Novel Self-expandable Stent Based Percutaneous Pulmonic Valve
- Pre-clinical study -

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Disclosure

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Problems of valved-stent in Korea

- Not available in Korea
- Too expensive: >30,000 Dollars/valve
- Too difficult to get Korean FDA approval
  - strict regulation for device importation

Melody valve

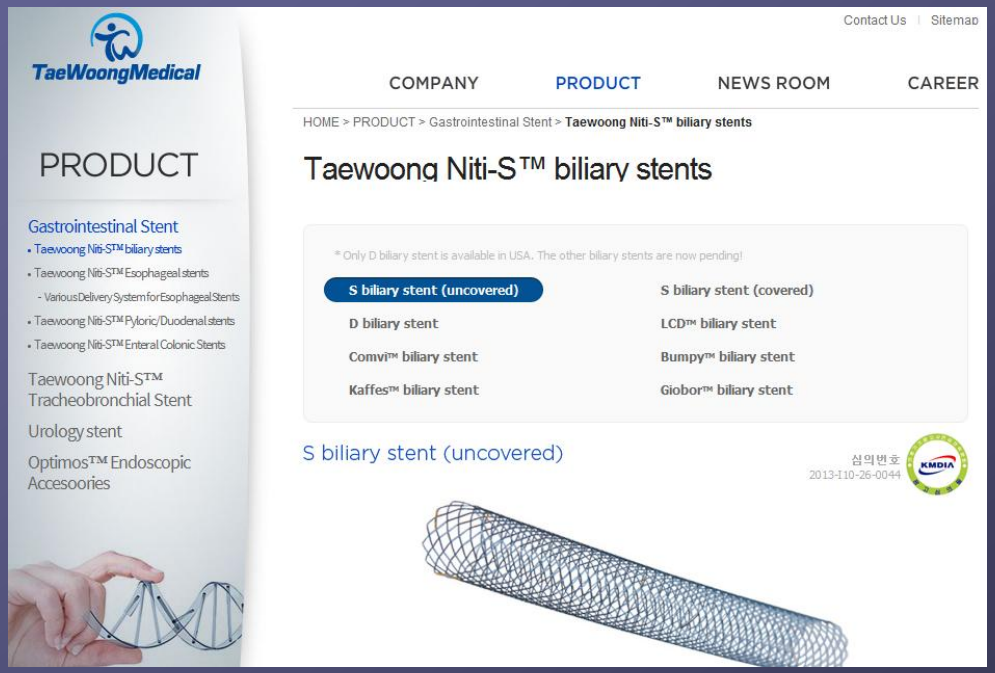
Edward- Sapien valve

Purpose of this study

- To see the feasibility of self-expandable valved-stent with Nitinol-wire backbone in pulmonic position
- To see the durability of artificial valve for > 6 months

Materials and Method

- Stent using **Nitinol-wire backbone**
  - **self-expandable**
- Tissue valve using **porcine pericardium**



Tissue preservation for porcine pericardium

1. **Decellularization** with 0.25% SDS (sodium dodecyl sulfate)

2. 0.1 units/mL **alpha-galactosidase** treatment

   (for **reduction of immunogenicity**)

3. **Space filler** with PEG (polyethylene glycol)

4. 0.5 % GA **fixation** with solvent (75% ethanol + 5% octanol)

5. **Detoxification** with 0.1M glycine

J Heart Valve Dis. 2012 May;21(3):387-97.

Eur J Cardiothorac Surg. 2012 Feb;41(2):383-90.

