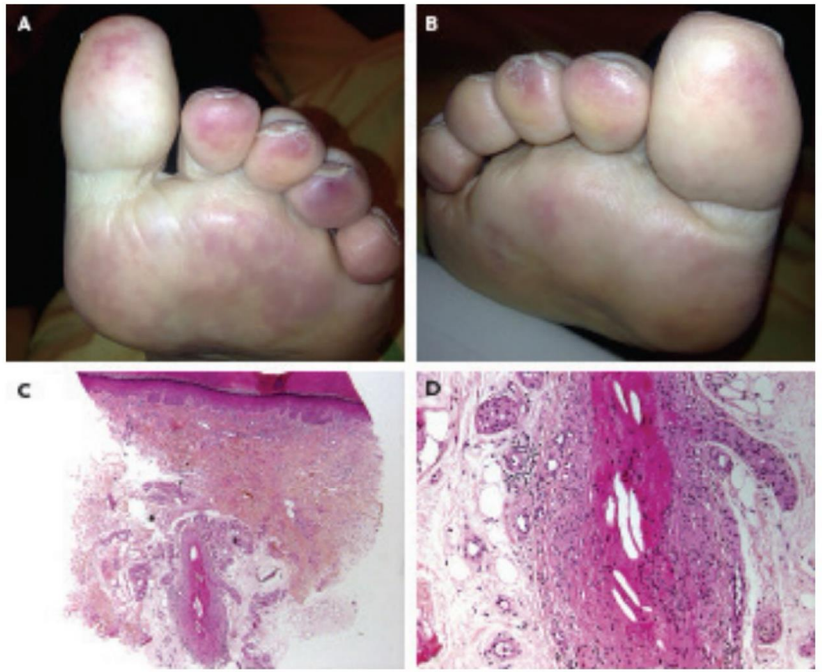
Abbreviations: AKI, acute kidney injury; AKIN, Acute Kidney Injury Network; RIFLE, Risk, Injury, Failure, Loss, and End-Stage; VARC, Valve Academic Research Consortium.

The NEW ENGLAND JOURNAL of MEDICINE

IMAGES IN CLINICAL MEDICINE

Lindsey R. Baden, M.D., *Editor*

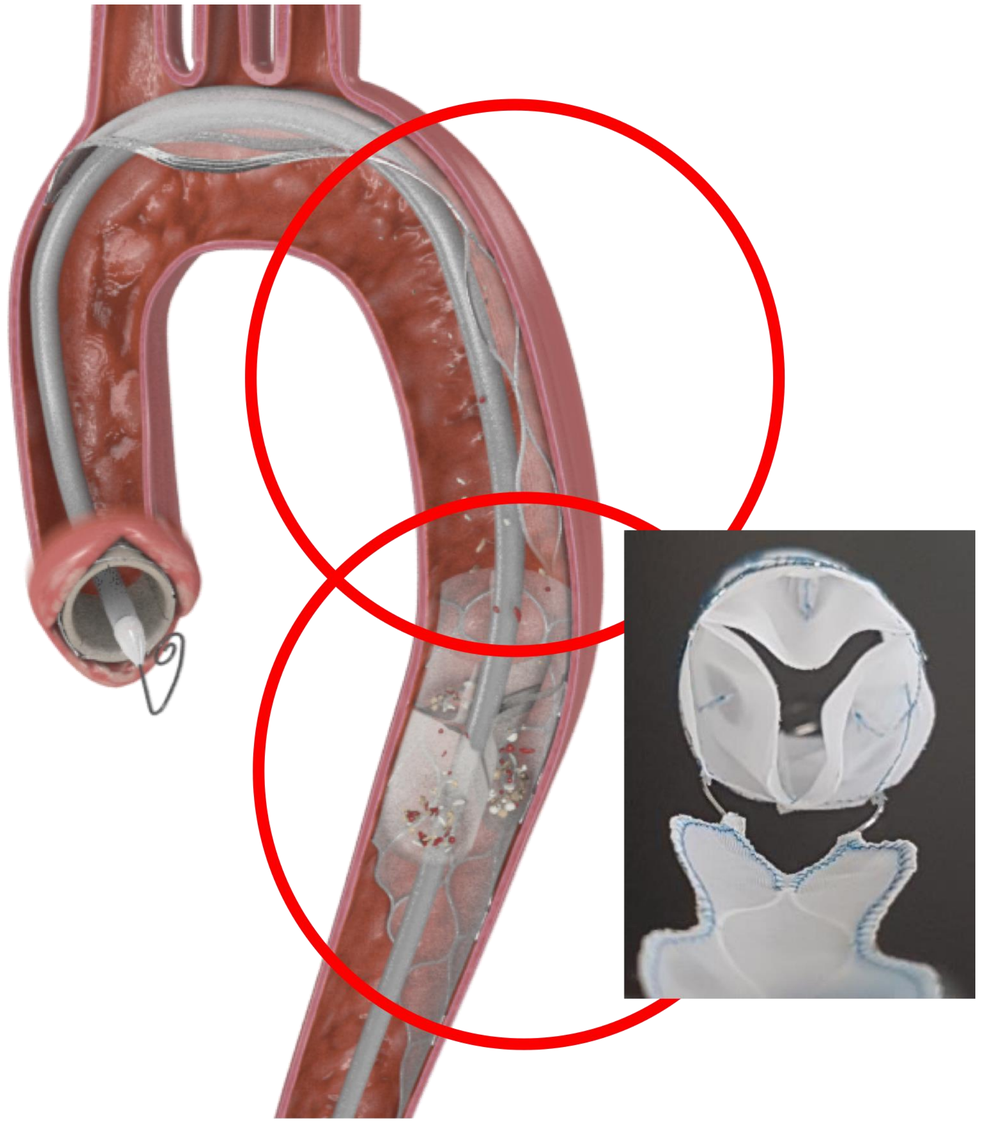
Cholesterol Embolization after Transcatheter Aortic-Valve Replacement



In Courtesy of Corindus, Filterlex

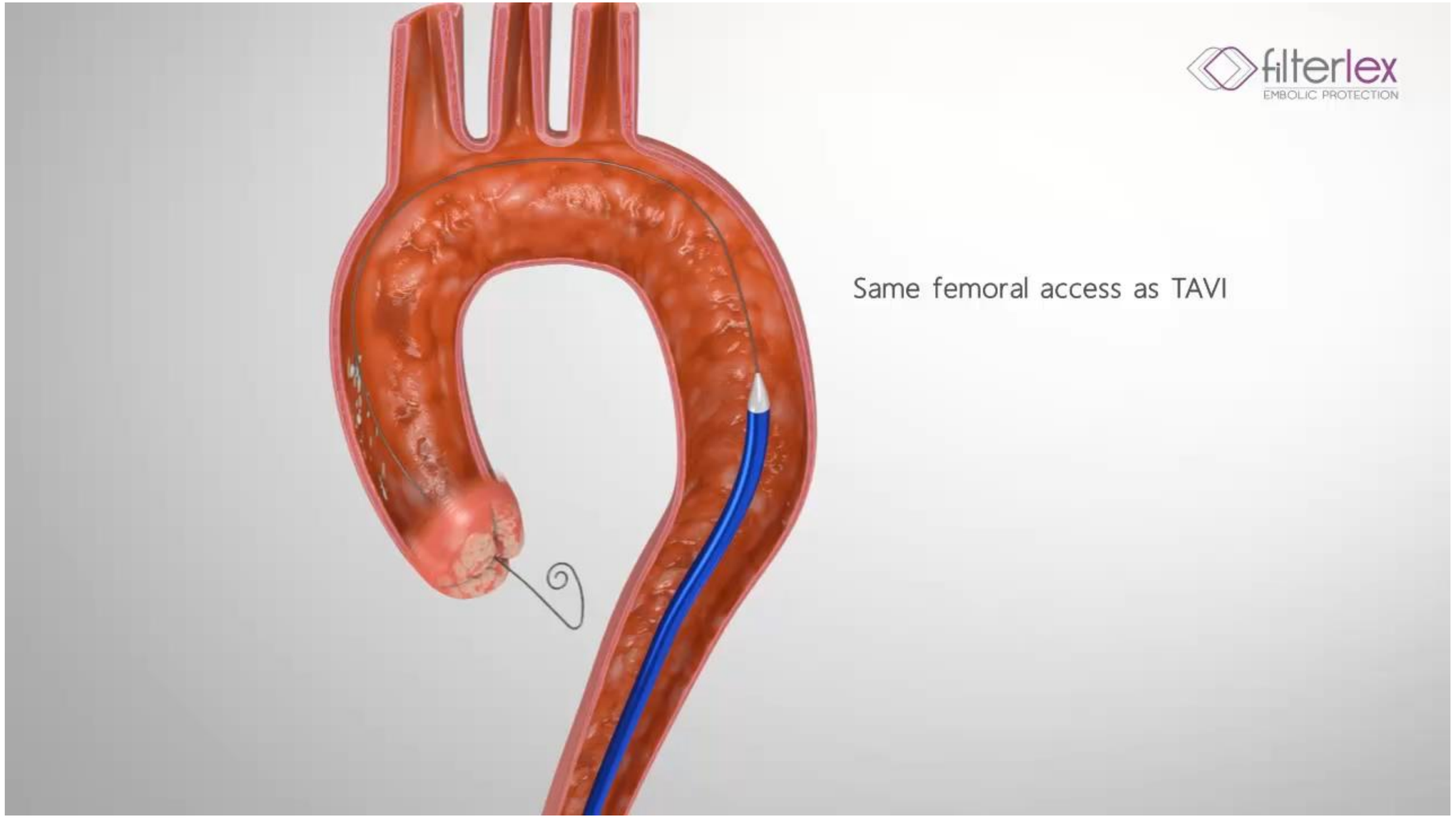
CEPD ; CAPTIS Total Body Protection Solution

