New Transcatheter Heart Valves

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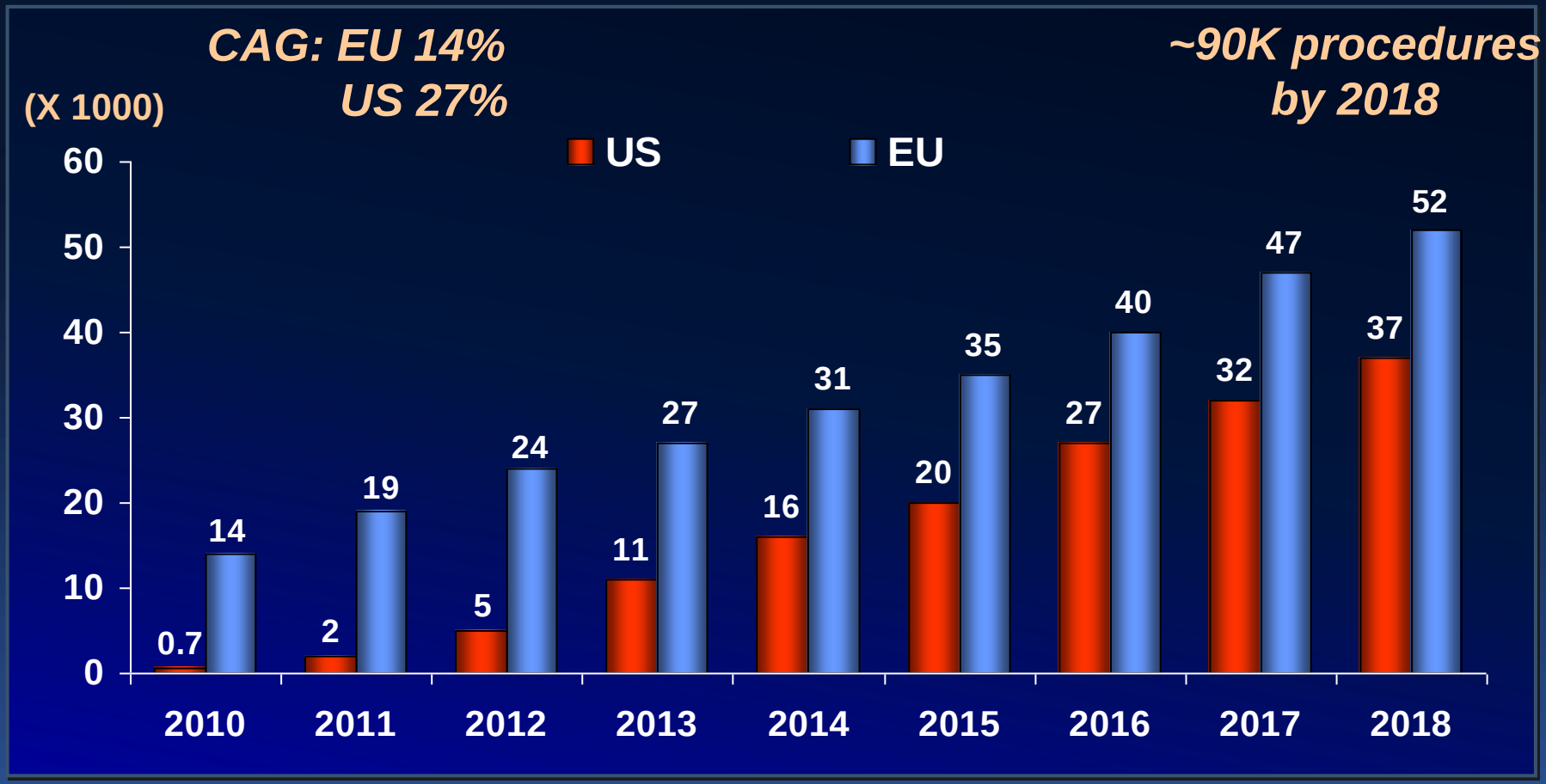
Disclosure Statement of Financial Interest

Within the past 12 months, I or my spouse/partner have had a financial interest/arrangement or affiliation with the organization(s) listed below.

Affiliation/Financial Relationship	Company
• Grant/Research Support	• Edwards Lifesciences
• Grant/Scientific Advisory Board	• Medtronic
• Executive Physician Council	• Boston Scientific Corp