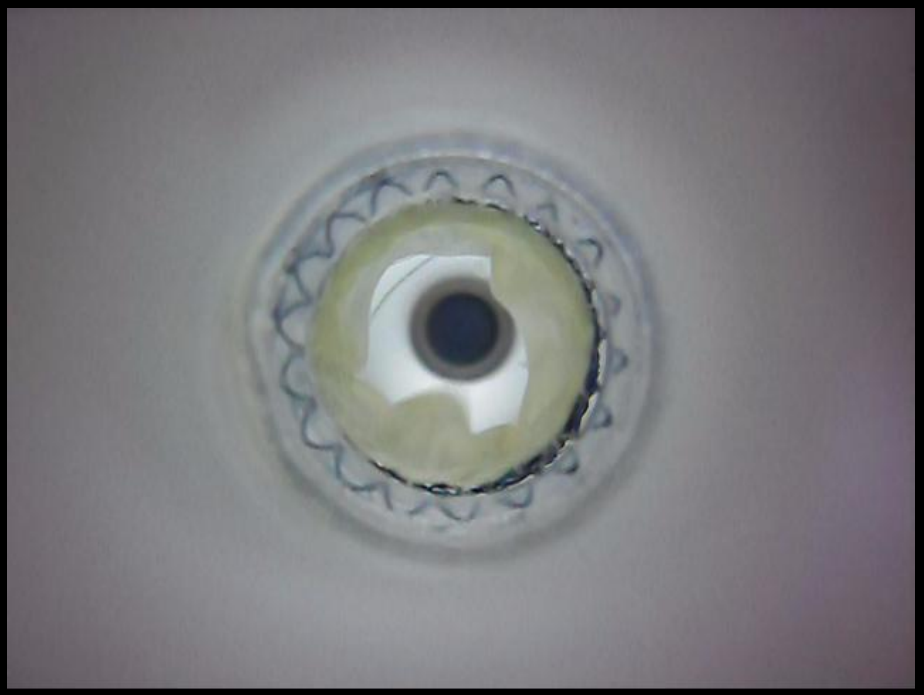
Pulmonary valved-stent shape

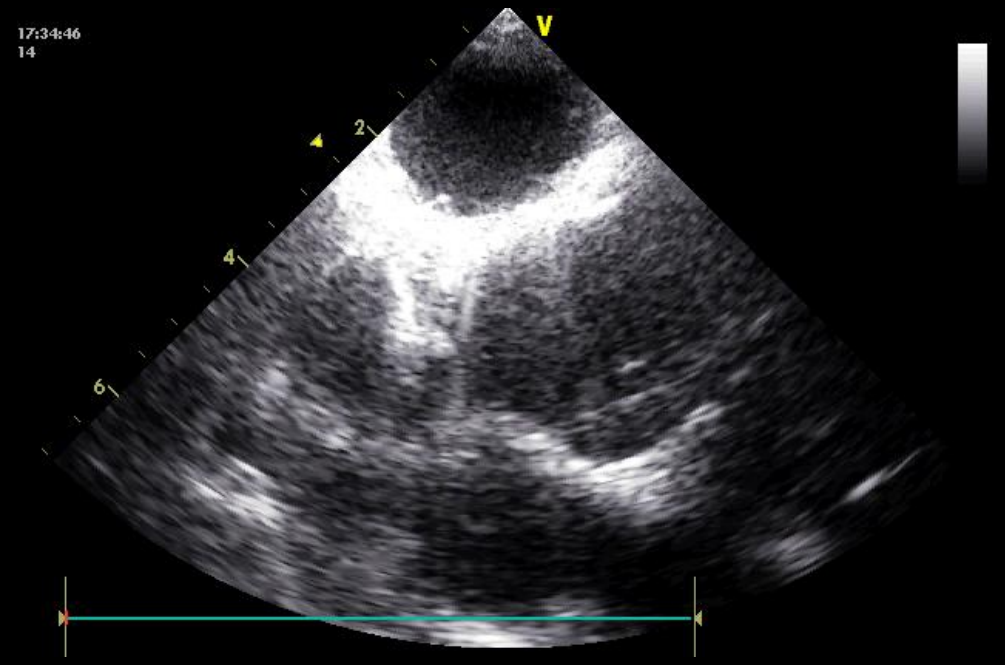


Valve Diameter (mm)	Head Diameter (mm)	Height (mm)	Valve height (mm)
20.0	24.0	24	12.5
22.0	26.0	25	14.0
24.0	28.0	28	15.5
26.0	30.0	33	17.0
28.0	32.0	34	18.0