- Complete protection of cerebral circulation
- Stable and safe anchoring
- Captures and extracts particles: Provides full body embolic protection
- Prevention of aortic surface injury
- Same arterial access as TAVR
- Applicable for a variety of left-heart procedures including mitral-valve, LAAC, AF Ablation



In Courtesy of Corindus, Filterlex

CEPD ; CAPTIS Total Body Protection Solution

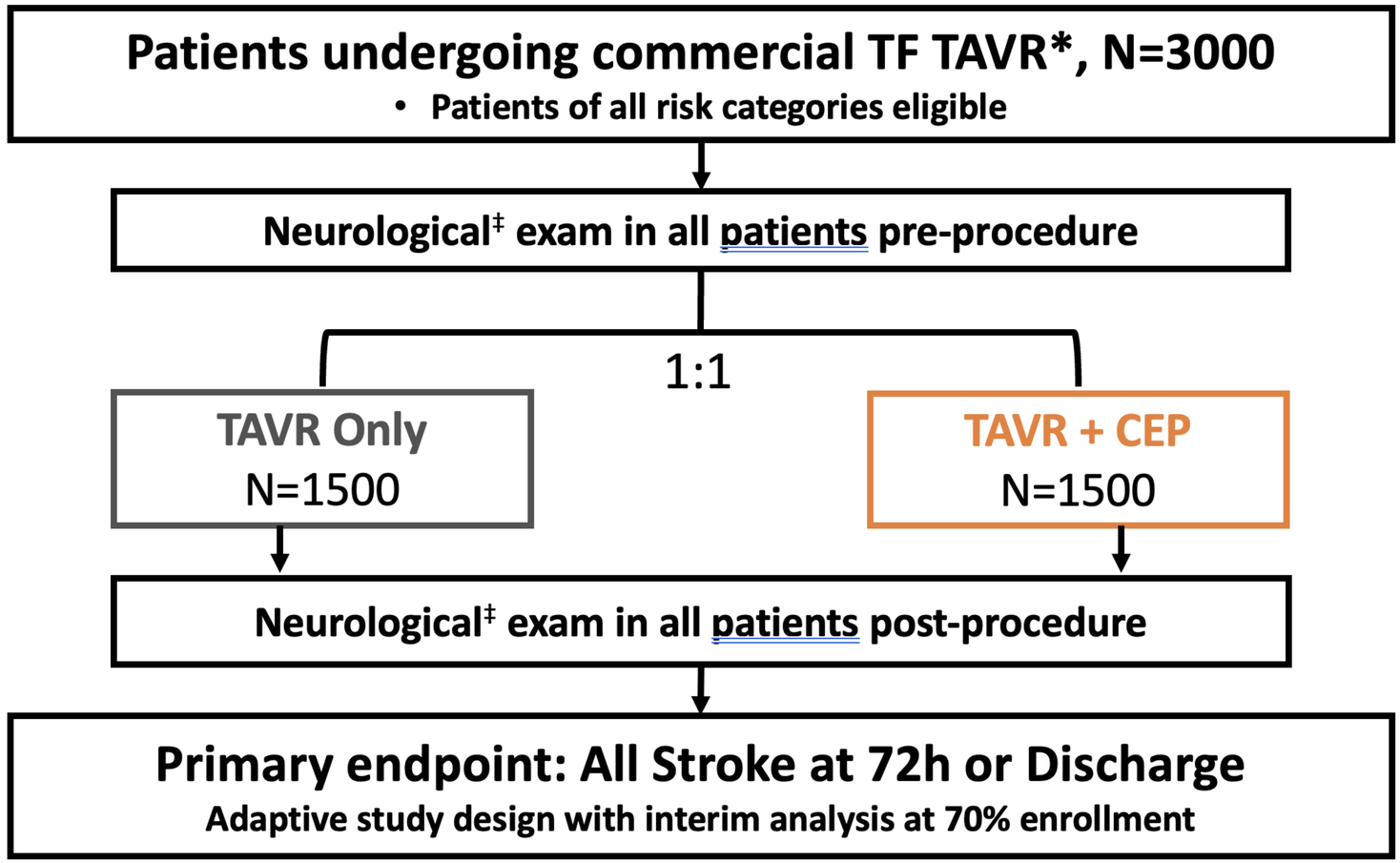


In Courtesy of Corindus, Filterlex

PROTECTED TAVR

Study Chair
Marty Leon, MD

Principal Investigators
Global PI: Samir Kapadia, MD
Co-PI: Axel Linke, MD



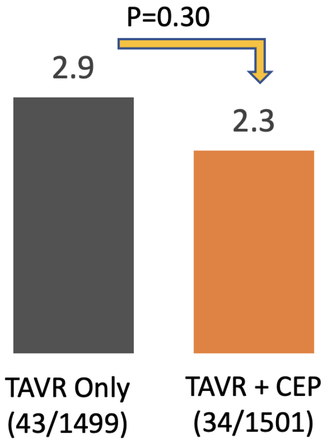
N Engl J Med 2022;387:1253-1263, DOI: 10.1056/NEJMoa2204961

PROTECTED TAVR

CONCLUSIONS

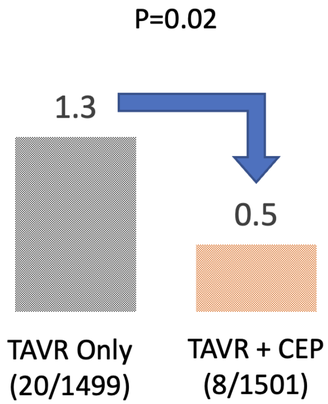
Among patients with aortic stenosis who were undergoing transfemoral TAVR, use of a CEP device during the procedure did not have a significant effect on the incidence of periprocedural stroke, although a potential benefit may not be ruled out.

Primary Endpoint: All Stroke



21%
relative risk reduction in
All Stroke
through 72 hours

Secondary Analysis: Disabling Stroke



60%
relative risk reduction in
Disabling Stroke
through 72 hours

- Largest randomized TAVR trial to date with 3,000 patients enrolled at more than 50 global sites
- Data demonstrated a non-significant but numerical trend toward a lower risk of stroke in patients treated with the SENTINEL device
- Secondary analysis of disabling stroke showed a statistical difference

N Engl J Med 2022;387:1253-1263, DOI: 10.1056/NEJMoa2204961

PROTECTED TAVR Limitations

- Trial design was practical in order to facilitate enrollment and data collection
  - As a consequence, the study was restricted to a small number of endpoints with only short-term follow-up
- Neurological professionals were not blinded to a patient's clinical course and hospital record
- The study was not powered to detect a treatment difference for disabling stroke

N Engl J Med 2022;387:1253-1263, DOI: 10.1056/NEJMoa2204961

British Heart Foundation Randomised Clinical Trial of Cerebral Embolic Protection in Transcatheter Aortic Valve Implantation (BHF PROTECT-TAVI)

Patients undergoing transfemoral TAVI (n=7730)*

↓

1:1 Randomisation

↓

TAVI with CEP (n=3865)	TAVI without CEP (n=3865)

(Standardised questionnaire to assess stroke free status with mandated stroke physician review)