TAVR Procedures

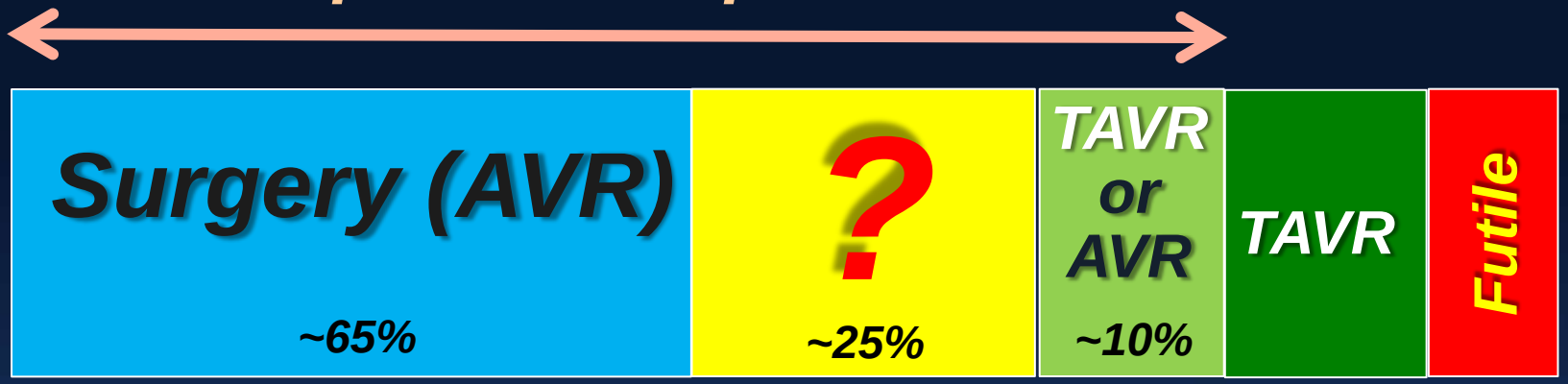
Growth from 2010 - 2018



Multiple Industry Sources - 2013

TAVR Categories
(risk is a continuum)

Operable AS patients



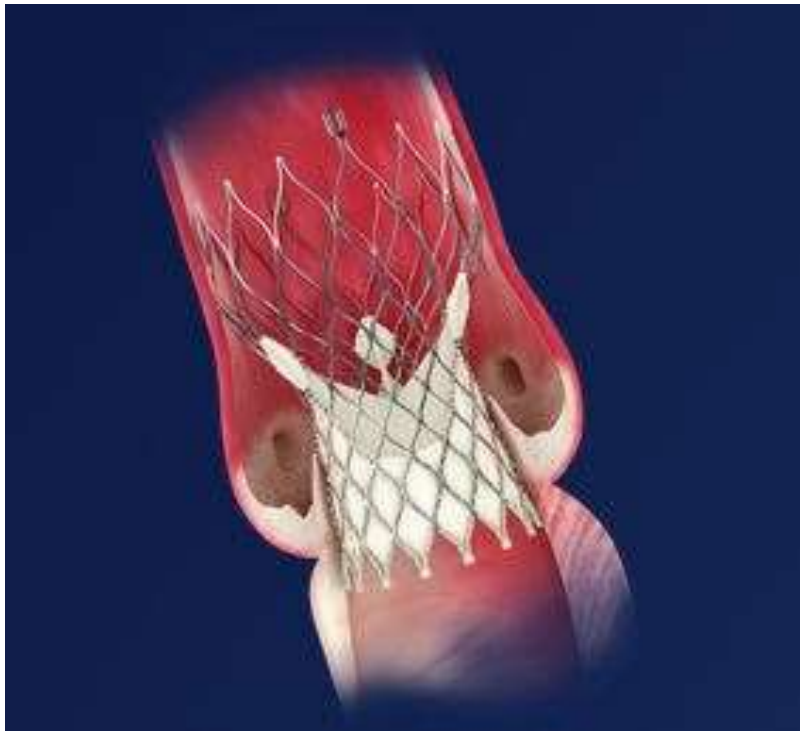
TAVR in 2015

Not ready today "equipoise" OK preferred No

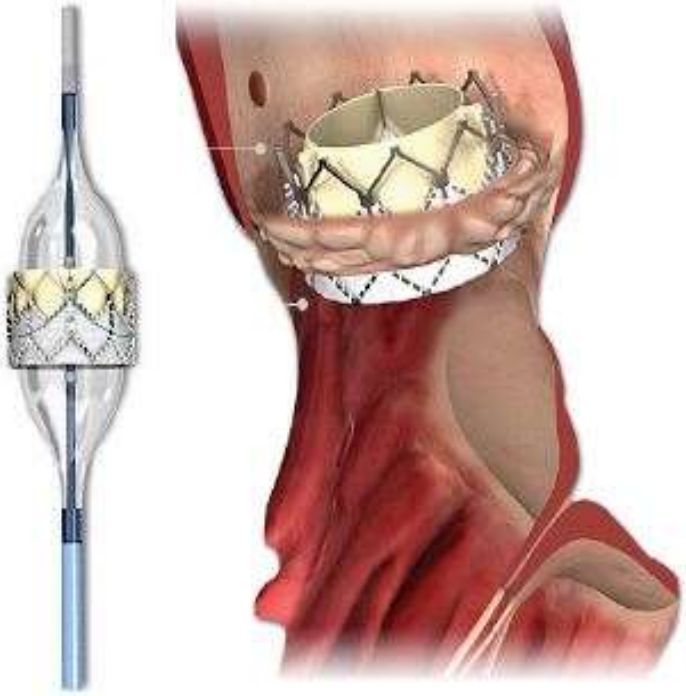
** Extreme risk = "inoperable"*

Balloon-expandable THV
Edward Sapien
(Stainless Steel stent frame, bovine pericardium)

