Development of Aortic Surgery simulators

AZIENDA OSPEDALIERO - UNIVERSITARIA
Città della Salute e della Scienza di Torino

Dr. R. Devotini

Erice, 1st - 5th May 2015

Scientific and technological advances in cardiac and vascular surgery a translational approach

EACTS 2013 Ethicon Cardiovascular Simulation Award Aortic root surgery

University Division of Cardiac Surgery – Città della Salute e della Scienza - Torino

In recent years there has been increasing emphasis on skills and simulation training for trainees in cardiothoracic surgery.

The use of simulators has been shown to improve surgical skills of trainees compared to traditional approaches.

Interactive CardioVascular and Thoracic Surgery Advance Access published November 2, 2012

Interactive CardioVascular and Thoracic Surgery (2012) 1–5
doi:10.1093/icvts/ivs451

NEW IDEA

A novel low-fidelity simulator for both mitral valve and tricuspid valve surgery: the surgical skills trainer for classic open- and minimally invasive techniques†

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ELSEVIER

The Journal of Thoracic and Cardiovascular Surgery

Volume 141, Issue 1, January 2011, Pages 107–112

Acquired cardiovascular disease

Simulation and skills training in mitral valve surgery

Read at the 36th Annual Meeting of The Western Thoracic Surgical Association, Ojai, Calif, June 23–26, 2010.

David L. Joyce, MD[a, b], Tanvir S. Dhillon, BS[c], Anthony D. Caffarelli, MD[a, b], Daniel D. Joyce, BA[d], Dimitrios N. Tsirigotis, MD, PhD[e], Thomas A. Burdon, MD[a, b], James I. Fann, MD[a, b]

Kyobu Geka. 2014 Nov;67(12):1047-50.

[Student education with using training simulator for

[Article in Japanese]

Uramoto H[1], Chikaishi Y, Nagata Y, Shimokawa H, Tanaka F.

ELSEVIER

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

European Journal of Cardio-thoracic Surgery 27 (2005) 910-916

www.elsevier.com/locate/ejcts

A high fidelity tissue-based cardiac surgical simulator

Paul S. Ramphal[a,*], Daniel N. Coore[b], Michael P. Craven[c,d], Neil F. Forbes[b], Somara M. Newman[c], Adrian A. Coye[a], Sherard G. Little[a], Brian C. Silvera[c]

[a]Department of Surgery, University of the West Indies, Mona Campus, Kingston, Jamaica
[b]Department of Mathematics and Computer Science, University of the West Indies, Kingston, Jamaica
[c]Faculty of Engineering, University of Technology, Kingston, Jamaica
[d]School of Electrical and Electronic Engineering, University of Nottingham, Nottingham, UK

Received 29 October 2004; received in revised form 7 December 2004; accepted 17 December 2004; Available online 19 February 2005

Surg Endosc. 2012 Nov;26(11):3215-24. doi: 10.1007/s00464-012-2327-z. Epub 2012 May 3

The effect of simulation in improving students' performance

Al-Kadi AS[1], Donnon T, Oddone Paolucci E, Mitchell P, Debru E, Church N.

EACTS, in partnership with Ethicon, is proud to announce the 3rd annual EACTS/Ethicon Cardiovascular Simulation Award

2011 WINNER

2012 WINNER

2013 WINNER

The Contest is to create a Simulator which replicates for training purposes one teachable component of an Aortic root surgery (Preferably as many different teachable components as possible and most certainly the essential ones: a low fidelity substitute for the aortic root prosthesis (essential), sizing, commissures, coronary re-implantation, valve or root implantation).
Development Criteria of the Simulator: Low Fidelity, Cost Effective, Reusable, Portable/Flat Pack assembly.
The project will be submitted in the form of a transportable self-construction package. It will have a graphical description of its building process and a textual description of the materials

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Is it really possible to create a simulator for the surgery of the aortic root?

These were our initial beliefs…

…. our starting point!

First steps

It was necessary to build an ideal prototype!

basic requirements :

- simulator able to reproduce the anatomical details of the aortic root.
- use of materials with excellent performance,
  realistic for the similarity with vascular structures in:
  resistance, elasticity and difficulty of exposition.
- low cost and simple construction tools.
- a complete simulator for - the structure (bulb, ring and aortic cusps and coronary ostia).
  - the operating mechanism.
- easy reproducibility.

Goals

Reproduce, in a real way the scenario offered to the surgeon in the operating room

Recreate the anatomy of the aortic root in detail

Aortic root Simulator

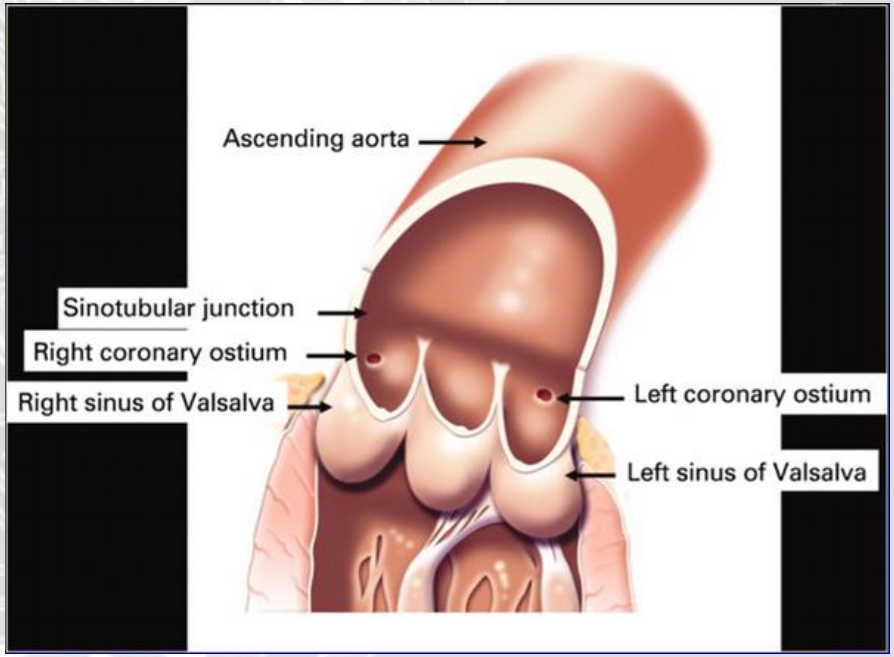
The materials used behave similarly to the vascular tissue as: silicone rubber – rubber latex

Realize the molds for a production serial, easy and quick.