Primary outcome: Discharge or Stroke at 72hrs

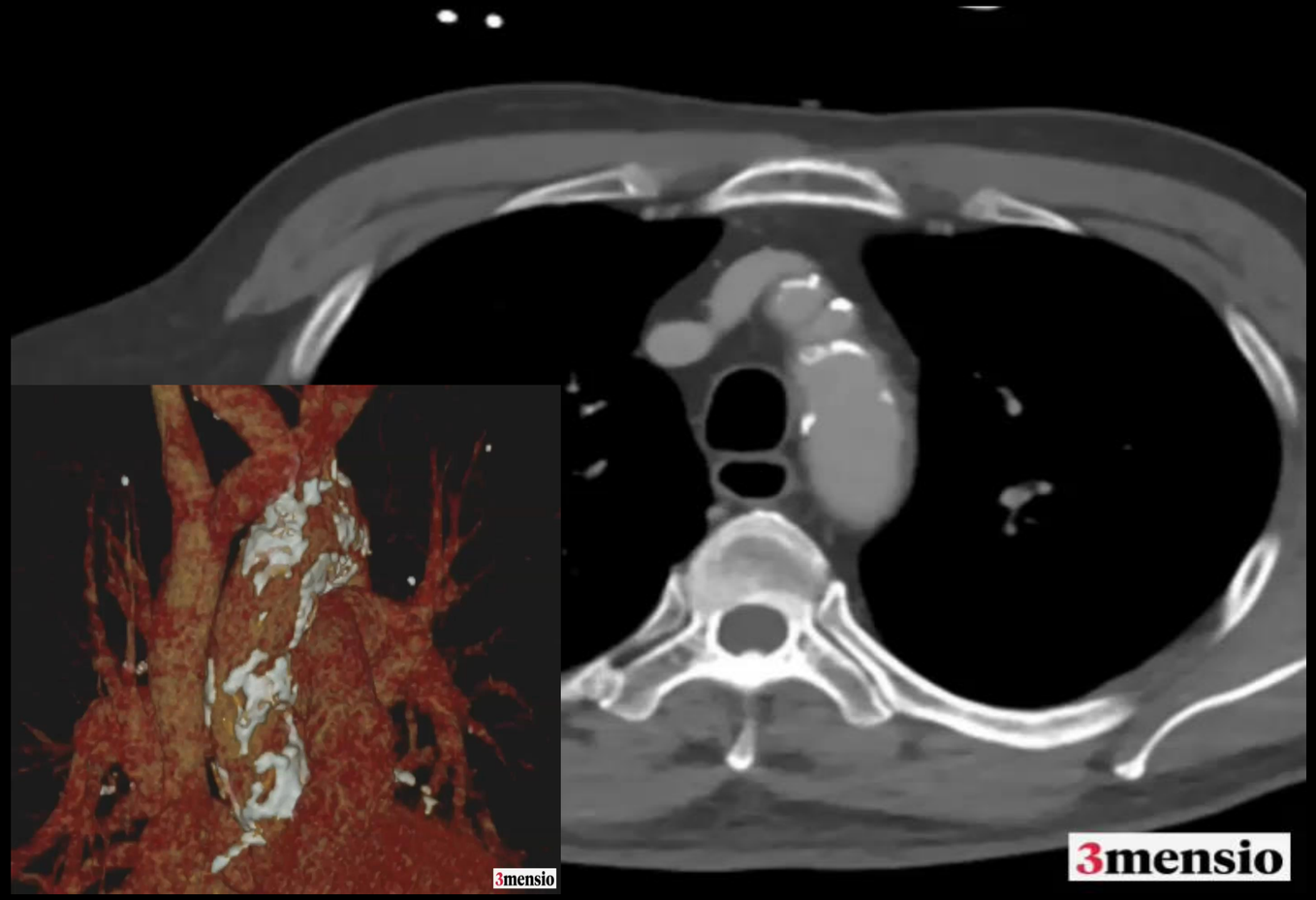
Planned interim analysis for efficacy/futility at 50% and 70%

UNIVERSITY OF OXFORD

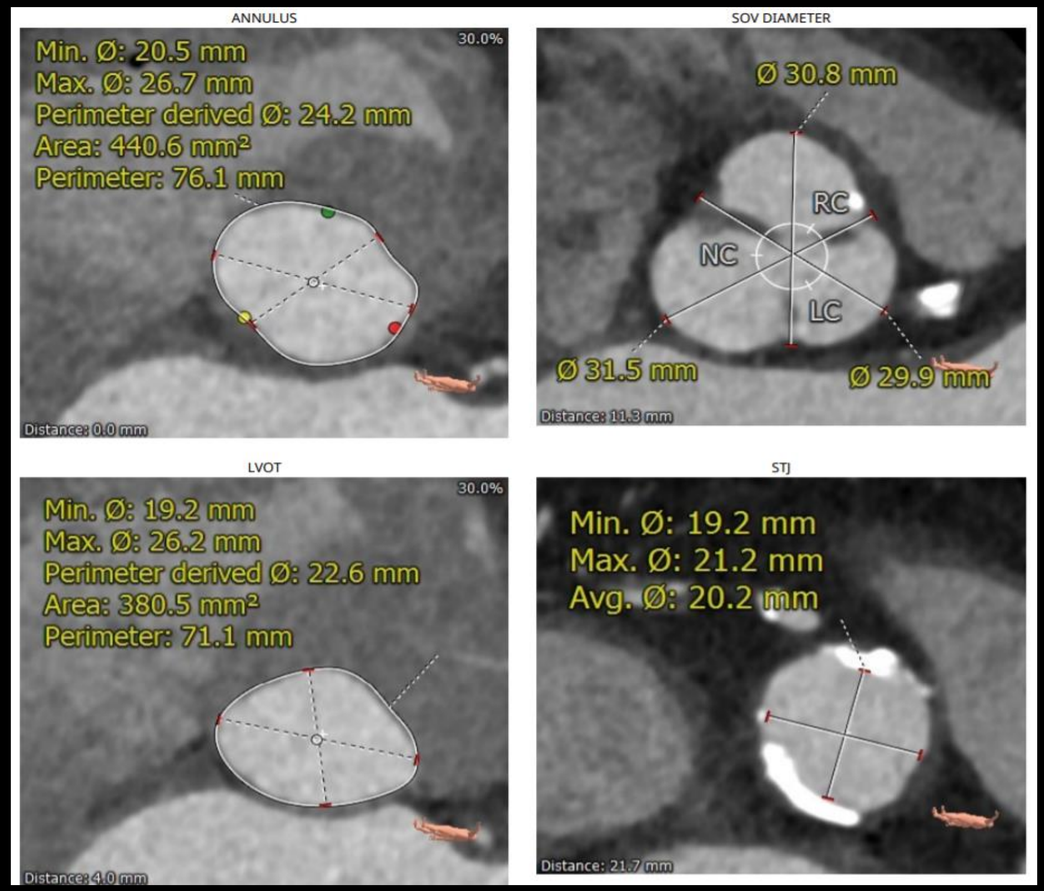
British Heart Foundation

* Powered for control event rate of 3% and effect size of 33%

CASE 1 80/M Pre TAVI CT review



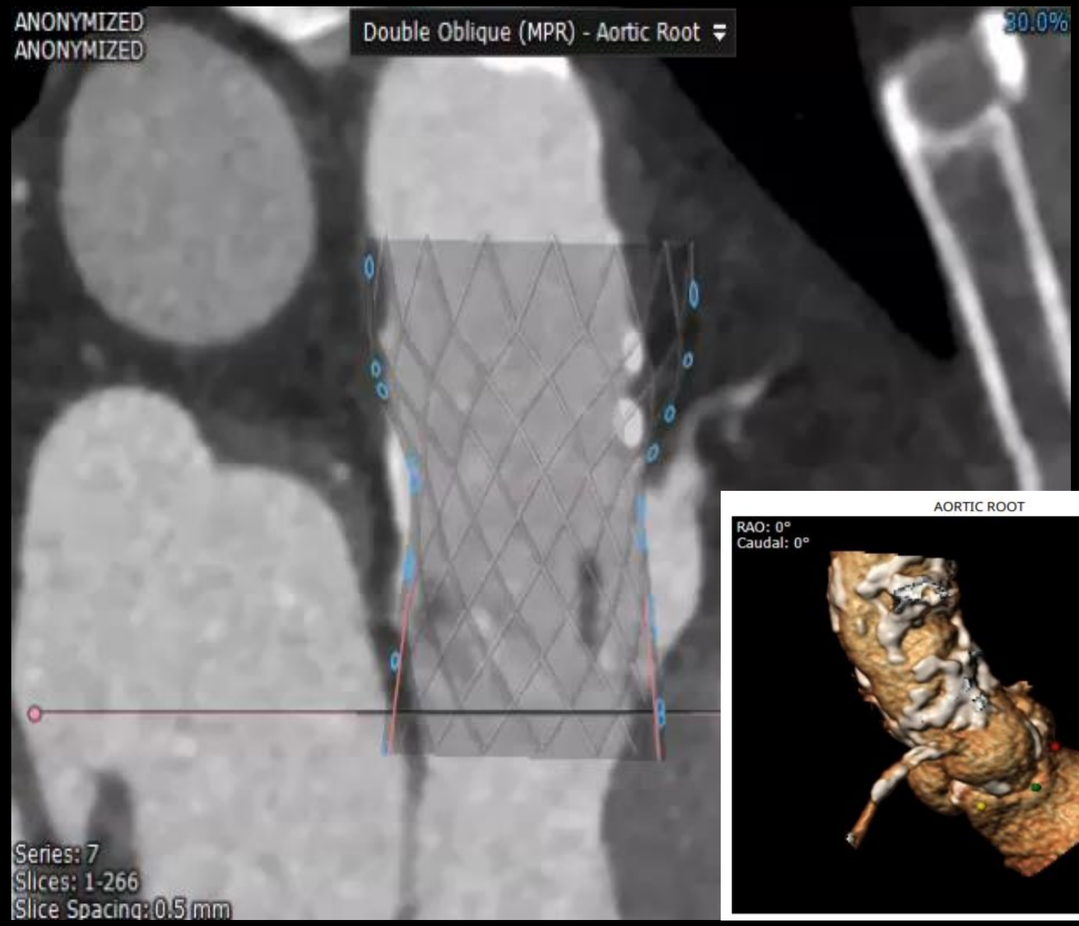
Diffuse atherosclerotic calcifications along aorta