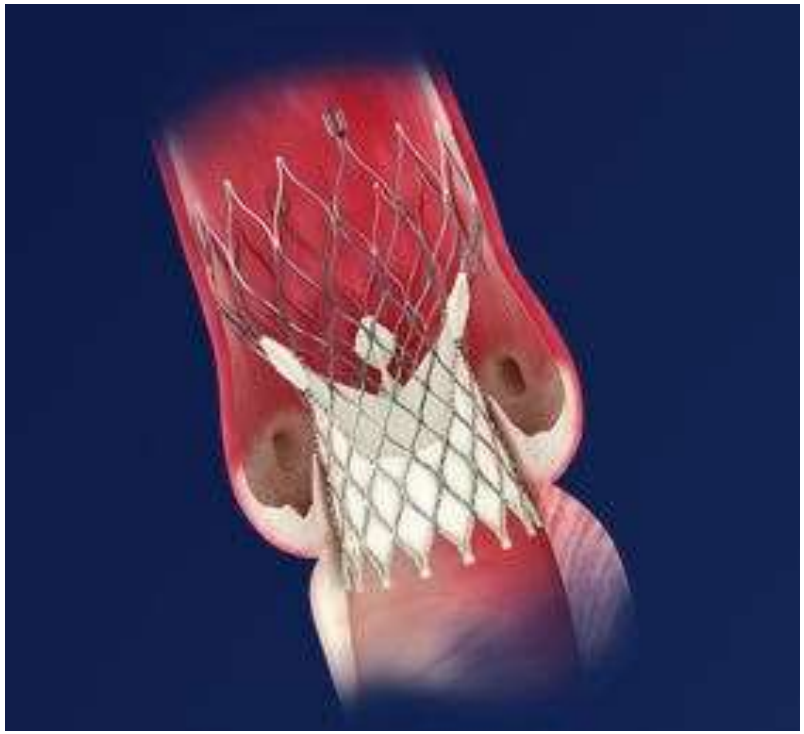
Self-expandable THV
Medtronic CoreValve
(Nitinol stent frame, porcine pericardium)



Balloon-expandable THV
Edwards Sapien XT
(Cobalt chromium stent frame, bovine pericardium)



Self-expandable THV
Medtronic CoreValve
(Nitinol stent frame, porcine pericardium)



Characterizing TAVR Technologies

New Self-Expanding TAVR Systems

PORTICO
(St. Jude)

ENGAGER
(Medtronic)

ACURATE
(Symetis)

EVOLUT R
(Medtronic)

Characterizing TAVR Technologies

Not All New TAVR Systems are Self-Expanding Designs

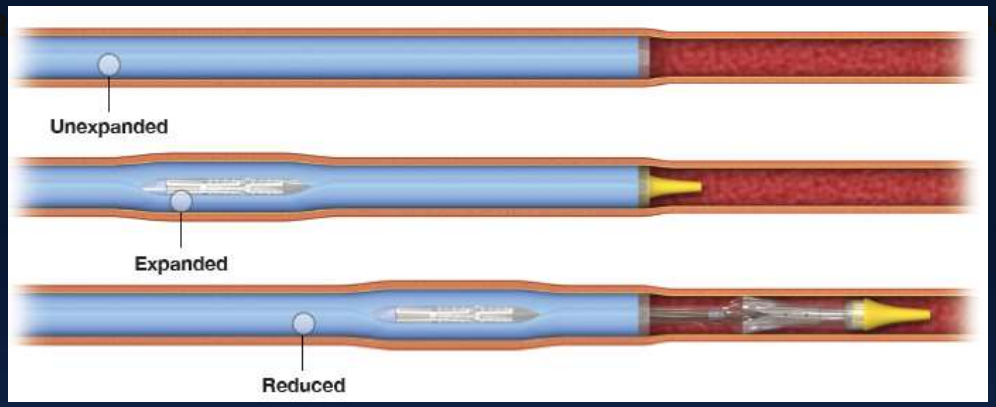
Direct Flow: *Polyester fabric cuff with two inflatable rings; positioning wires for placement; bovine tissue valve*

Lotus: *Nitinol wire frame, bovine tissue valve; outer PU skirt; mechanical expansion and locking*

Jena Valve: *Nitinol-based, positioning feelers and clipping mechanism; porcine aortic root valve*

SAPIEN 3: *balloon exp (4 sizes), cobalt frame; bovine tissue valve; outer skirt; precise positioning*