.....A SIMPLE IDEA …….. MAY HIDE A MORE COMPLEX PROJECT

behind a simple idea it is hidden a more complex project that arises from the consideration anatomic aortic root as the set of four distinct components:

- the sino-tubular junction (STJ)
- the bulb with the aortic sinuses of valsalva,
- the aortic valve with its aortic annulus and
-junction ventriculoarterial (VAJ).



in everyday practice, the surgeon is often called upon to treat pathologies of these anatomical structures of the aortic root individually or with varying degrees of association.

STEP BY STEP

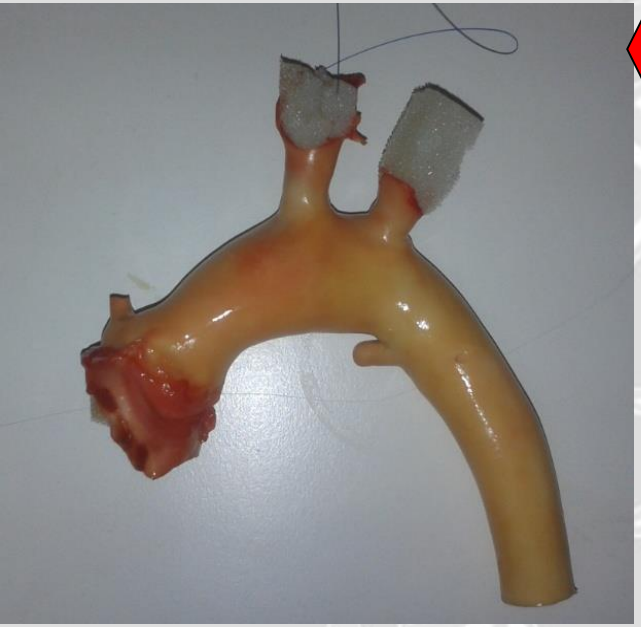
THIS ANATOMICAL AND PHYSIOPATHOLOGICAL CONSIDERATION WAS THE INSPIRATION FOR THE PROTOTYPE COMPOSED OF THREE COMPONENTS:

1) **ASCENDING AORTA**
2) **AORTIC ROOT (the simulator)**

} **INTERCHANGEABLE COMPONENTS**

3) **SUPPORT (the heart)** → **FIXED COMPONENT**

SEQUENCE OF REALIZATION OF THE AORTIC ROOT ASCENDING AORTA AND AORTIC ARCH



The smooth intimal surface of the aorta was reversed. Filling the aortic lumen with a sponge to prevent the collapse of the walls

Aorta with silicone rubber coating

Casting marmorina

Mould marmorina

Coating of the mold with rubber latex

Aorta rubber latex

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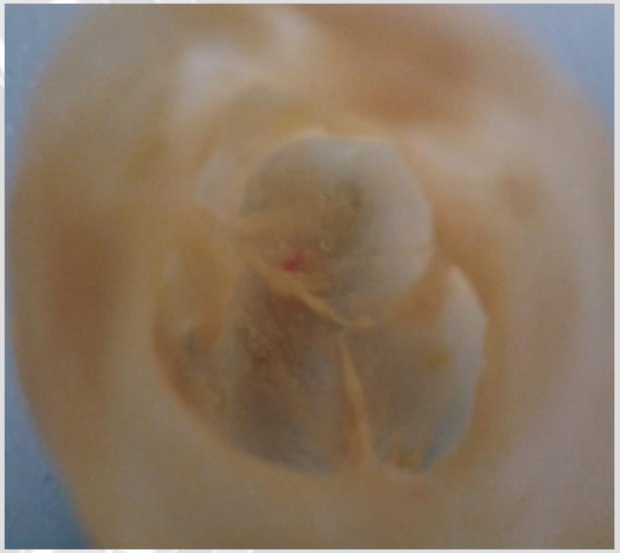
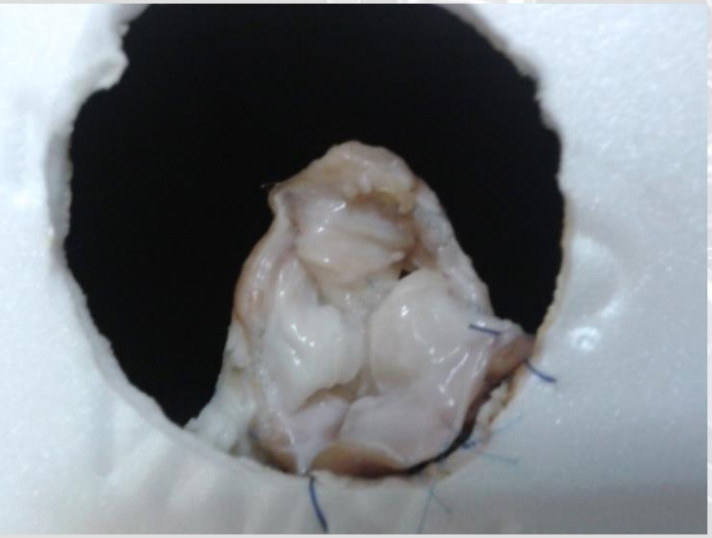
AORTIC ROOT: SEQUENCES OF REALIZATION