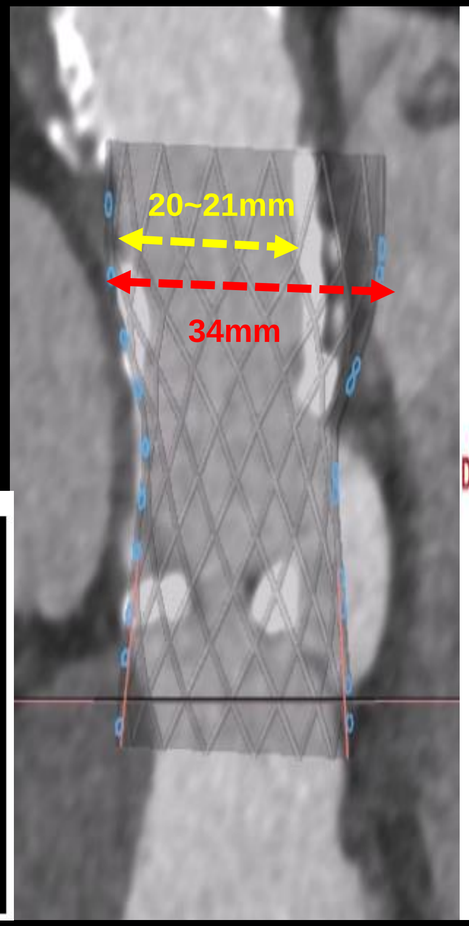


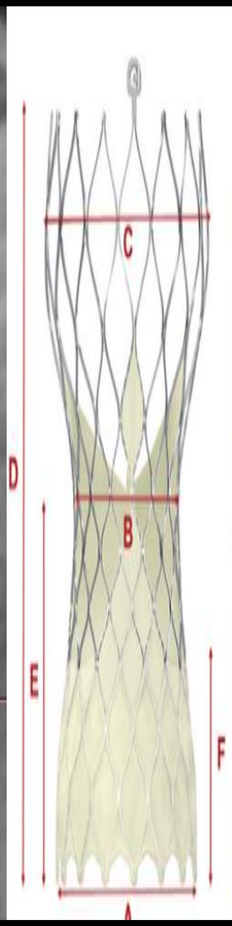
Perimeter: 6.1mm (AnnulusDiameter : 24.2mm)

Evolut R/PRO 29mm (20% Oversizing)

Pre TAVI CT review







	23mm Evolut R / PRO	26 mm Evolut R / PRO	29mm Evolut R / PRO	34mm Evolut R
A. Inflow Diameter	23 mm	26 mm	29 mm	34 mm
B. Waist Diameter	20 mm	22 mm	23 mm	24 mm
C. Outflow Diameter	34 mm	32 mm	34 mm	38 mm
D. Frame height	45 mm	45 mm	45 mm	46 mm
E. Commissure Height	26 mm	26 mm	26 mm	26 mm
F. Skirt Height	13 mm	13 mm	13 mm	14 mm