➢ Height : Valve diameter ≒ 1.2

Valve motion

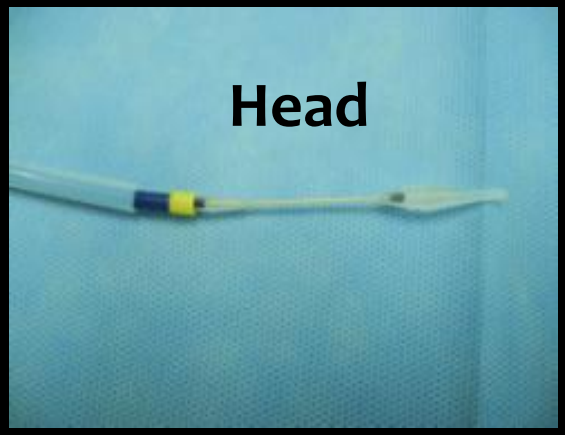




In Vitro

In Vivo

Trans-catheter delivery system



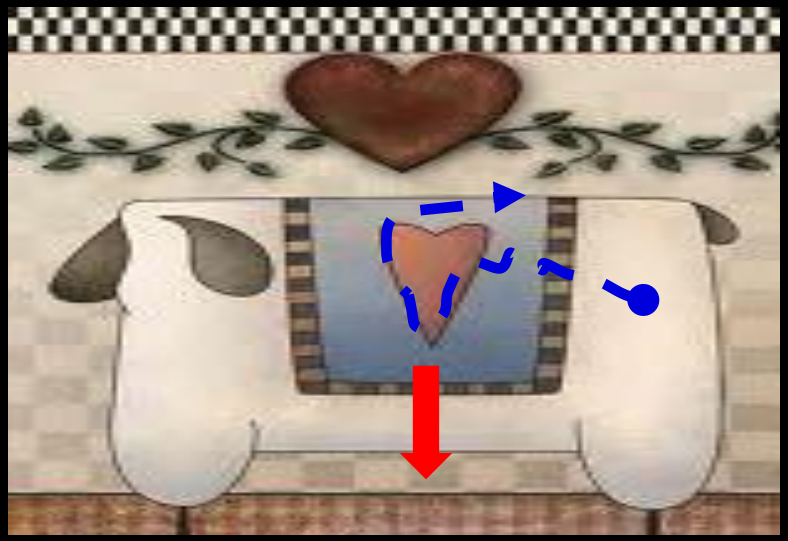
Animal

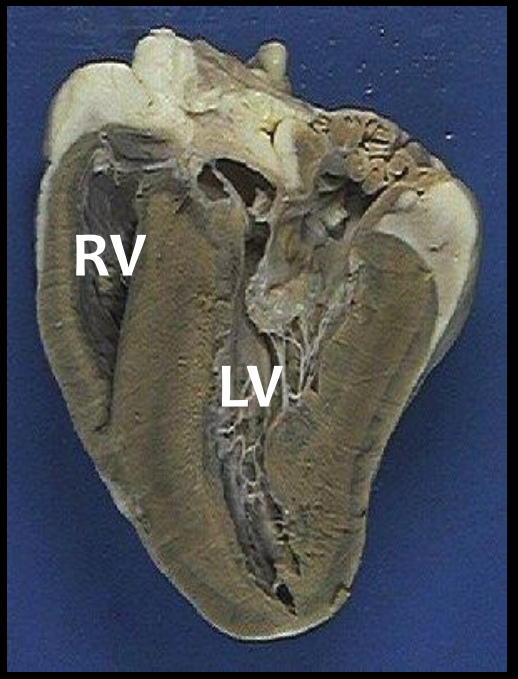
- **Sheep** : about 6 month-old
- Method
  - Under **general anesthesia** and **mechanical ventilator**
  - **cut-down : inguinal area or cervical area**
    - **Femoral or Jugular vein** : 6 Fr. short sheath,
    - **Femoral or Carotid artery** : 4 Fr. short sheath
  - **Hemodynamic study and angiography** at just below Pul. valve
  - **18 Fr. long delivery catheter** exchange
  - **Stent implantation** with self-expandable method
    - Deployment under the guidance of **C-arm** and **transthoracic echocardiography**

Characteristics of heart and vessel of sheep

- **Acute angle from RA to PA** : apex of heart points the land
- **Rather small RV** with relatively large pulmonic valve annulus

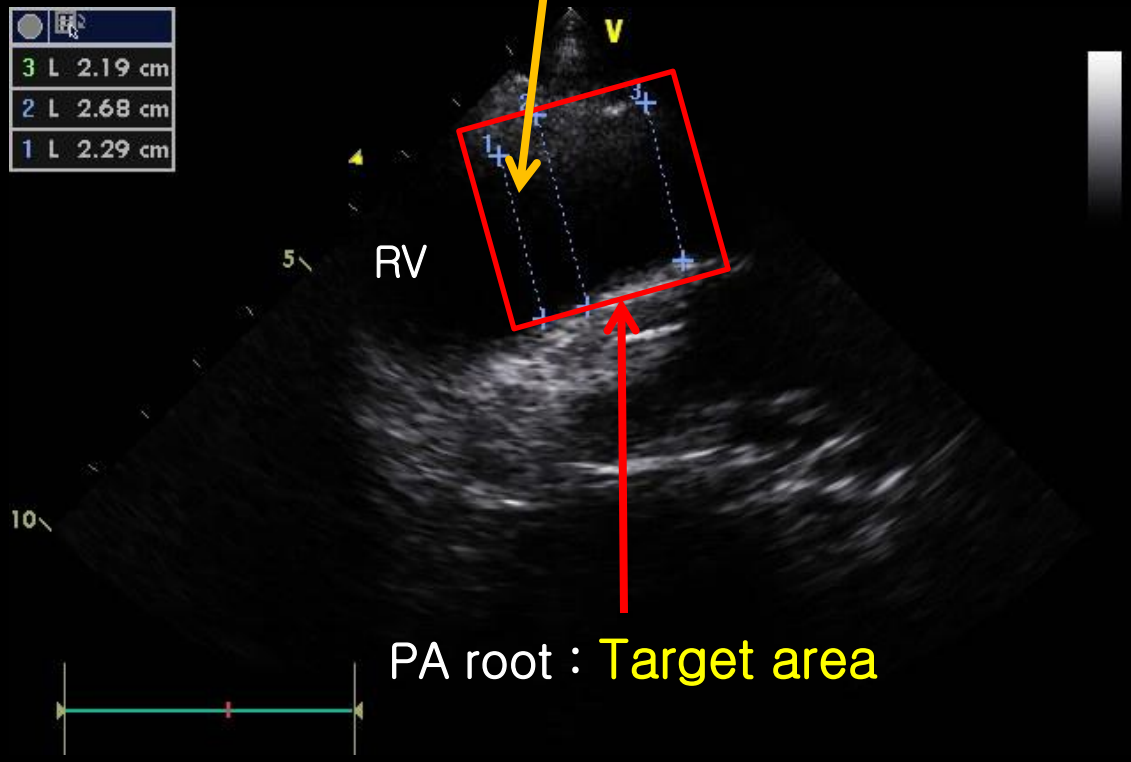
  ➔ difficult to stent introduction from RA to PA
- **Femoral vein is relatively small**