Edwards Expandable Introducer Sheath

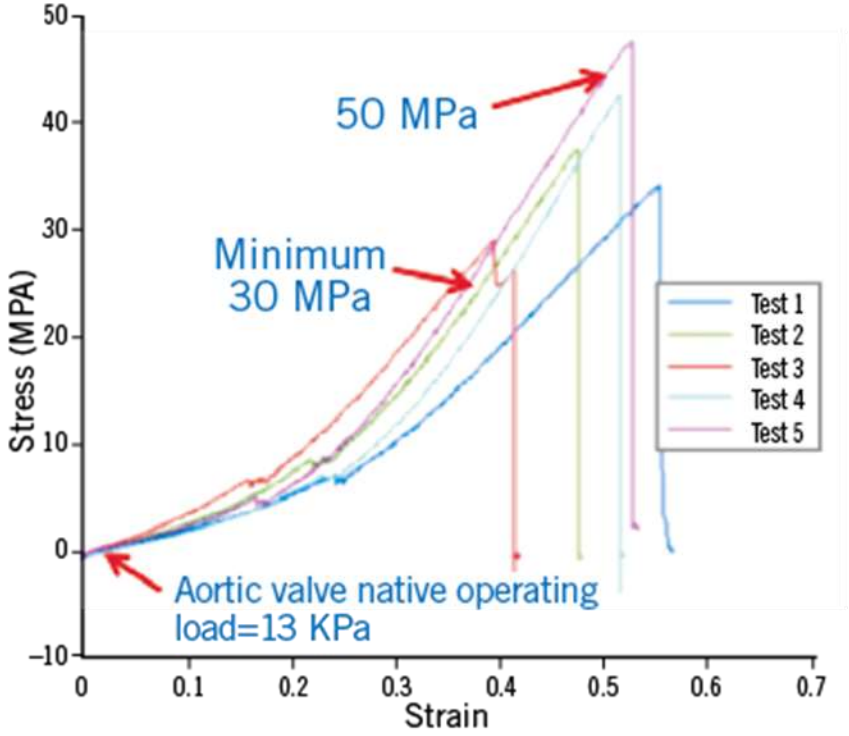


THV	eSheath I.D. (unexpanded)	eSheath OD (unexpanded)	Minimum Vessel Diameter*
23 mm SAPIEN 3	**14F (4.6 mm)**	**6.0 mm**	**5.5 mm**
26 mm SAPIEN 3	**14F (4.6 mm)**	**6.0 mm**	**5.5 mm**
29 mm SAPIEN 3	**16F (5.3 mm)**	**6.7 mm**	**6.0 mm**
23 mm SAPIEN XT	16F (5.3 mm)	6.7 mm	6.0 mm
26 mm SAPIEN XT	18F (5.9 mm)	7.2 mm	6.5 mm
29 mm SAPIEN XT	20F (6.6 mm)	8.0 mm	7.0 mm

CoreValve and EnVeoR Sheath

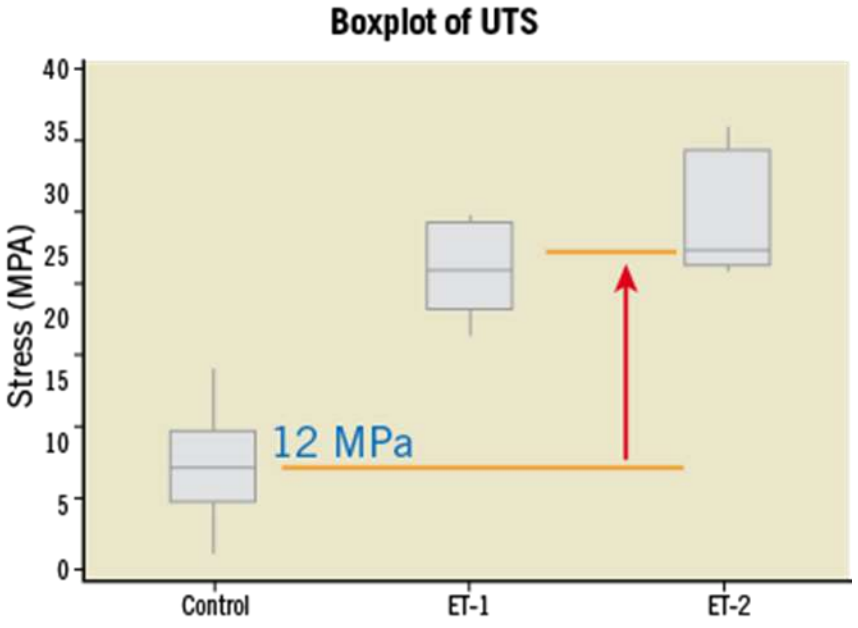
Calibri Heart Valve
« DRY » TECHNOLOGY

- Makes tissue thin, strong, durable
  - 70% reduction of mass compared to a « wet » membrane



Wet tissue stress-strain samples

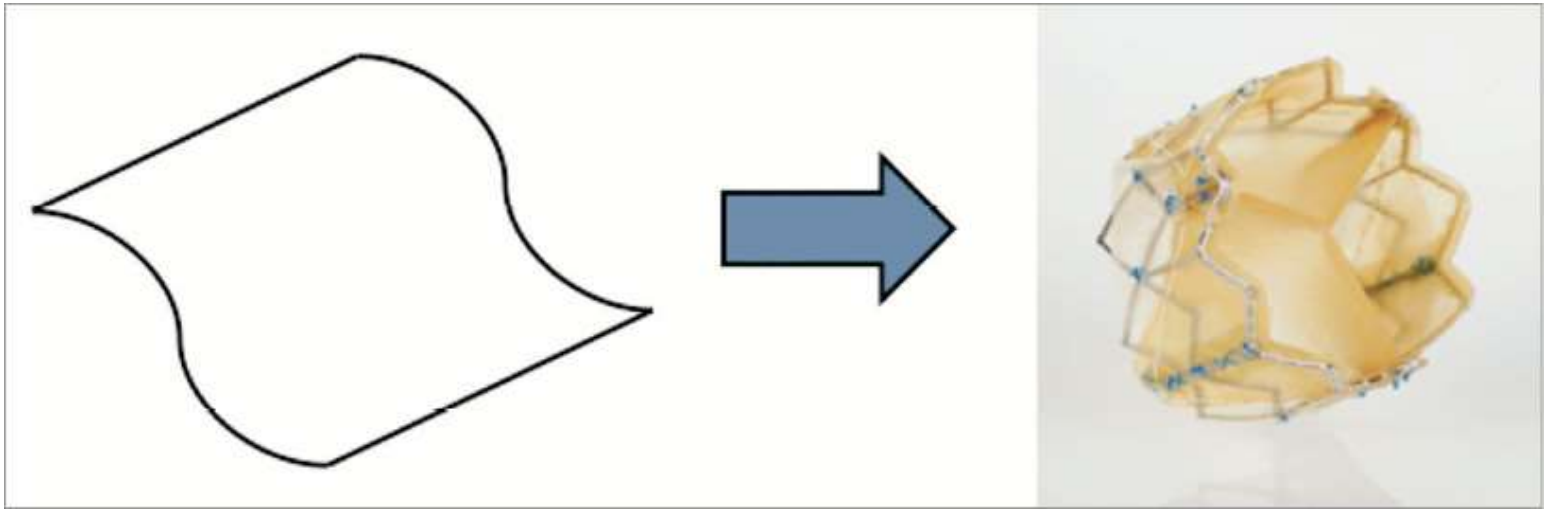
Tissue strength superior to industry standard