Spyder FX

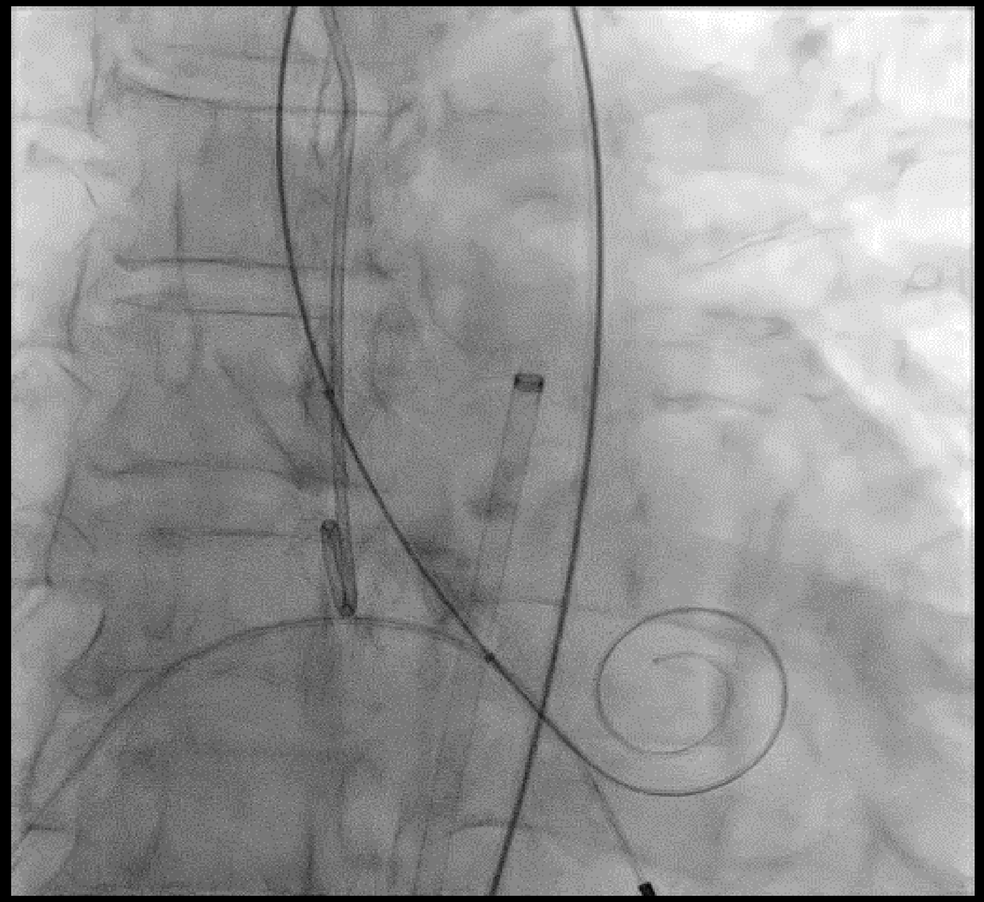
HEALTHCARE PROFESSIONALS

SpiderFX Embolic Protection Device

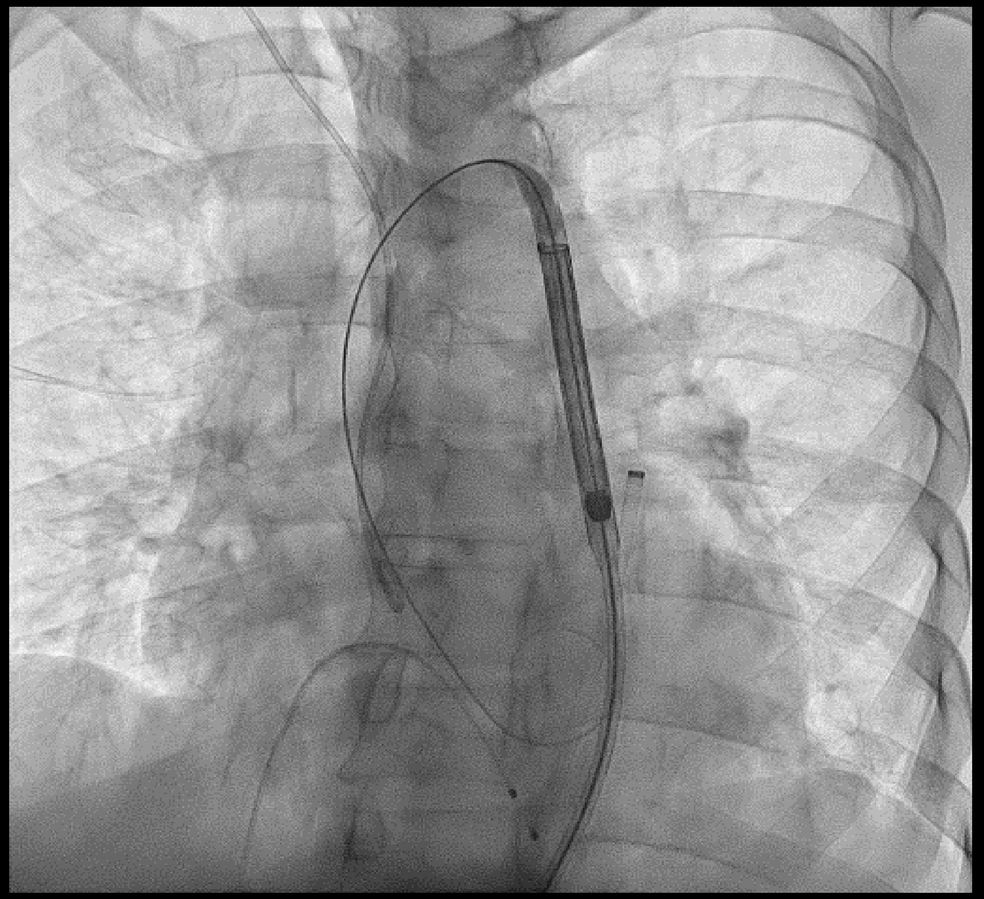
Peripheral Interventions

Extensive SpiderFX™ Portfolio

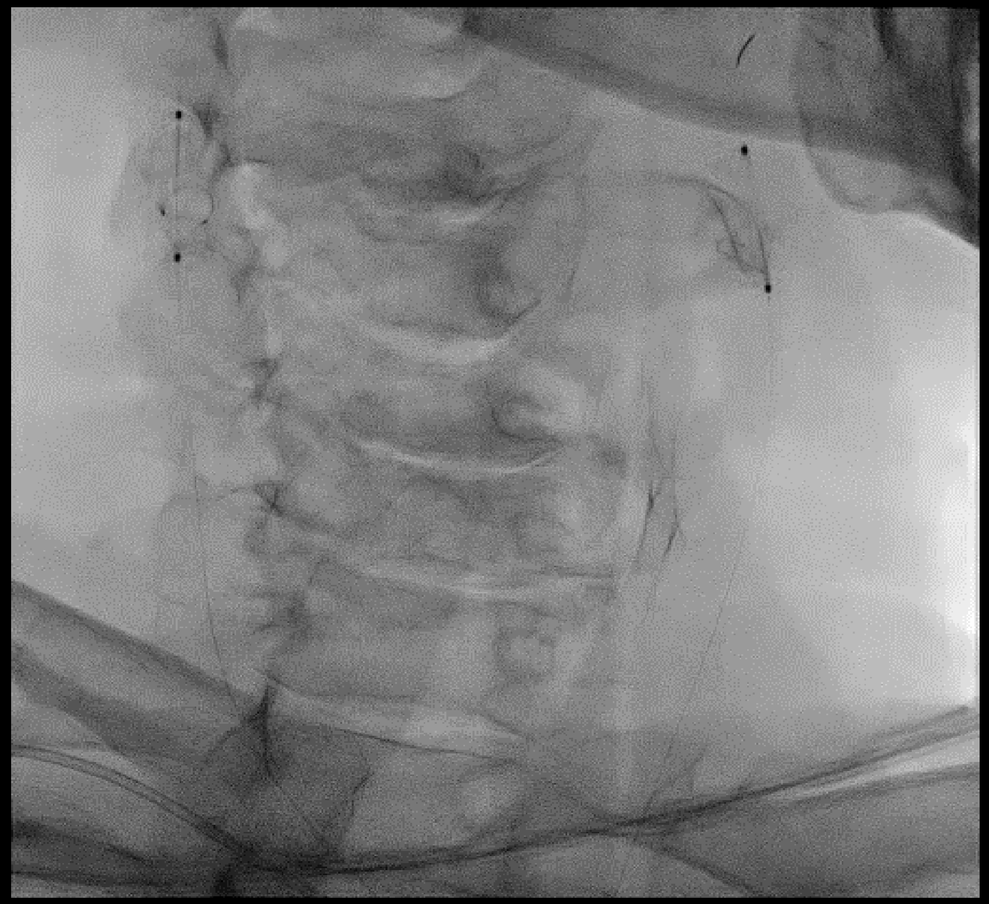
SpiderFX™ device is available in a variety of sizes (3 mm to 7 mm) for optimal fit and apposition in a range of vessels.