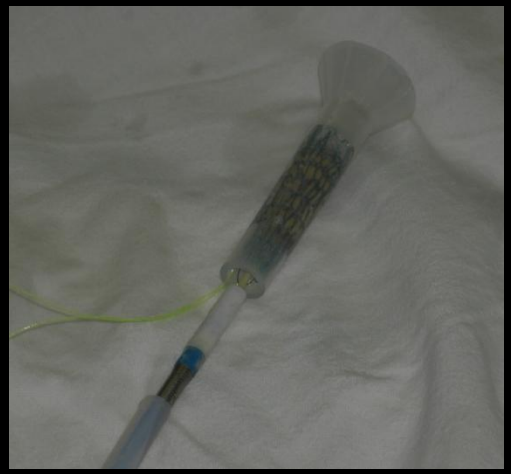


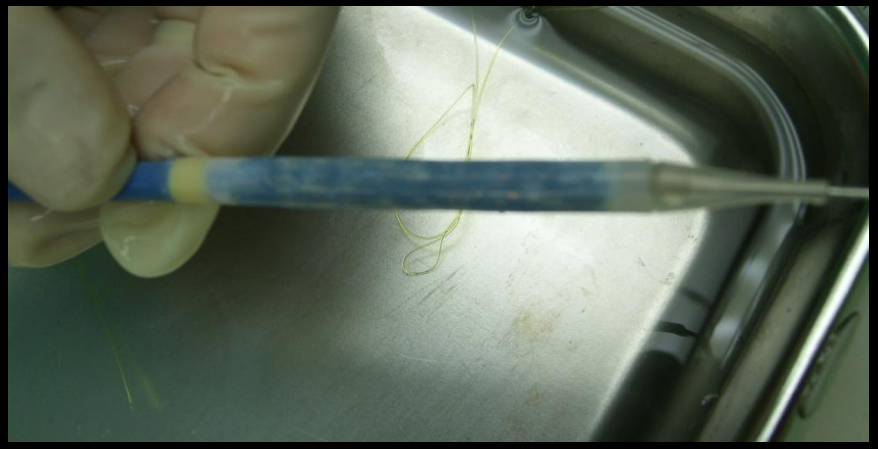
Target area at echocardiogram

- Sheep, body weight : 35 kg
  - Pul. valve annulus : **22.9** mm
  - Femoral vein : **6.5** mm