Ultimate tensile strength

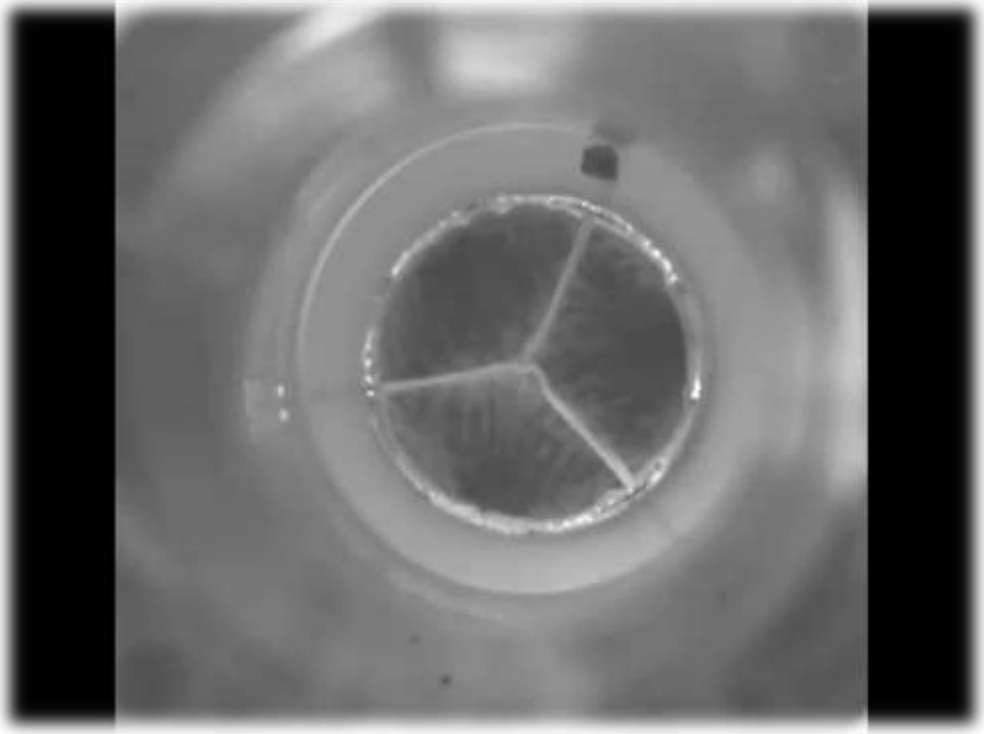
« DRY » TECHNOLOGY

- Allows folded design creates continuous surface
  - Minimum of sutures in operating surface (durability)
  - Less than 200 sutures for mounting (manufacturing)



« DRY » TECHNOLOGY

- Independent low-mass folded leaflet allows compensation
  - Larger effective orifice area
  - Adjust to out of round anatomies (eccentric calcifications, bicuspid valve)



Low Profile Pre-Packaged TAVI System

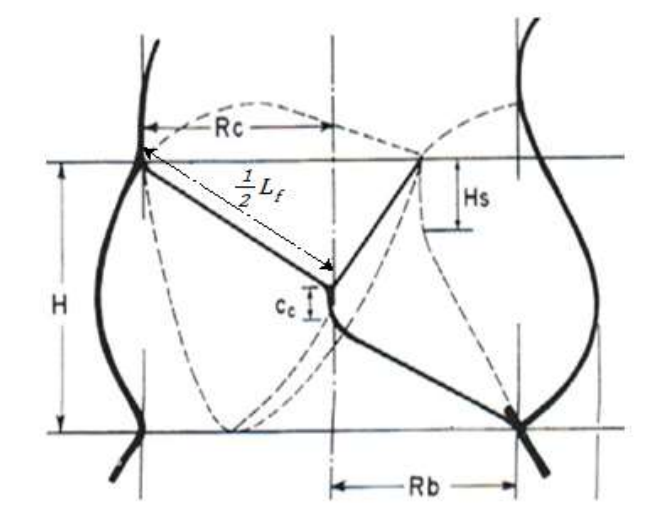
- Pre-mounted, pre-crimped, pre-packaged
- Pre-loaded, sterilized and **Ready-For-Use**
- Balloon expandable: delivered through ***14 Fr*** sheath (24mm valve)