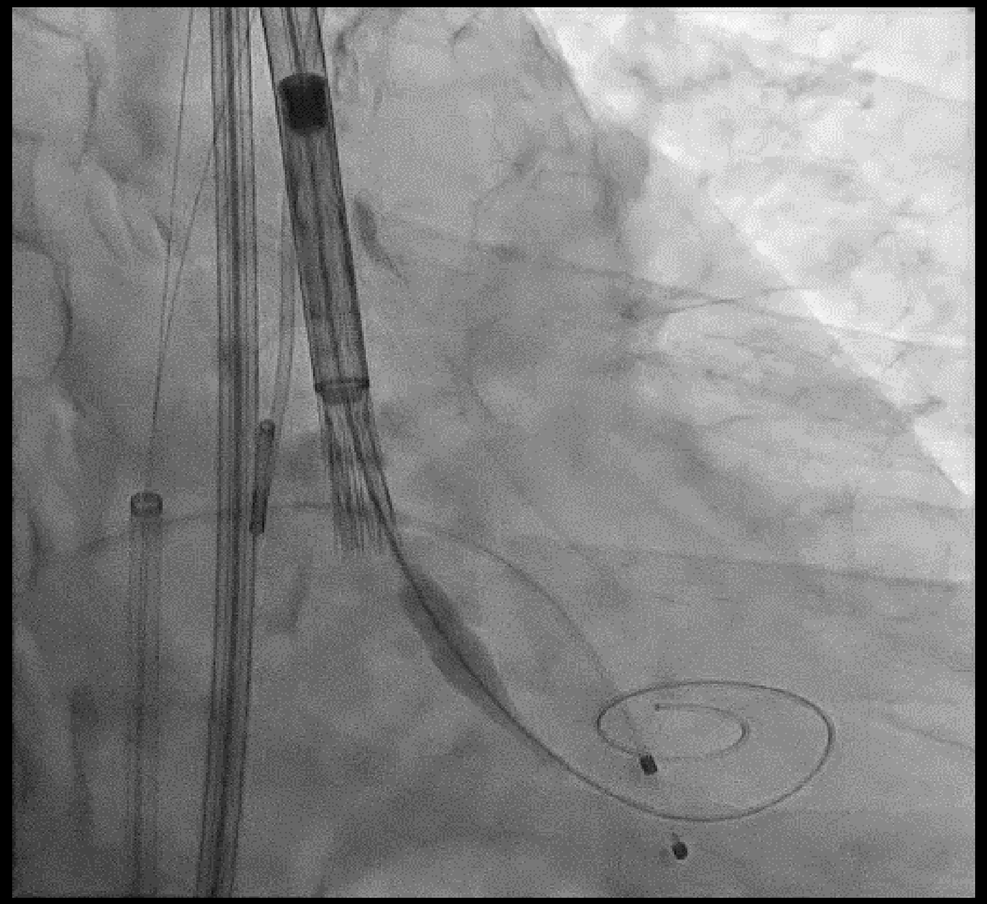
18mm Pre balloon



Carefully place the valve on ascending Aorta

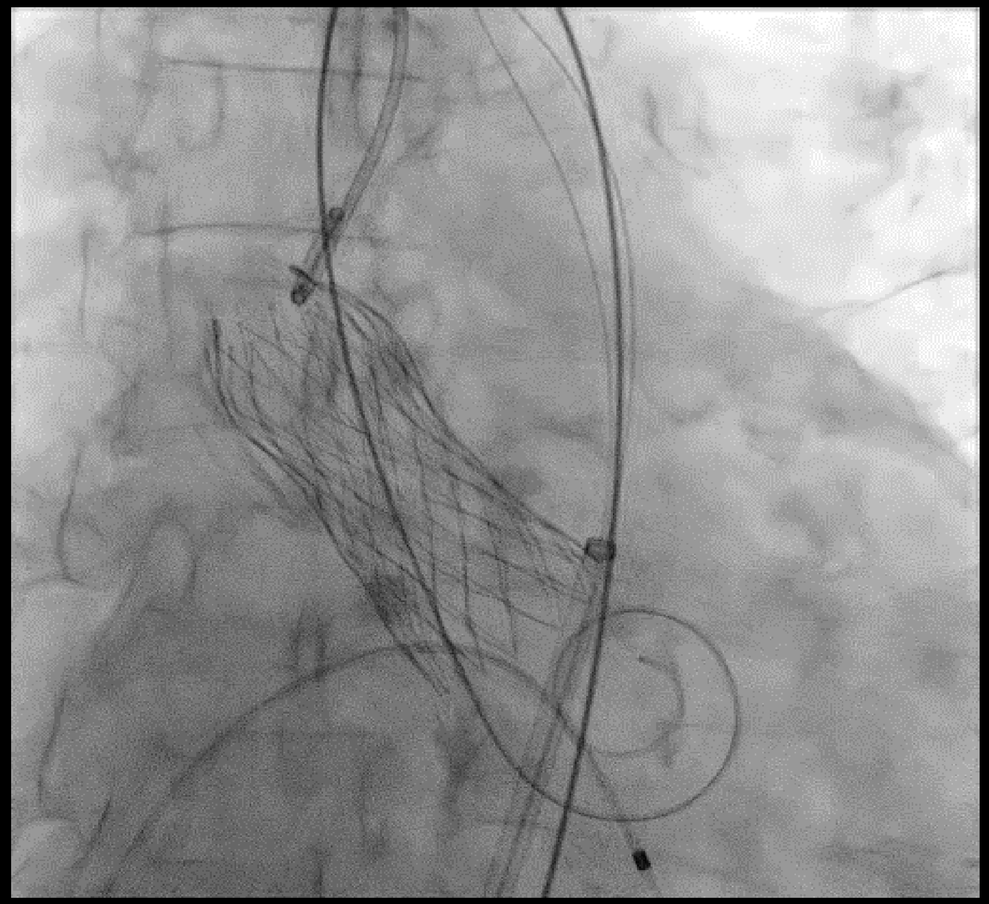


8Fr ANSEL with Spider 7mm in both CCA

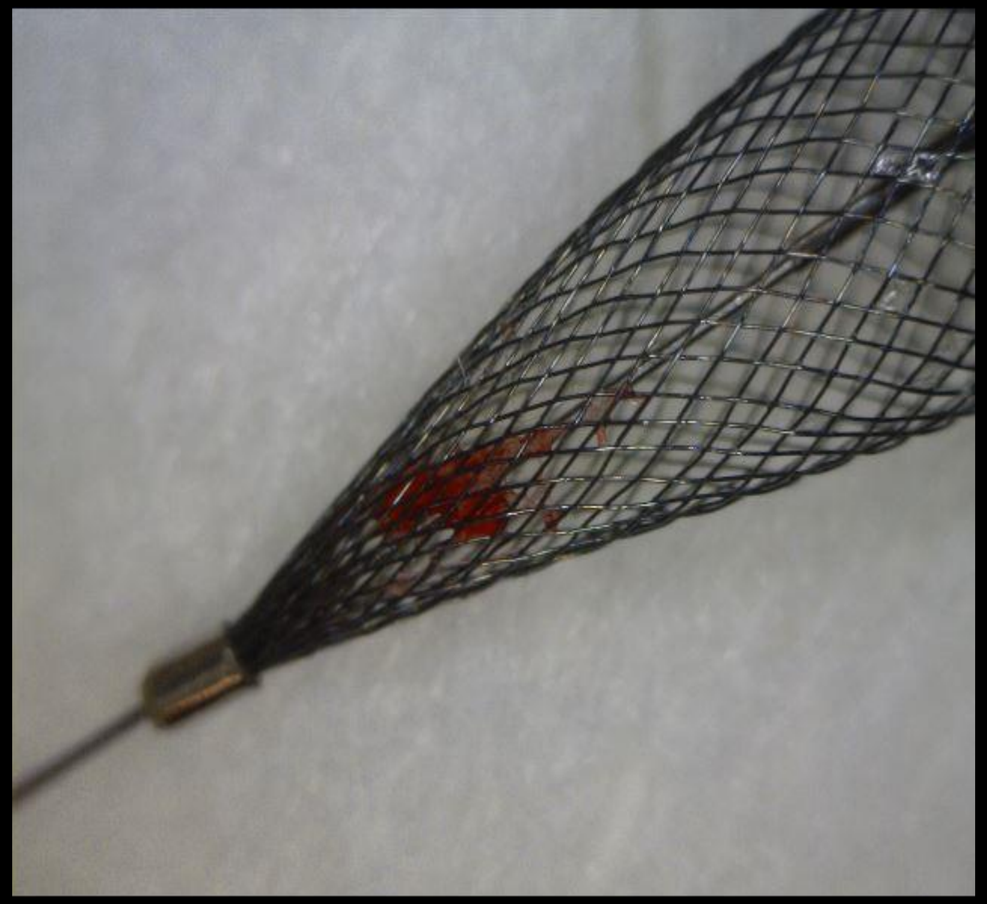


Cusp overlap view

Final Angio



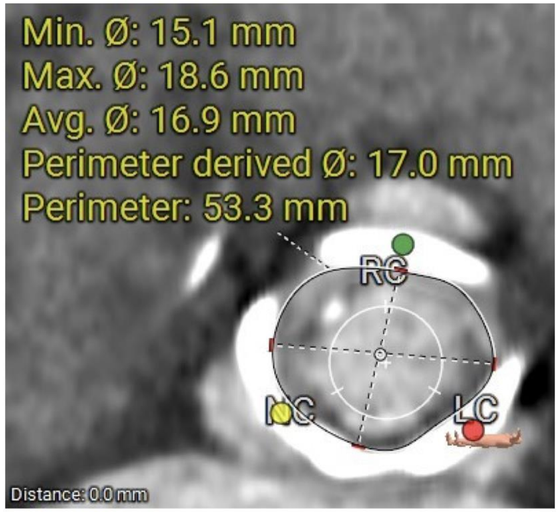
Final angiography



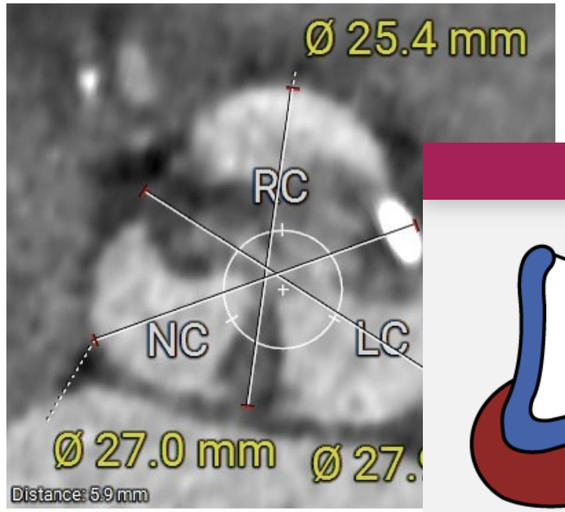
Debris in Rt. CCA Spyder filter

Case 2 82/F, previous AVR, stroke Hx.