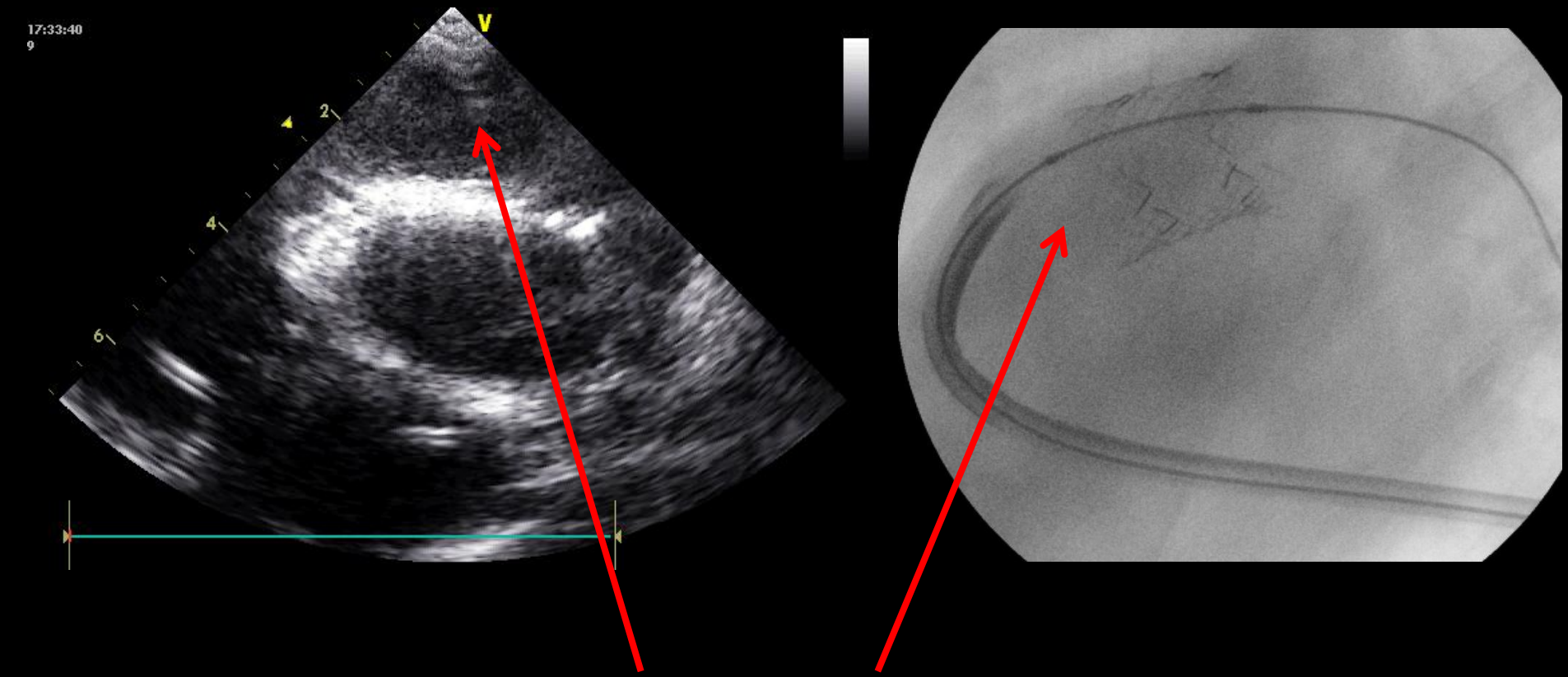
Stent loading procedure





Deployment of Valved Stent

Pulmonary valved-stent implantation



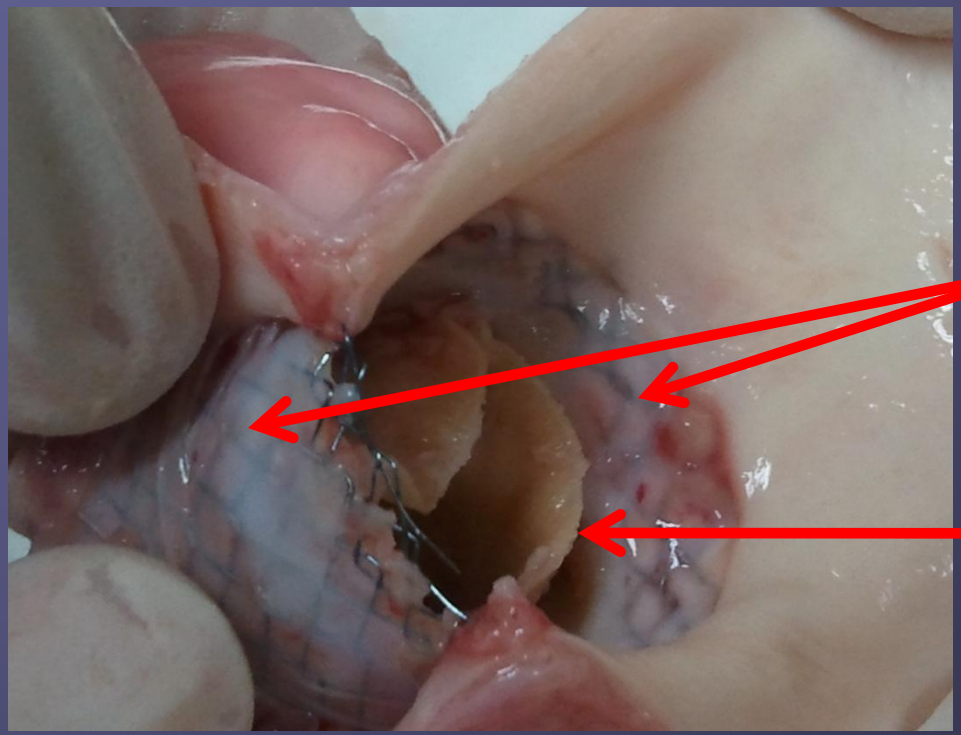
Implanted stent's valve motion
: good valve motion
: good position at targeted area