Optimum TAV: Design based on the Natural Aortic Valve

Optimal performance criteria used for the design:

1. A defined coaptation height.
2. No folds in the leaflet.
3. A minimum valve height.
4. A minimum leaflet flexion.

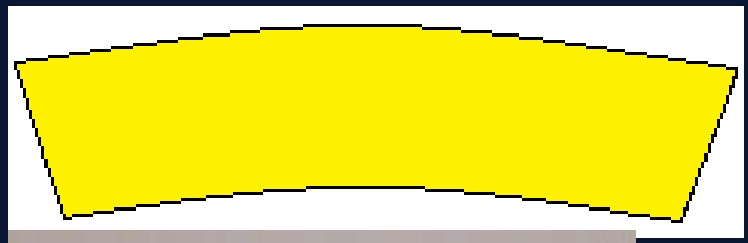
The Criteria is enforced using equations containing valve dimensions

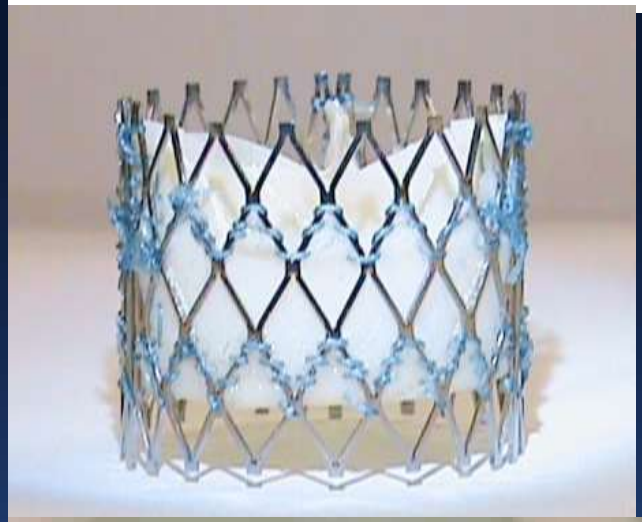


- **Rb = radius of the bases**
- **Rc = radius of the commissures**
- **H = the valve height**
- **L_f = length of leaflet free edge**
- **Hs = Commissural height**
- **Cc = Coaptation height**

Optimum Valve Design

- Single bovine pericardial cut-out used for all three leaflets
- The valve has commissure posts
  - Provides proper opening
  - Provides proper coaptation surface
- Valve design minimizes sutures
  - Total sutures – 274
  - No suture holes in moving leaflets (similar to surgical valves)
- 25mm OD Nitinol frame
  - Designed for up to 23mm annulus
  - Designed for stronger radial force
  - 19mm height