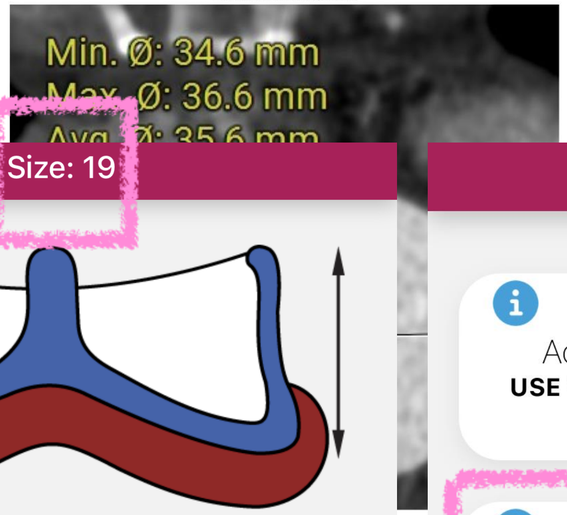
ANNULUS



SOV DIAMETER

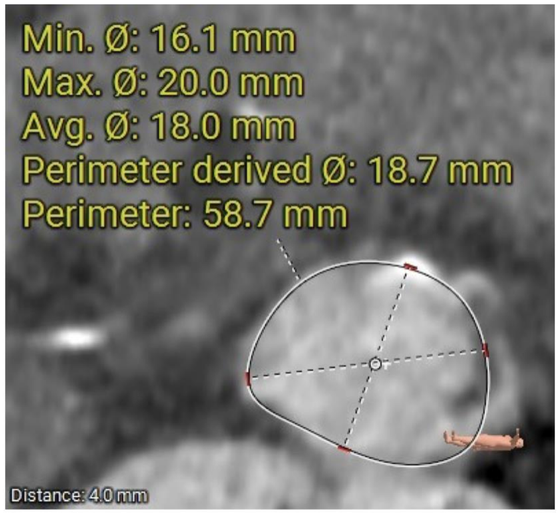


ASCENDING AORTA

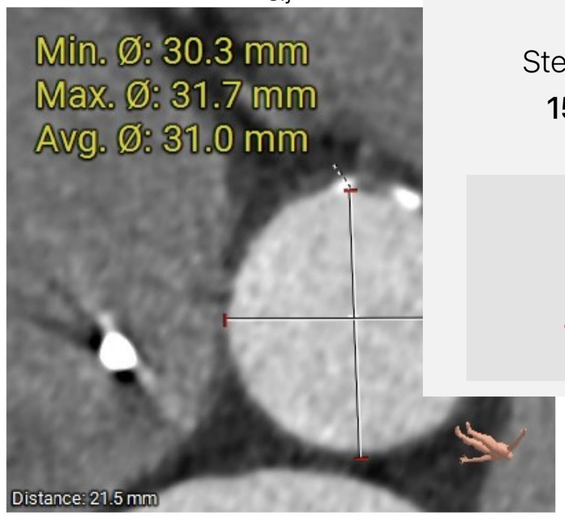


AORTIC VALVE CALCIFICATION

LVOT



STJ



Size: 19

Stent ID	Height	True ID
15.4	11	15.4

Fracturable

True Balloon Size: 18/20mm

After fracture
THV size needed may be larger

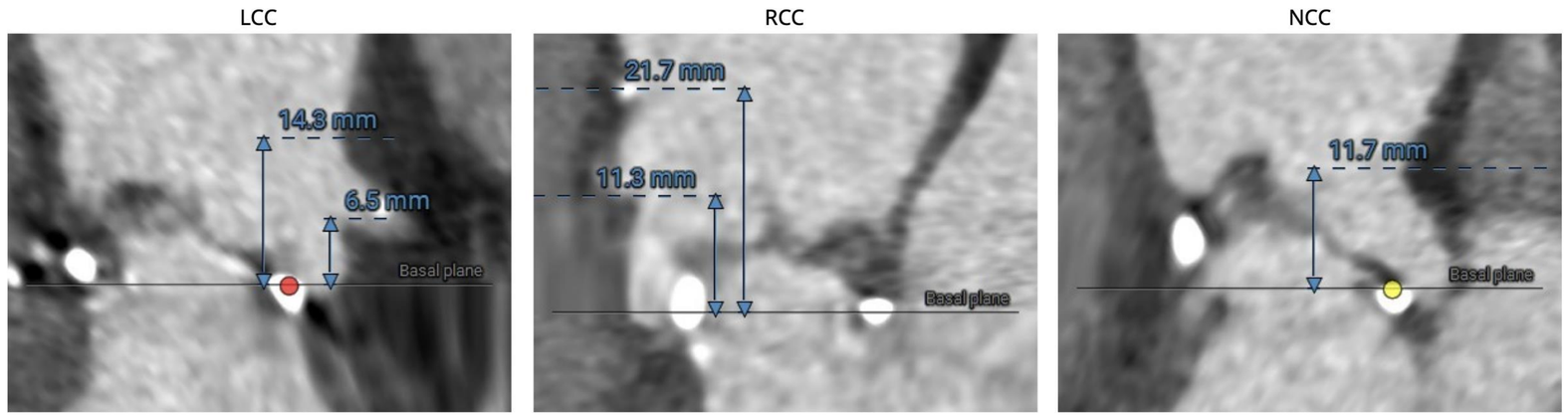
Area (mm²) 263.2 , Derived Ø (mm) 18.3

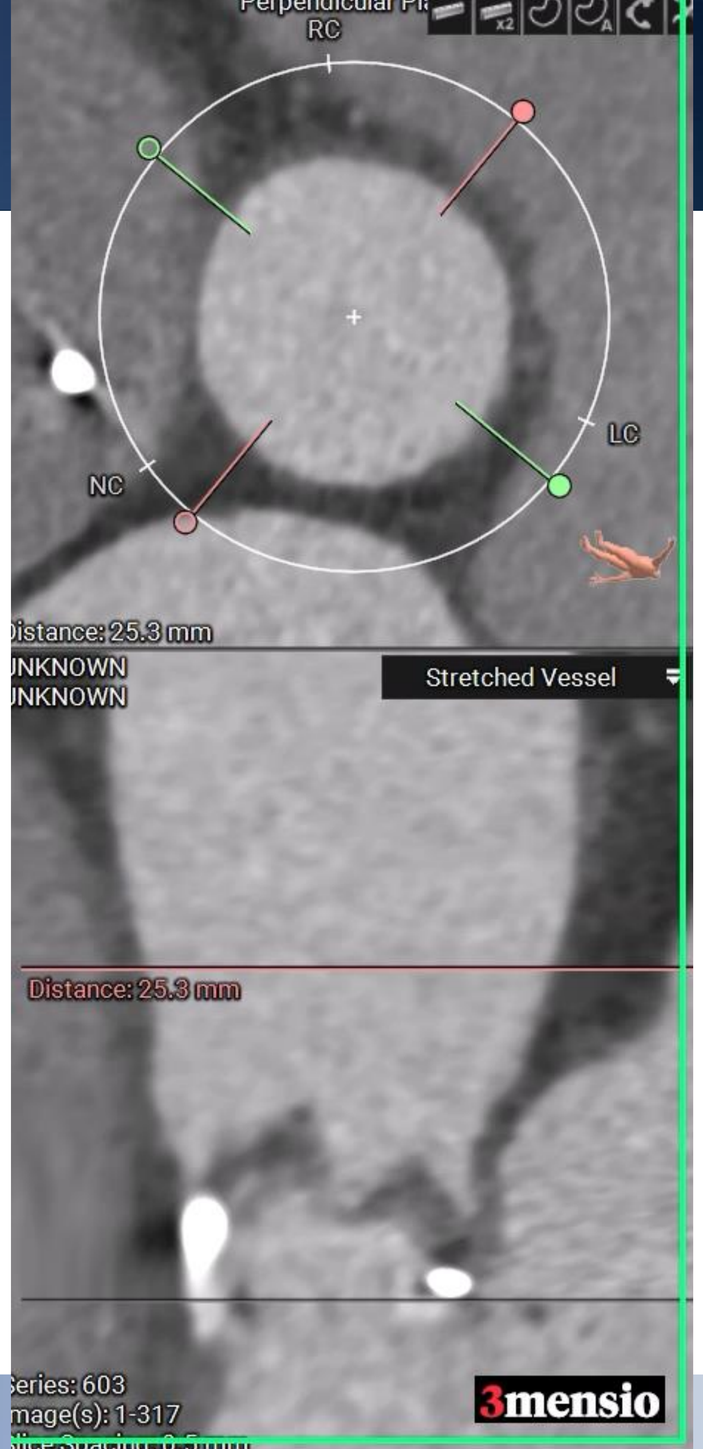
THV Selector: Current

- Acurate NEO — **USE WITH CAUTION**
- Allegra — **USE WITH CAUTION**
- Evolut — **USE WITH CAUTION**
- Portico — **USE WITH CAUTION**
- S3 — **USE WITH CAUTION**