F/U schedule

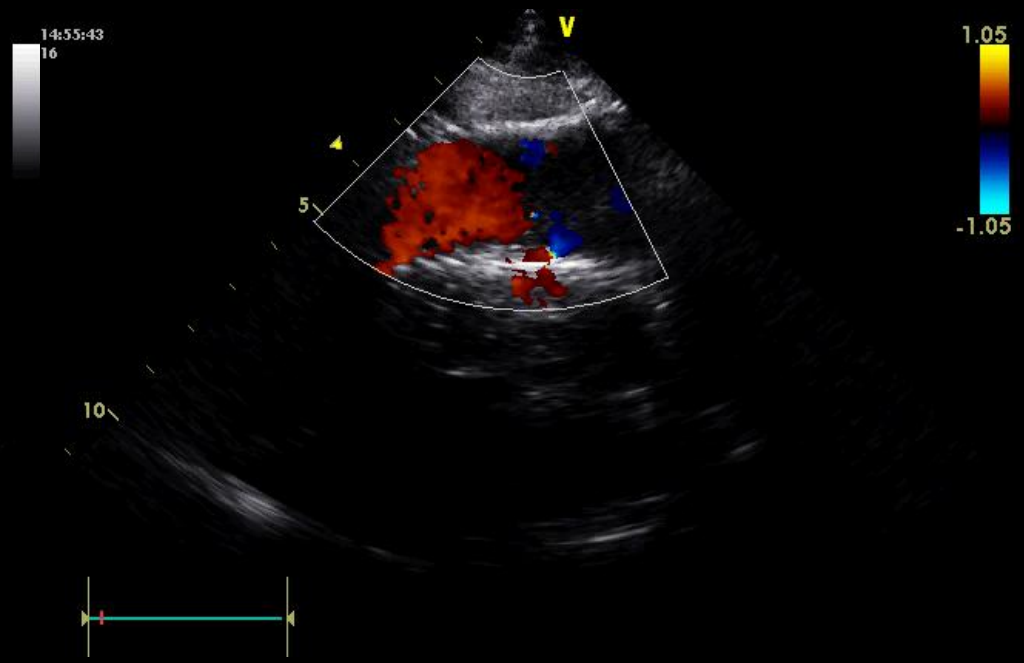
- **Echocardiography**
  - Procedure day
  - **4-6 weeks** later
  - **6 months** later before sacrifice
- **Cardiac cath.**
  - Procedure day
  - **6 months** later before sacrifice
- **Sacrifice**
  - **6 months** after initial implantation

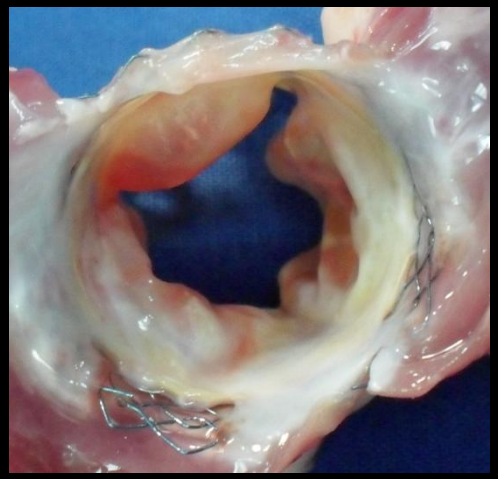
Autopsy findings – 4th sheep

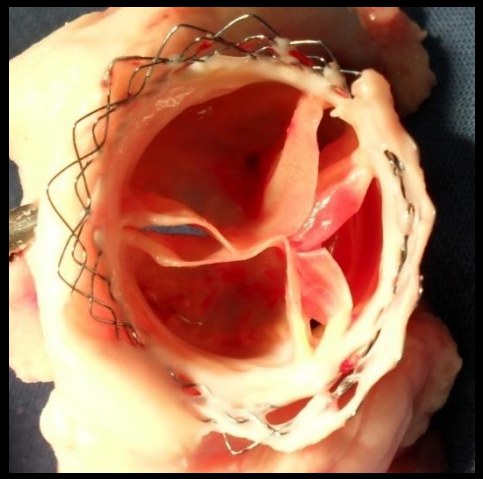
- PV implantation : 26 mm at 2011.10.5
- General weakness from 2011.12. 2nd week
- Died at 2011.12.30
- Cause : unknown, R/O infection ?
- Last echocardiography at 2011.11.9 : trivial PR, no PS