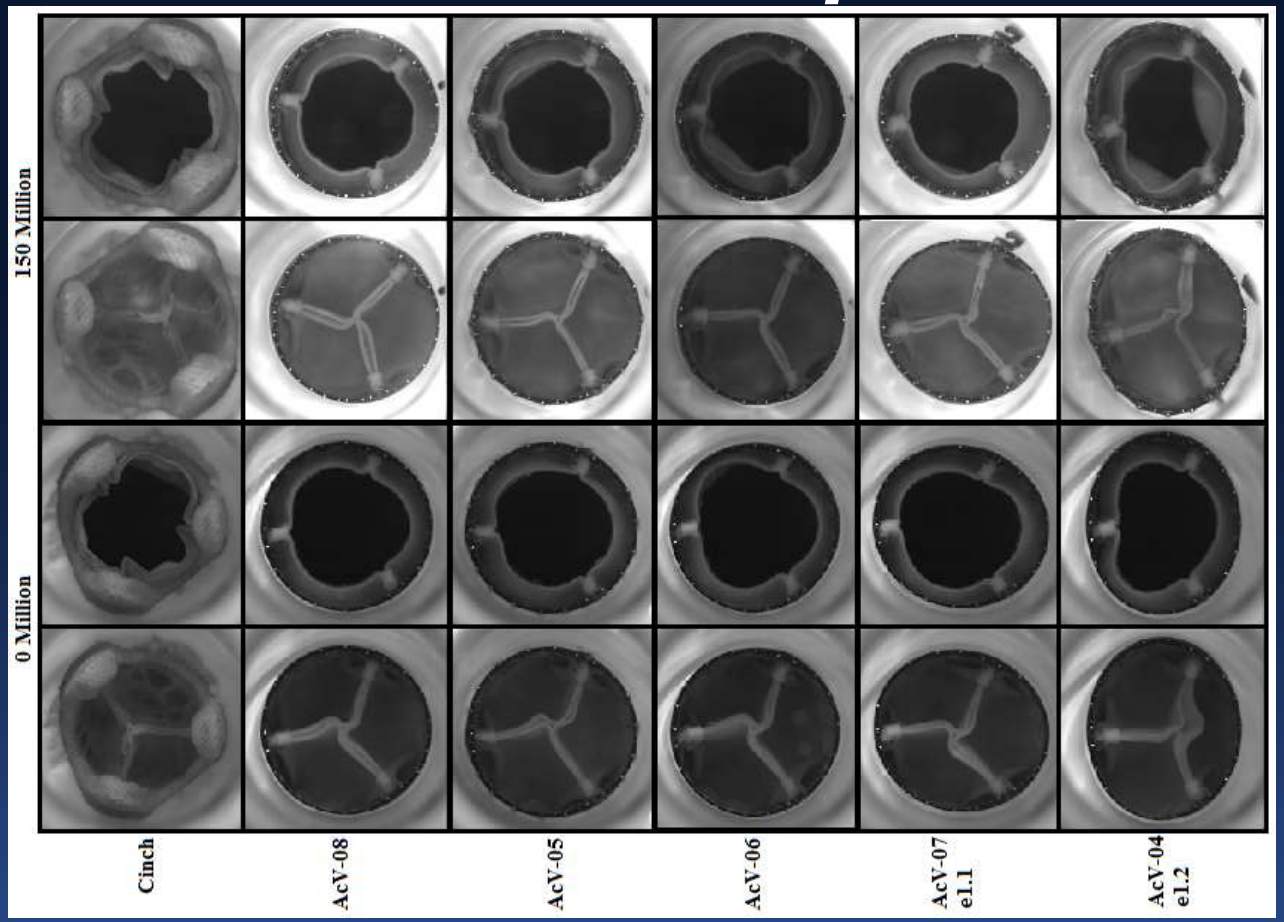




The Optimum TAV - Durability Tester

- Regurgitant fraction 4.5% (less than the surgical control).
- EOA 2.1 sq cm.

Durability Testing in Pulse Duplicator



- 5 Optimum TAV and 1 surgical control
- 3 circular and 2 elipitical
- All have completed 210 million cycles – no evidence of significant wear or change in hemodynamics

An Ultra-low Profile TAVR System

12 Fr delivery catheter (3.8 mm diameter)
for all valve sizes (1st generation)

Device Components

Frame Module → ***Assembled Device*** ← **Valve Module**

1. Nitinol self-expanding frame module inserted in optimal annular location
2. Valve module is reconstituted in ascending Ao
3. Valve module is docked to frame

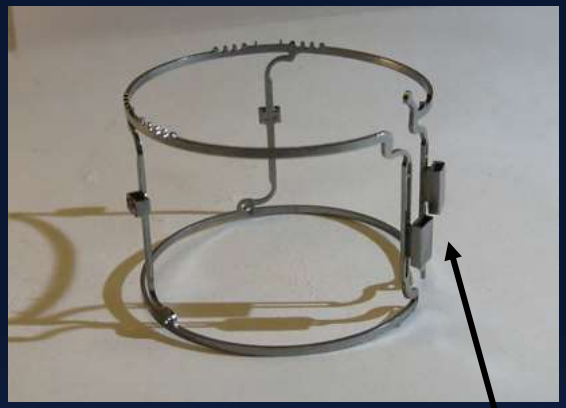
An Ultra-low Profile TAVR System

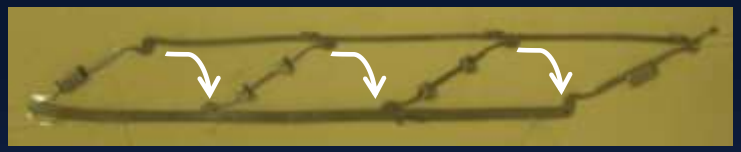
12 Fr delivery catheter (3.8 mm diameter)
for all valve sizes (1st generation)

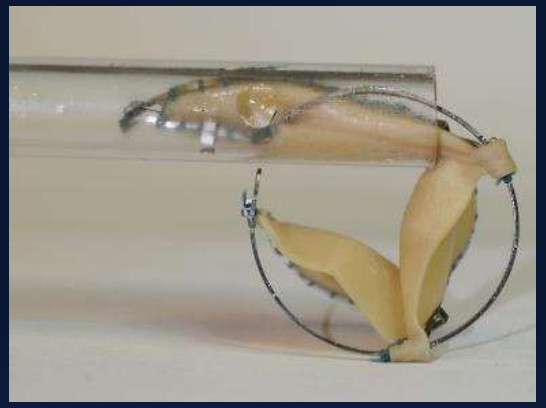
“Unique” Valve Medical Design Features

- Ultra-low profile – 12 French delivery system for all valve sizes
- Modular design (frame and valve separate)
- Folded valve design (not crimped)
- 3-D valve leaflet construction
- *In-situ* docking (valve to frame in ascending Ao)
- Coating to reduce Para-valvular regurgitation
- Temporary valve (in descending Ao) for safety