Pre-TAVI CT Measurements

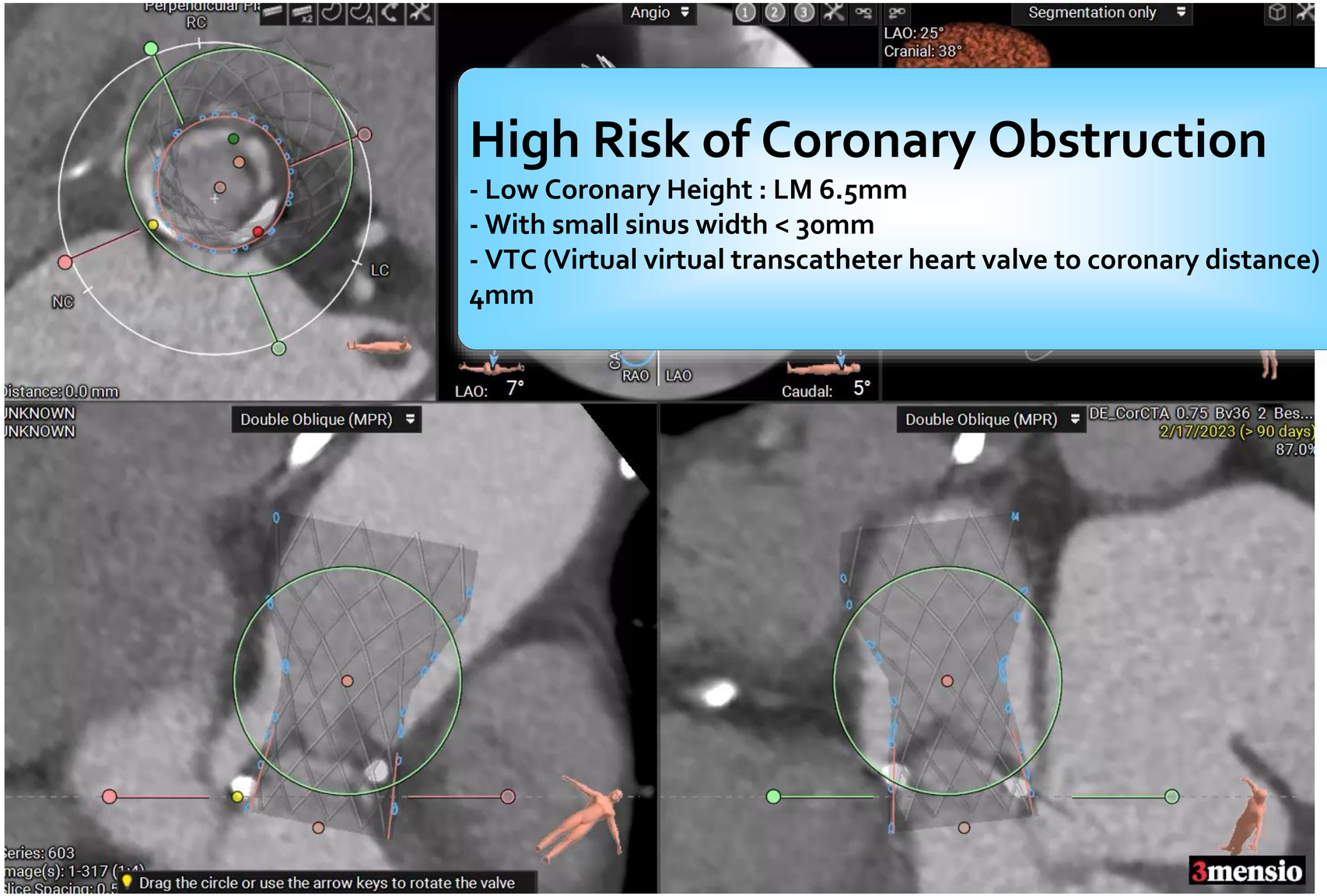
SINUS HEIGHT





Low Coronary Height : LM 6.5mm

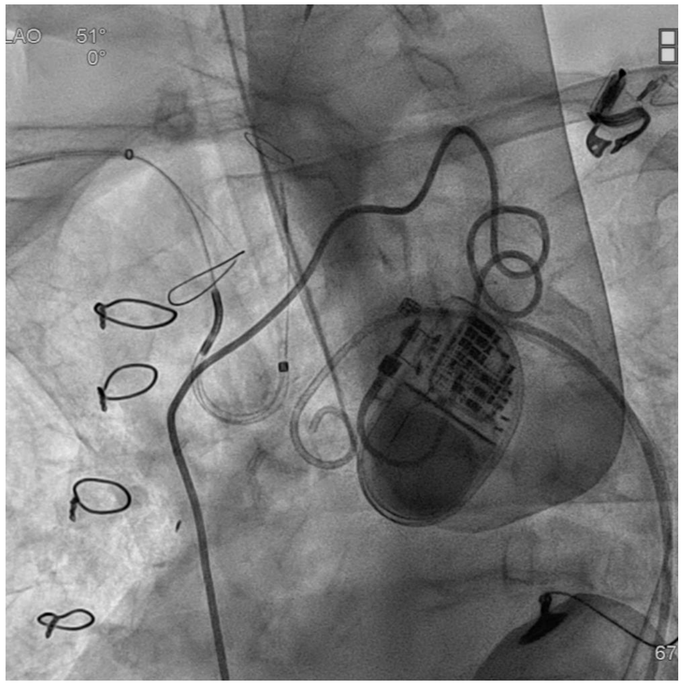
3D simulation by pre-TAVI CT



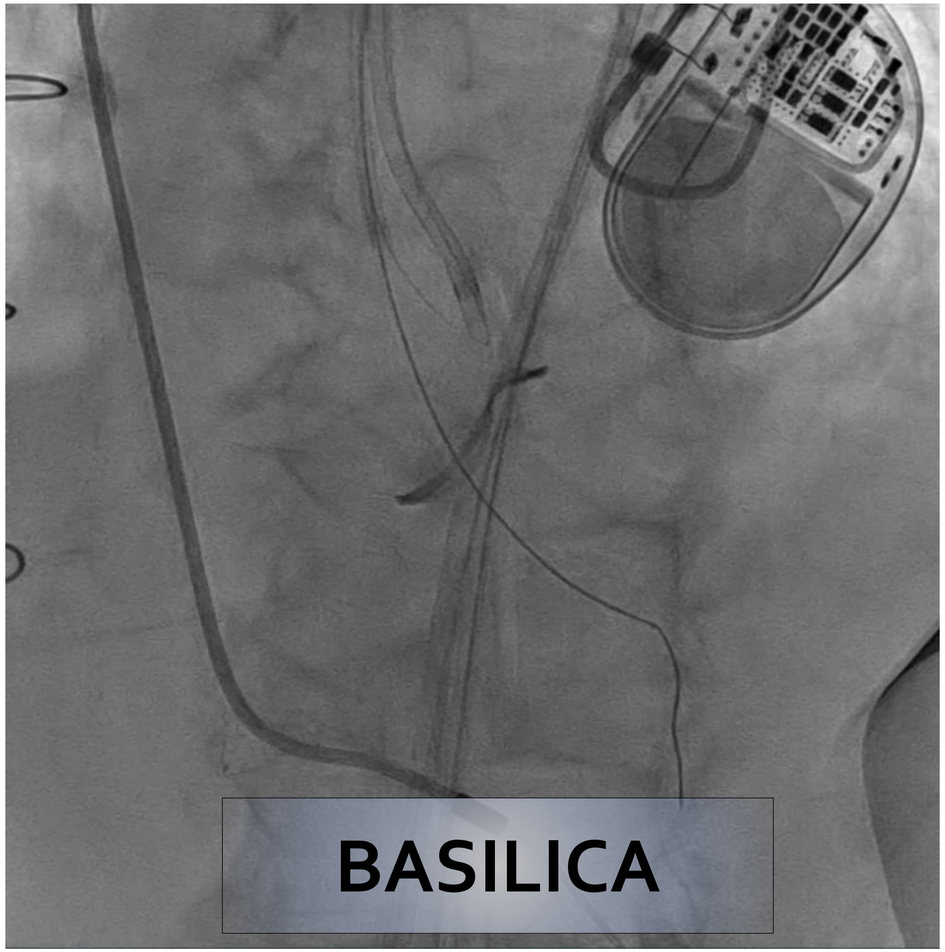
High Risk of Coronary Obstruction

- Low Coronary Height : LM 6.5mm
- With small sinus width < 30mm
- VTC (Virtual virtual transcatheter heart valve to coronary distance) < 4mm

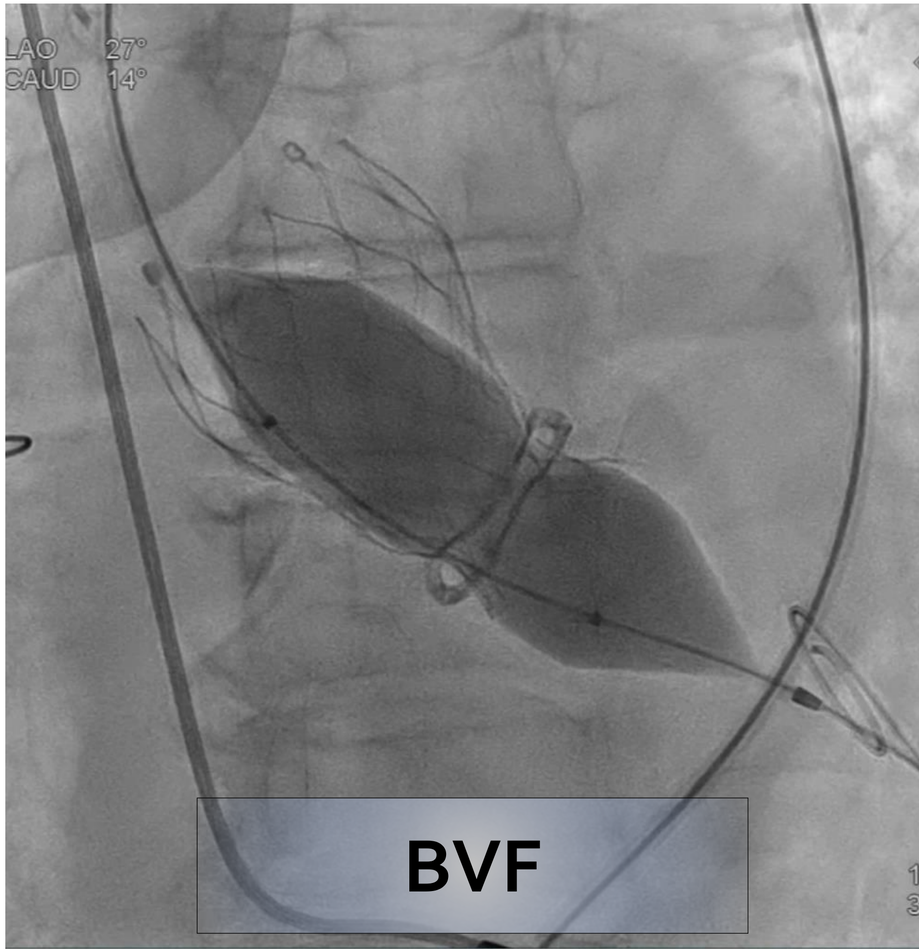
High Risk TAVR d/t small annulus & previous small AV



Sentinel Device

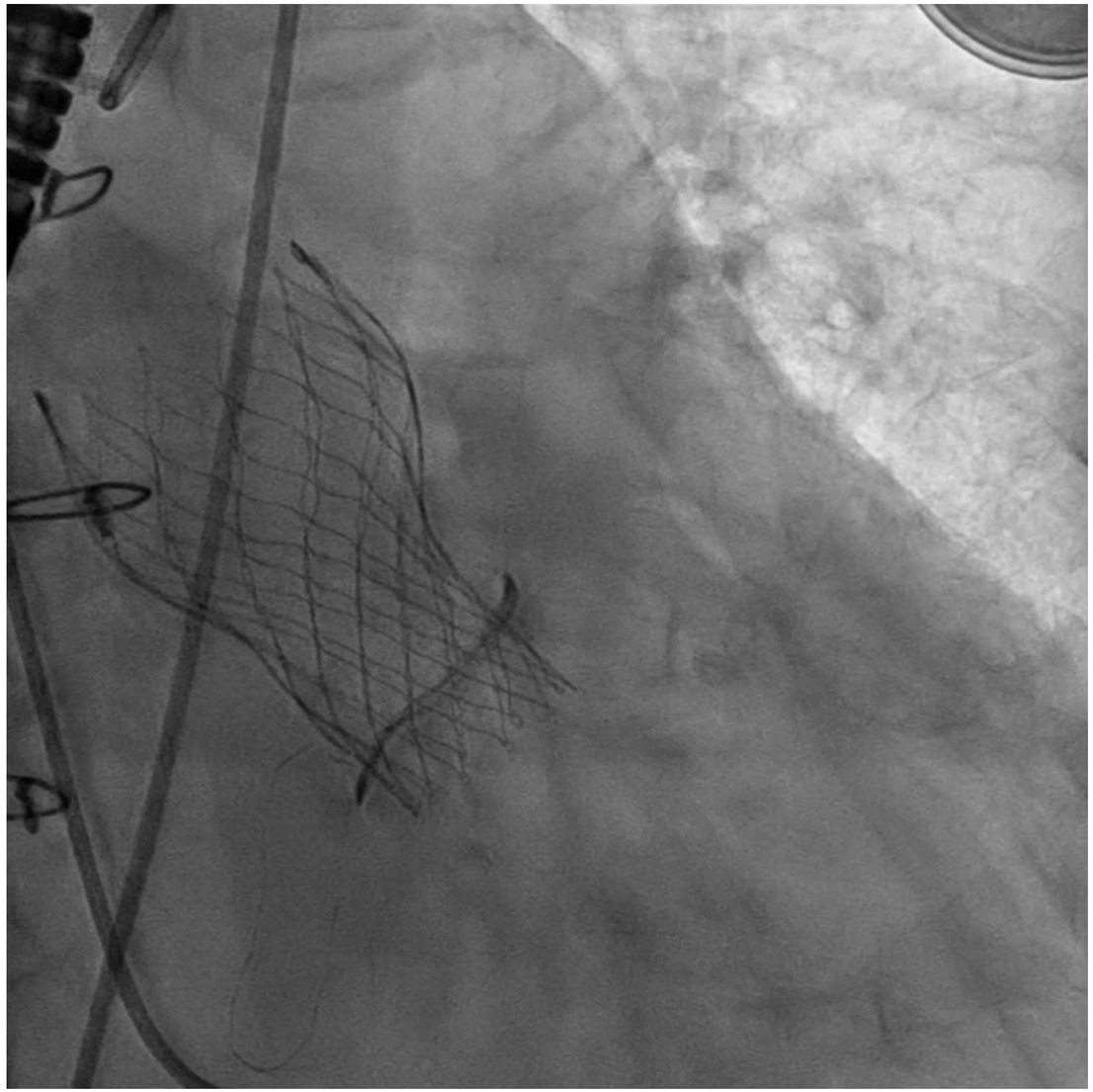


BASILICA



BVF

Final Result



Take Home Messages

- Good device nowadays, but 2-4% stroke
- good procedure… -> minimize total time in cathlab & time of catheter management in pt.'s body
  - Accurate pre-procedural imaging for sizing & approach
  - Overcome aorta to iliac tortuosity with multiple techniques
  - Rapid pacing only when needed
  - Balloon predilatation only when needed (no routine predilatation)
  - Delicate & accurate LV wire manipulation (never let LV wire fall back to aorta!)
  - Harmony between 1st & 2nd operator is important
- ***Cerebral Embolization Protection Device can be a very useful device for minimizing stroke, but routine use of CEPD need more studies, consider in…***
  - ***Bicuspid, heavy Aortic Valve leaflet Calcium, LVOT calcium (especially under RCC), Valve-in-Valve*** ; even more consider with BEV
  - ***Look for calcium distribution in 3D simulation***