Mold silicone rubber aortic root

Aortic root in rubber latex

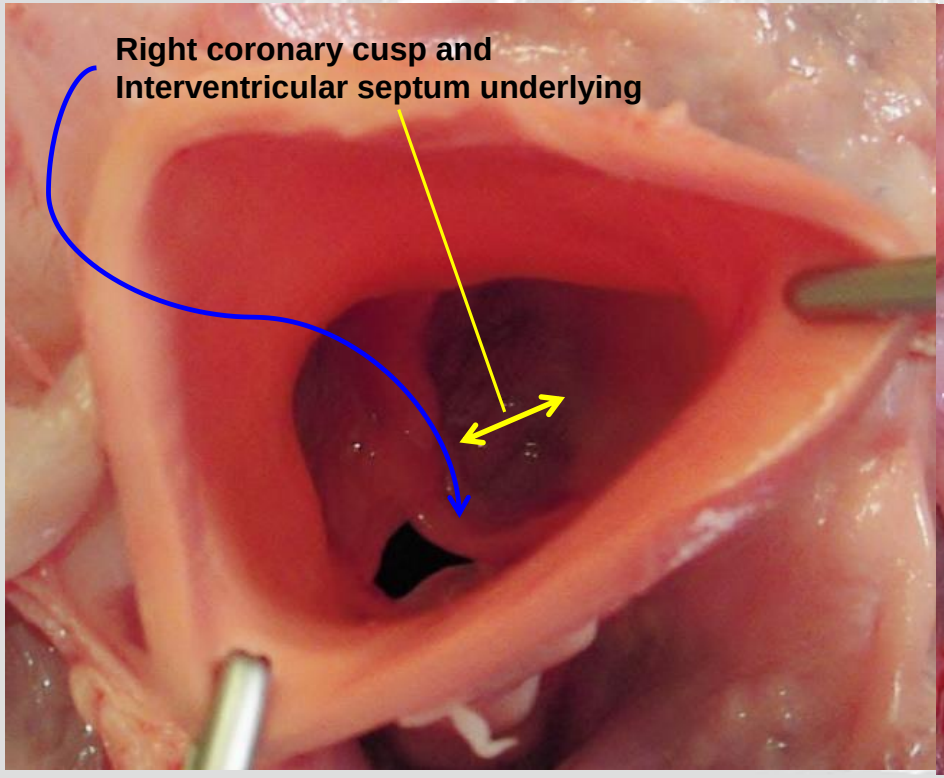


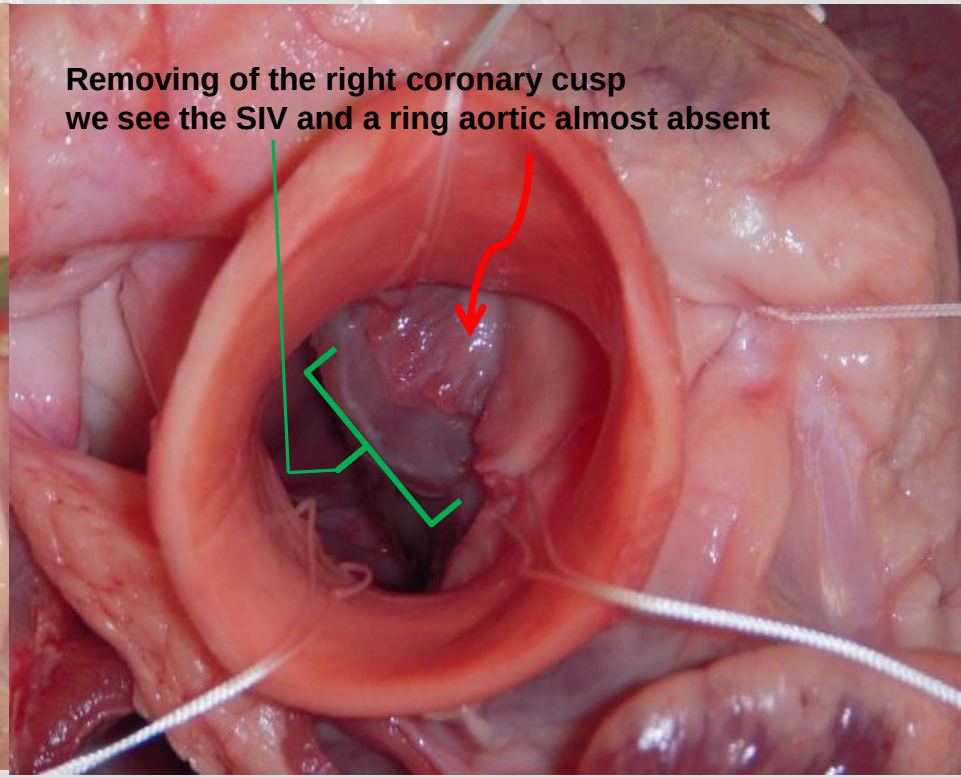


Mold of the aortic root in marmorina

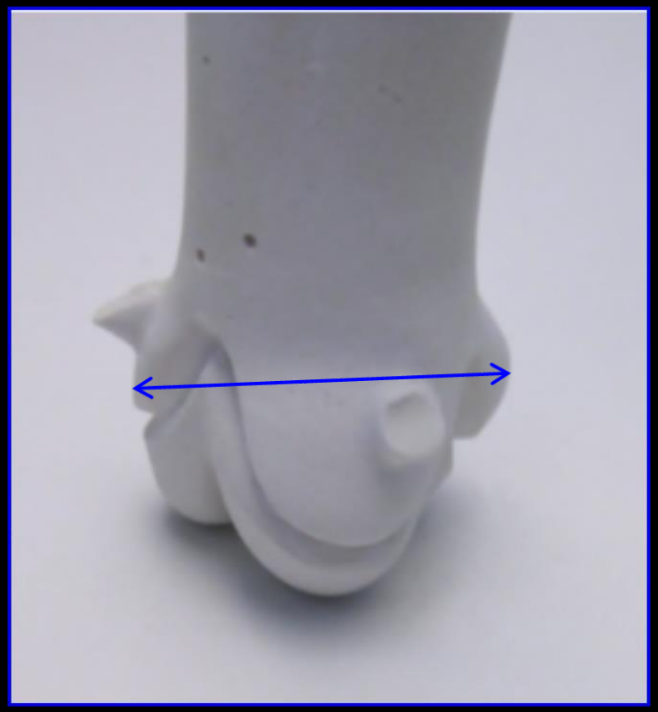
Mold Aortic Root Pig: these limits

- Annulus and aortic roots often small.
- Aortic annulus is a structure scarcely represented in the pig heart.
- In fact, in SC right the annulus is almost absent and the right cusp continues with SIV.

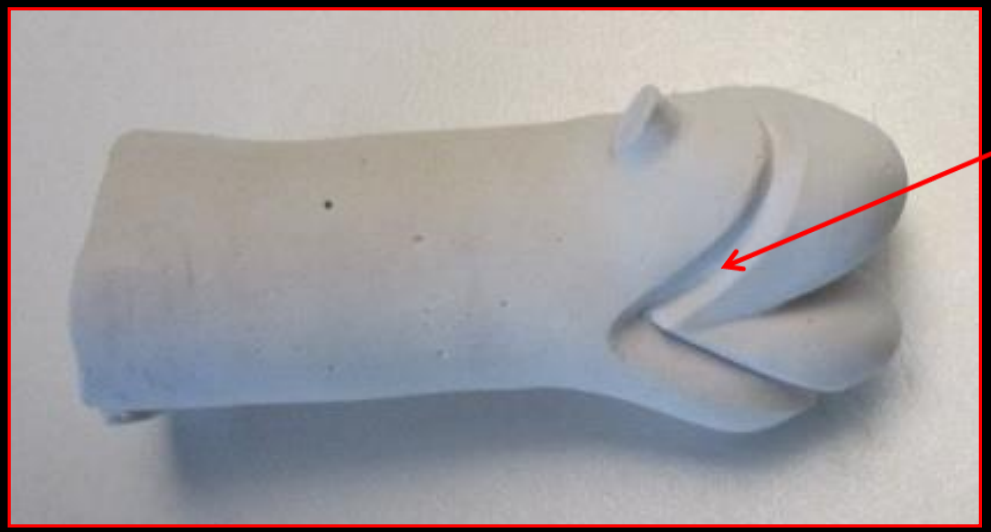




Modifications the mold of the aortic root:



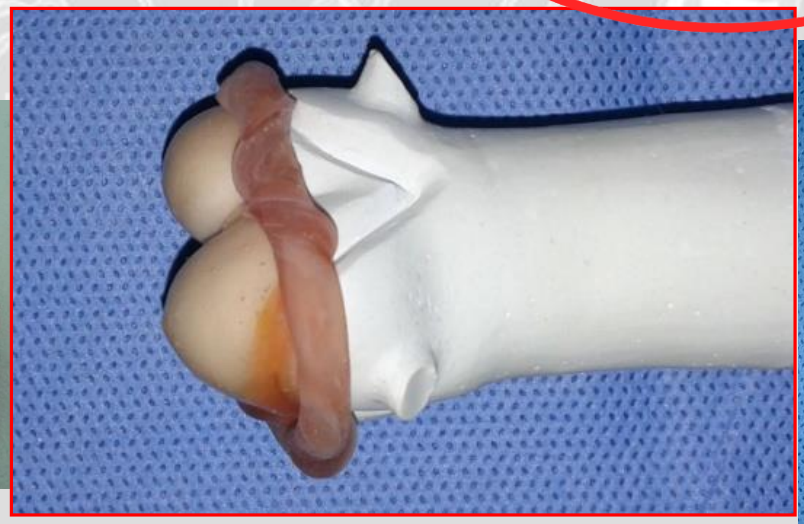
1) enlargement of the diameter

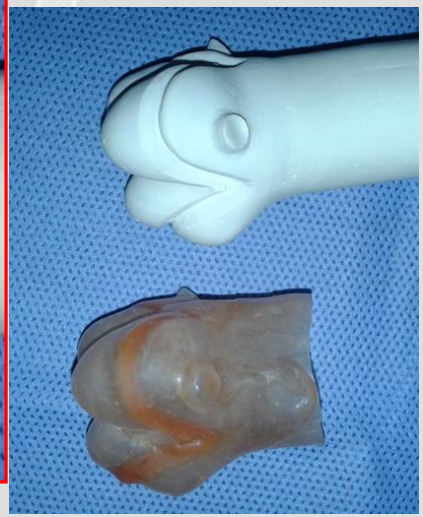


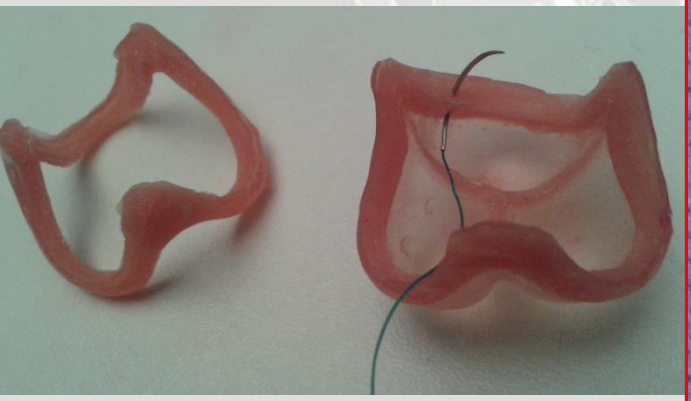
2) creation of the aortic annulus executing an incision mold

SERIAL PRODUCTION OF AORTIC ROOTS USING THE MOLD OF MARMORINA

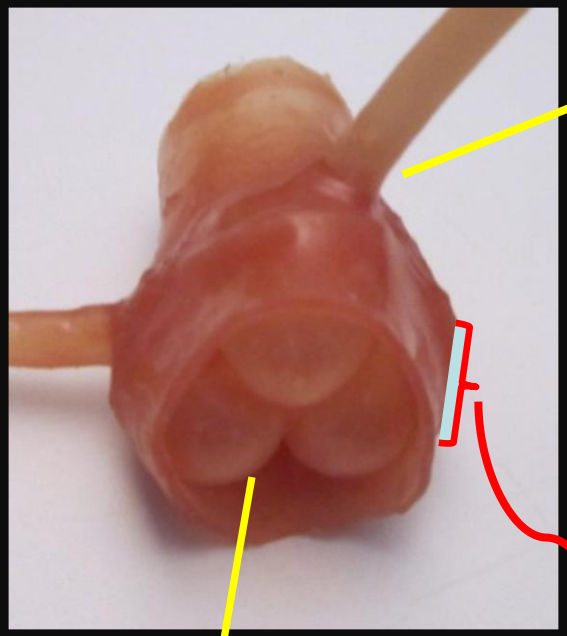
JUST IN ONE STEP



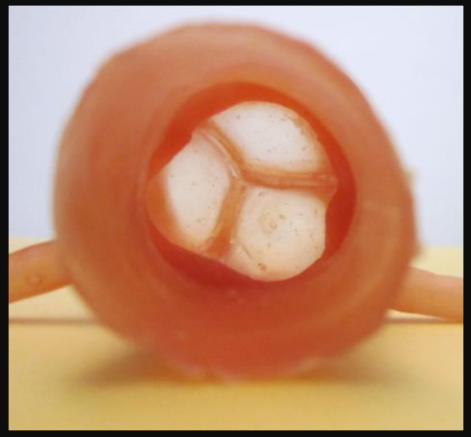


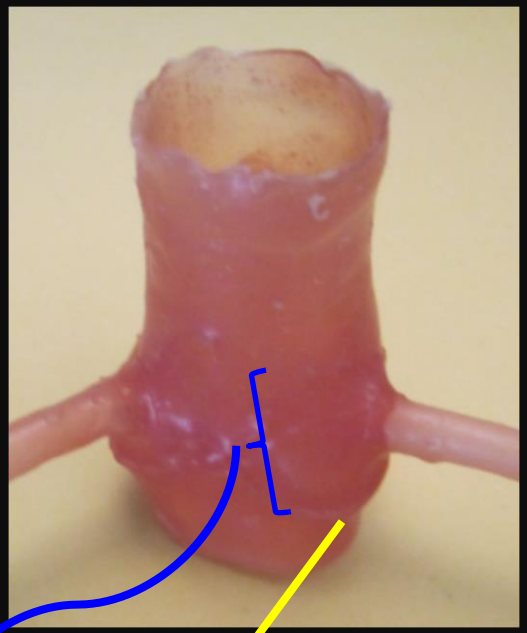


THIS IS THE AORTIC ROOT COMPLETE!