Valve Module Reconstitution



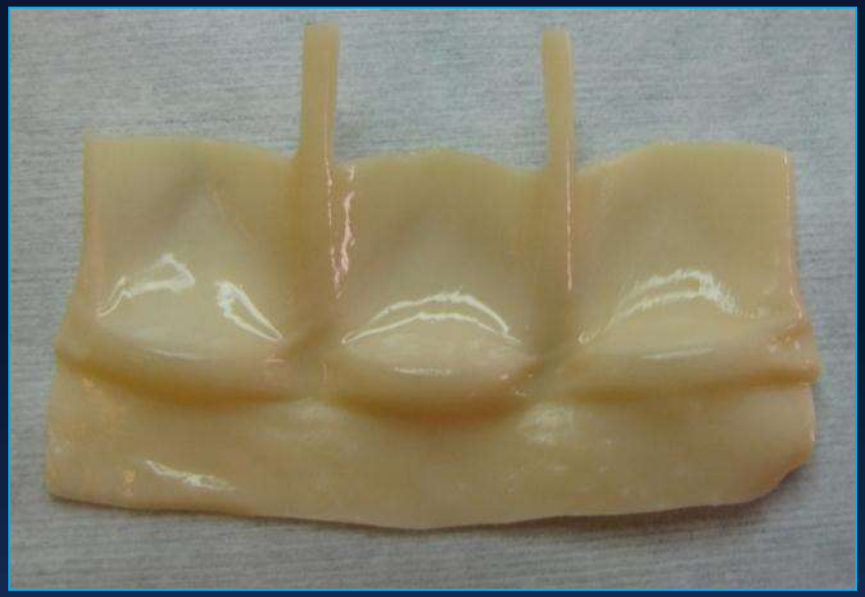




Zip lock

- Rings are collapsed and opened to a flat configuration
- Lengthwise folding of rings + valve and inserted into delivery catheter
- All valve sizes loaded into same low profile delivery catheter

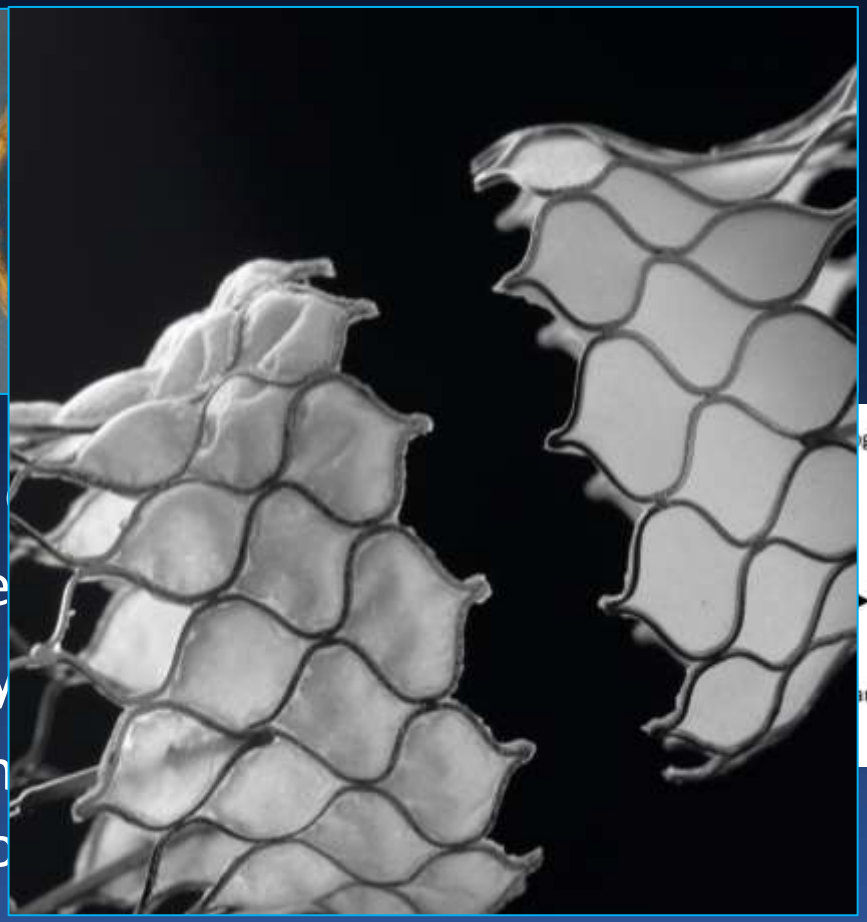
3-D Valve Leaflets

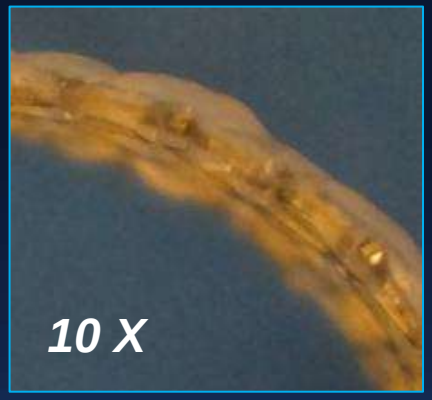


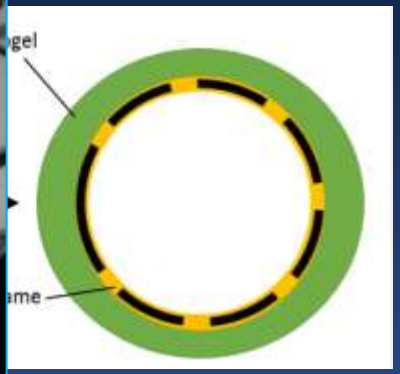
- Single piece of pericardium is fixed 3D on a mandrel
- Fewer stiches ➔ improved manufacturability and durability
- Enhanced coaptation ➔ wider opening and improved hemodynamics
- Full thickness bovine pericardium (500 microns)

Polymer Coating

Para-valvular leak prevention







- Two-layer polym
- External hydroge
- Frame stored dry
- Following implan
  hydrogel swells c

Device Evolution

- What is the balance between French size and leaflet technology?
- Is repositionability necessary?
- What tools can we add to promote coplanar deployment of the valve?
- Will skirt marker be helpful to accurately placement of the valve?
- What can be done to tackle asymmetric calcification of the leaflets leading to poor apposition?