6 Month F/U







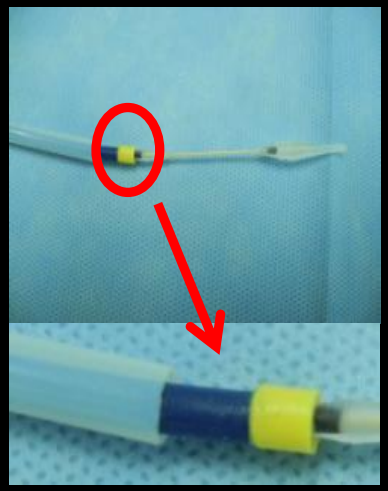
Results

Sheep	B.Wt (Kg)	Stent (mm)	route	position	F/U (Mo)	result	valve function
1	34.5	24	FV	good	6	sacrificed	tissue loss
2	45	24	FV	MPA distal	6	sacrificed	attached to wall
3	51	26	FV	good	2.5	died	thick leaflet
4	45	26	FV	RVOT	6	sacrificed	attached to wall
5	47	26	FV	good	6	sacrificed	good
6	41	24	FV	good	6	sacrificed	good
7	39	24	JV	good	6	sacrificed	good
8	48	24	FV	RVOT	4	died	thick leaflet
9	39	24	FV	MPA distal	2	died	attached to wall
10	45	26	JV	good	4	died	tissue loss
11	40	24	JV	good	6	survive	good
12	53	26	JV	good	6	survive	good