CORONARY OSTIA





VENTRICULOAORTIC JUNCTION

SINUSES OF VALSALVA

AORTIC CUSPS

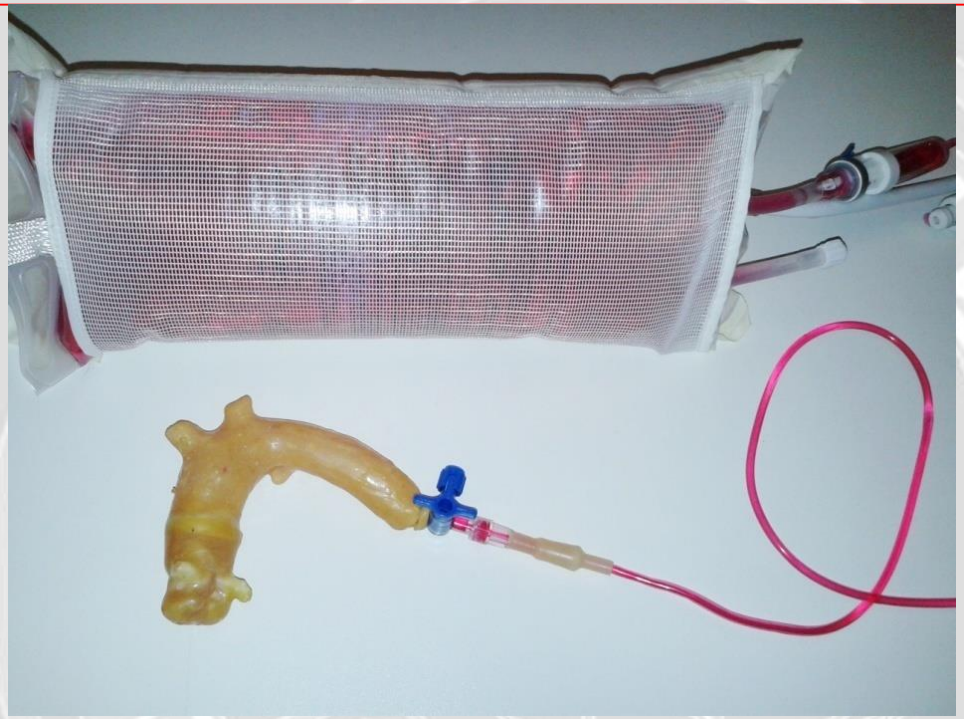
AORTIC RING

ASSEMBLY OF THE AORTIC ROOT TO ASCENDING AORTA: NEOAORTA

The neoaorta created, latex rubber, is perfectly elastic like the human

You can create a positive pressure within the neovaso, infusing of normal saline

Finally we have created a working prototype



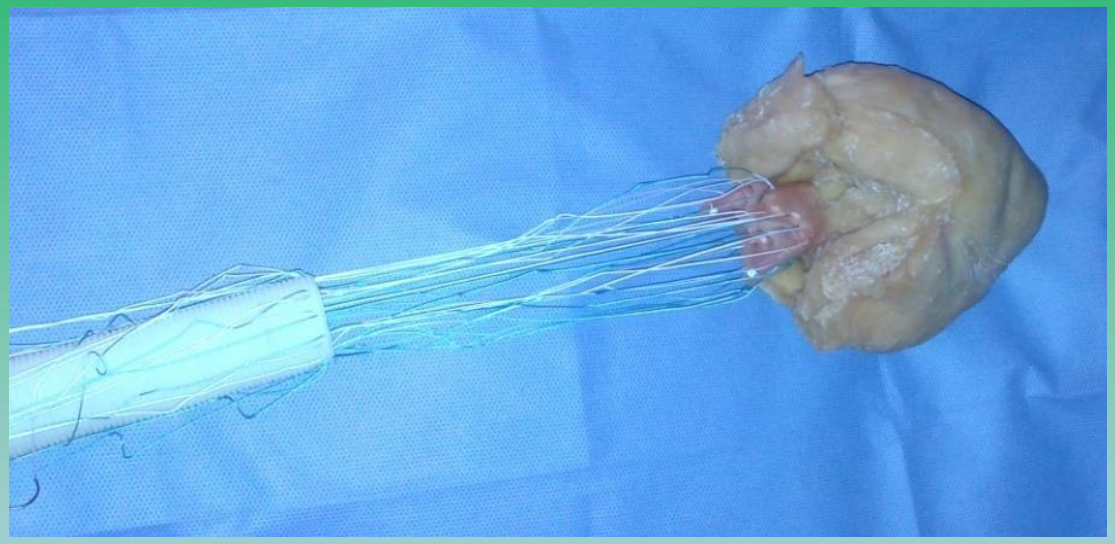
In fact, you can create a positive pressure within the neovaso with the infusion of normal saline.

This allows surgeons to train in:

- packing of the aortic bags
- in the aortic cannulation

Aortic bags and aortic cannulation

David procedure: example



You can really appreciate the simulator just trying it

STEP BY STEP

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1) ASCENDING AORTA

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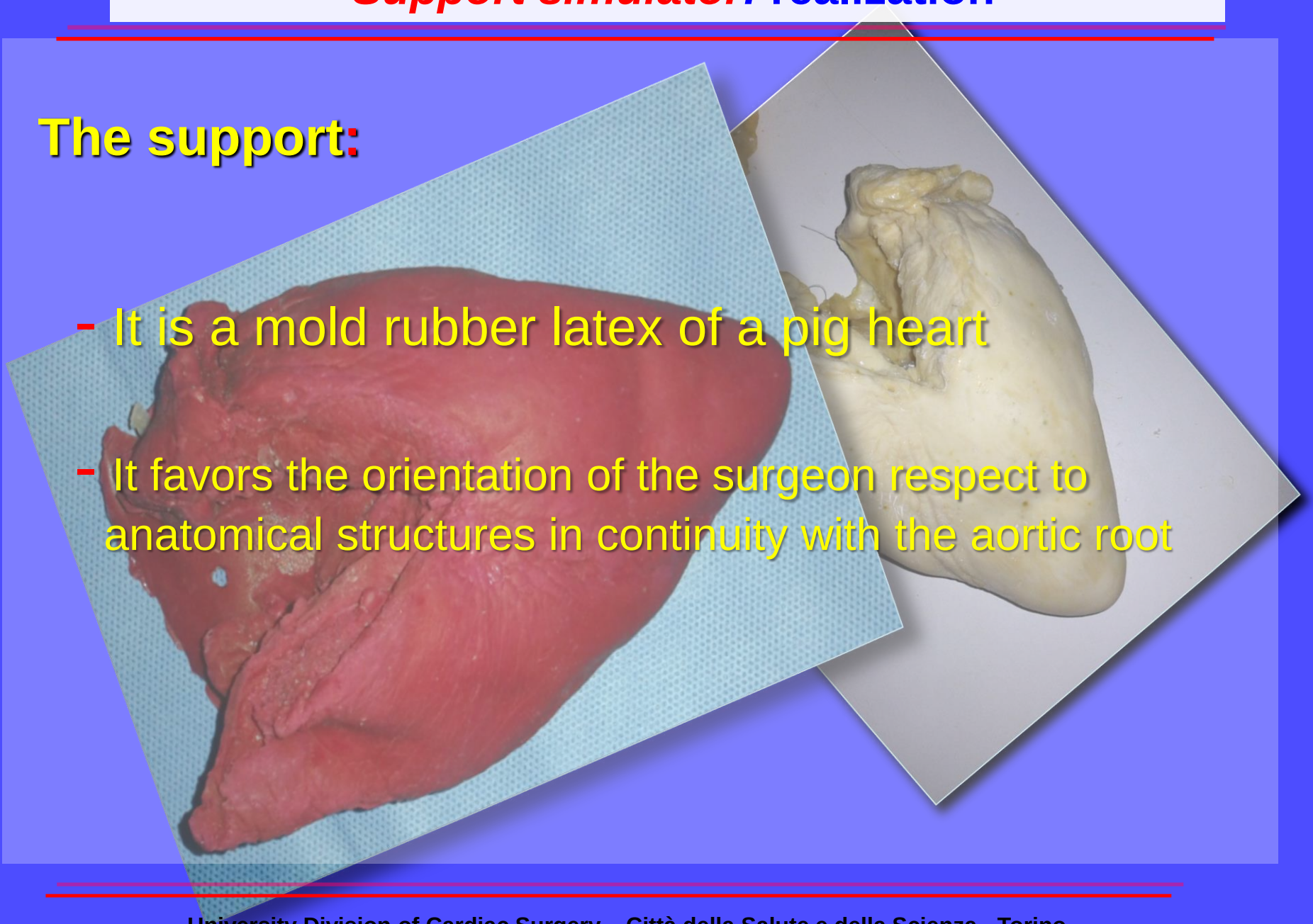
} **INTERCHANGEABLE COMPONENTS**

3) SUPPORT (the heart) → **FIXED COMPONENT**

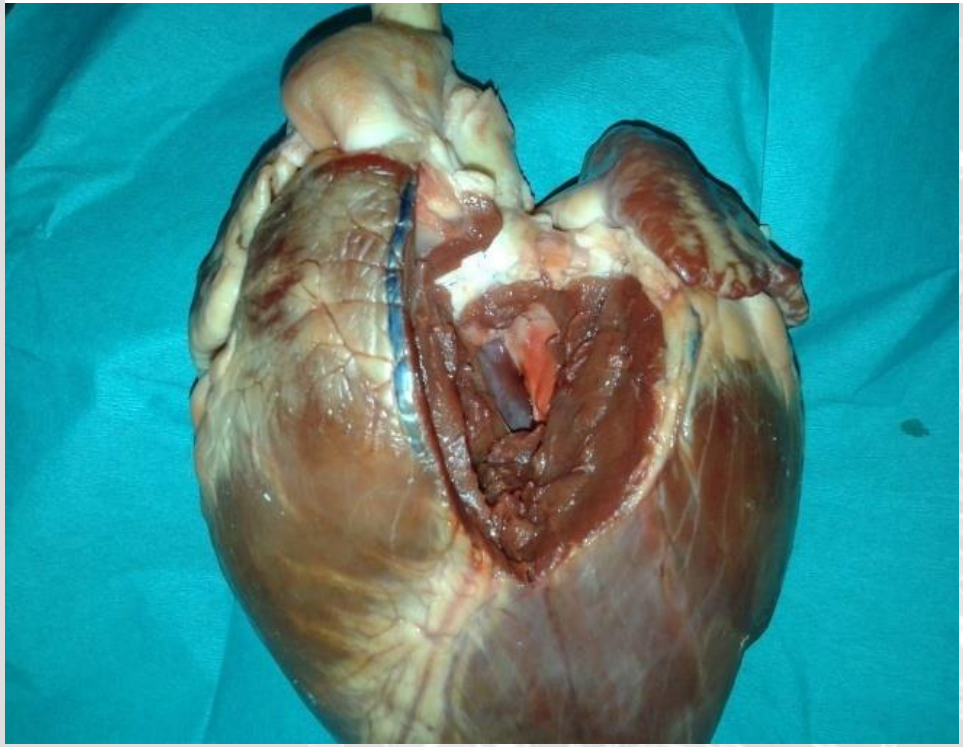
Support simulator: realization

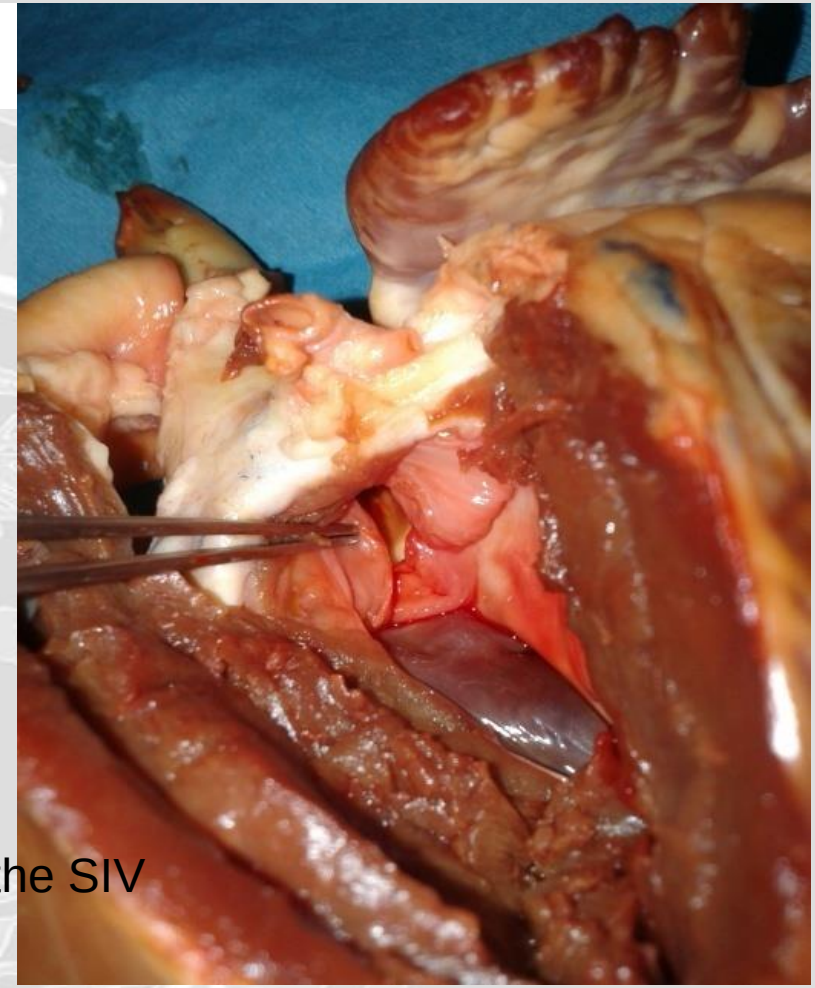
The support:

- It is a mold rubber latex of a pig heart
- It favors the orientation of the surgeon respect to anatomical structures in continuity with the aortic root



SUPPORT: SEQUENCE OF THE REALIZATION



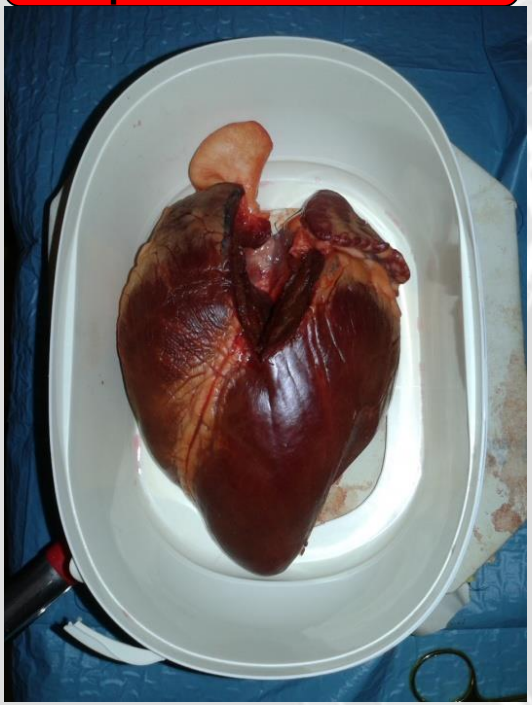


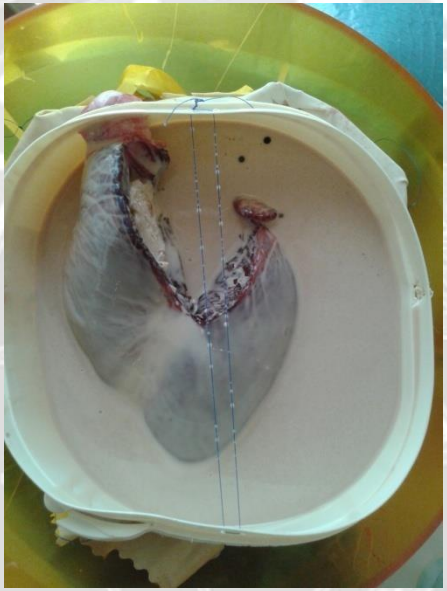
An incision (Konno procedure) It is made across the SIV and a triangle of myocardium is removed allows:

- **- The visualization of intra-ventricular anatomical structures in continuity with the aortic valve**
- **- The possibility to continuously inspect every single surgical act performed by the surgeon on the aortic ring or the aortic cusps**

SEQUENCE OF REALIZATION OF THE SUPPORT OF THE PROTOTYPE (AORTIC ROOT)