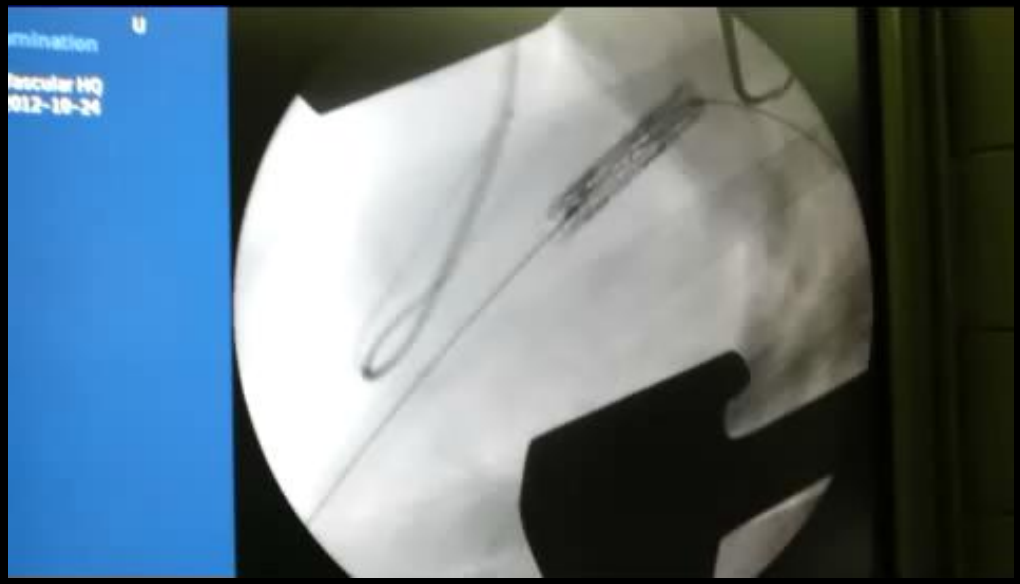
* FV: femoral vein, JV: jugular vein

Modifications during pre-clinical study

- **Hook block** for controlled deployment

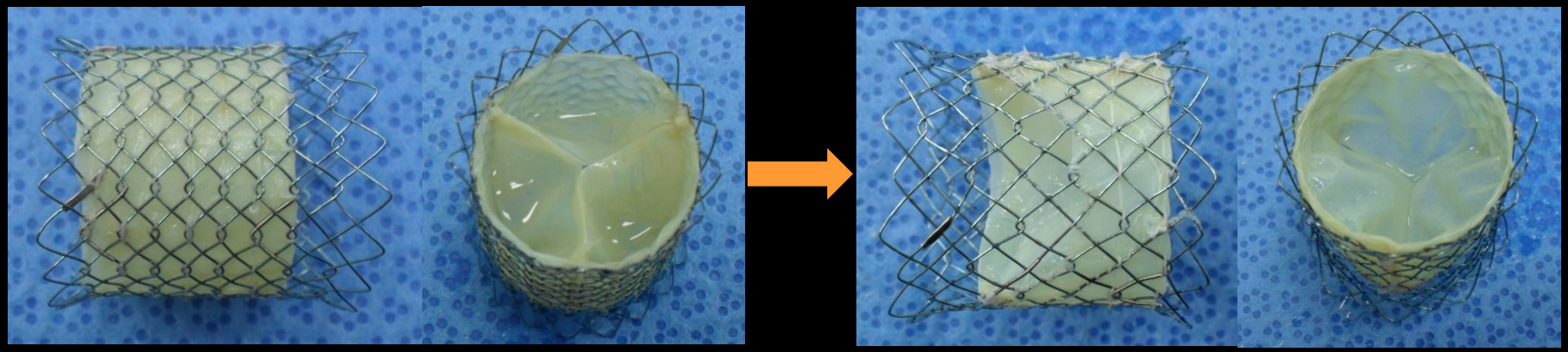


Hook block



Modifications during pre-clinical study

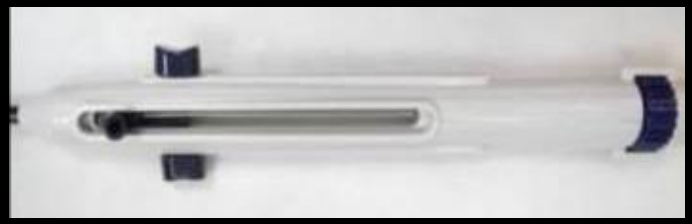
- **Stent type** modification (D type ➔ M type)



Type	D type	M type
	Can be folded in longitudinal axis	No folding in longitudinal axis
Wire thickness	0.008 inch (0.2mm)	0.010 inch (0.25mm)
Delivery system	18Fr	19Fr
Valve Wall	Full	Partial
Diameter x Total Length	20 mm x 24 mm 22 mm x 25 mm 24 mm x 28 mm 26 mm x 33 mm	20 mm x 30 mm 22 mm x 33 mm 24 mm x 36 mm 26 mm x 38 mm
Radial Force	0.17~0.20 kgf	0.40~0.5 kgf

Modifications during pre-clinical study

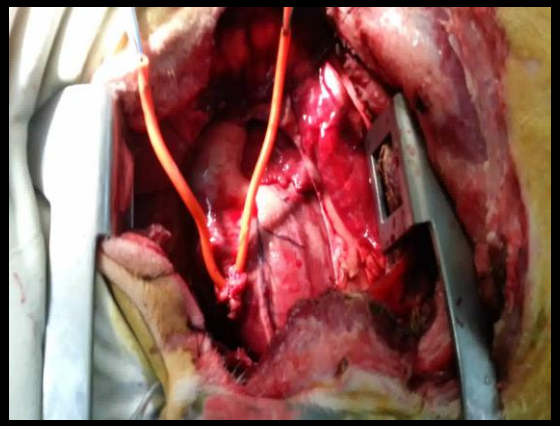
- delivery sheath modification : handle, shaft's material and color

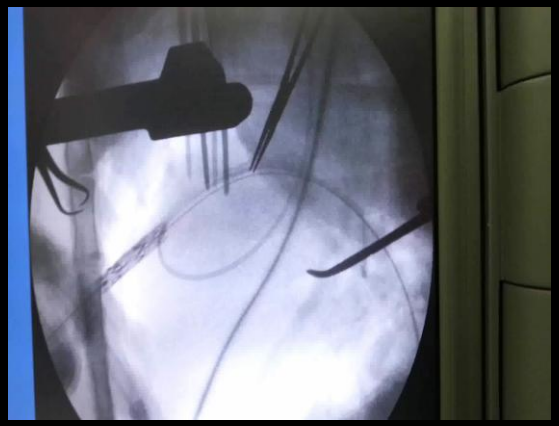


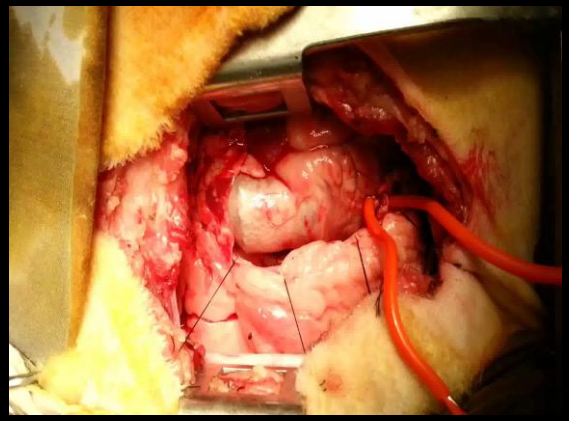
New trials

- **Per-ventricular pulmonary valve implantation**
  - Lateral thoracotomy
  - RV per-string at the RV anterior wall

22 Fr. 30 cm length







  - 6 cases : deployed at the good position in all
    - 1 sheep died after sternal closure due to coronary compression from coronary anomaly

Conclusions

- **Transcatheter** implantation of **Nitinol-based self-expandable valved stent in pulmonic valve position** was feasible in a **preclinical animal study**
  - **Tissue valve durability** should be validated more
    : 6 months result was satisfactory
    : anticoagulation and other supportive measures will be beneficial for longer durability in the human clinical study
  - **Stable deployment** should be validated more
    : TEE, biplane fluoroscope and hook block could be helpful definitely in the clinical study
- **Now, we are planning to do clinical study**