Preparation of the heart to perform the mold





Silicon rubber mold of the heart

Mould Marmorina

+

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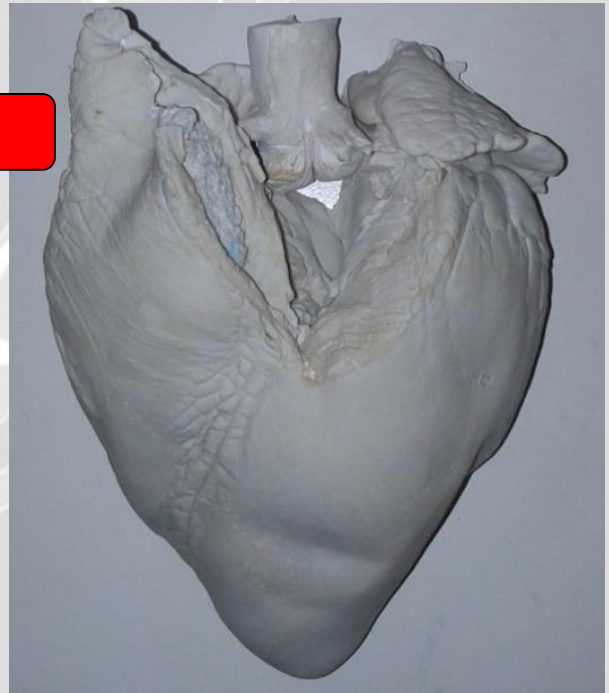
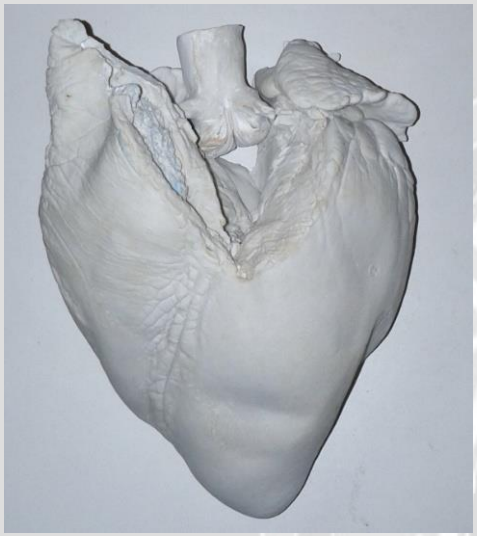
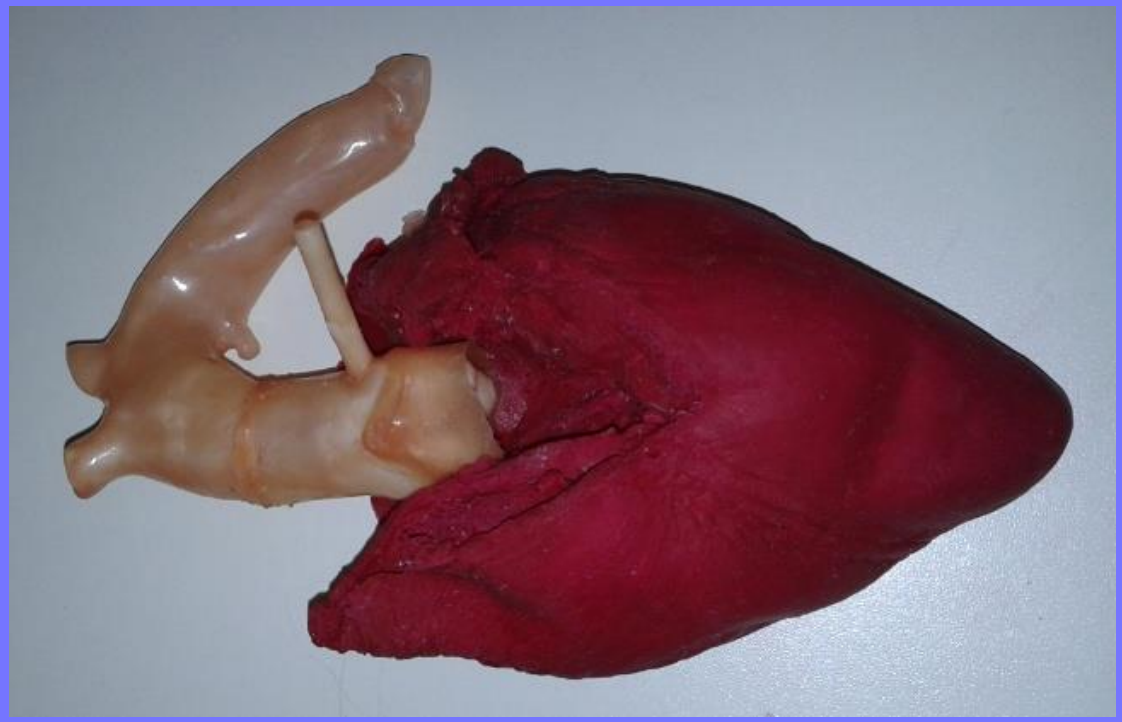


Sequence of realization of the support of the prototype



Support of the prototype in rabber latex

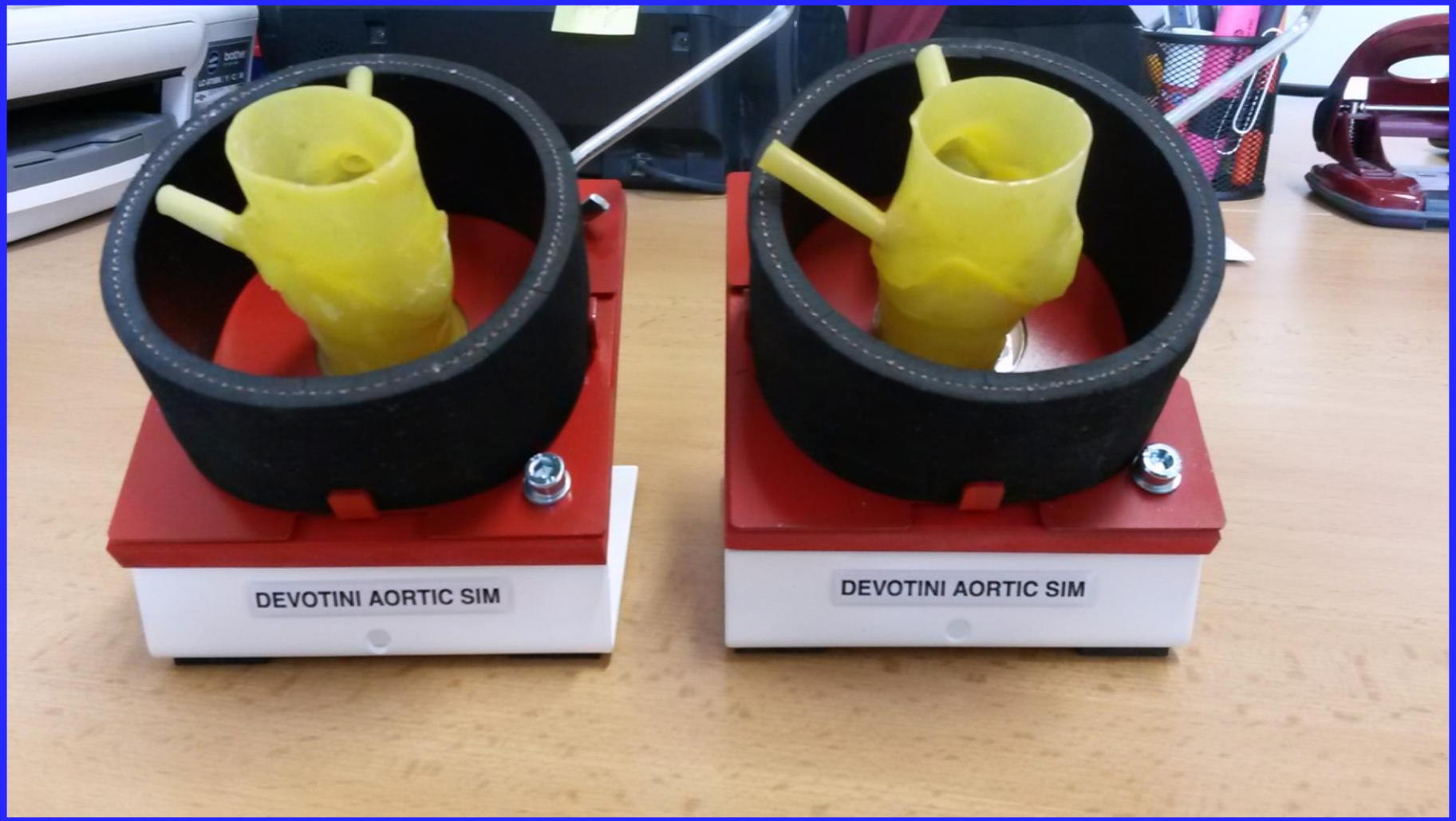
Aortic Root simulator complete



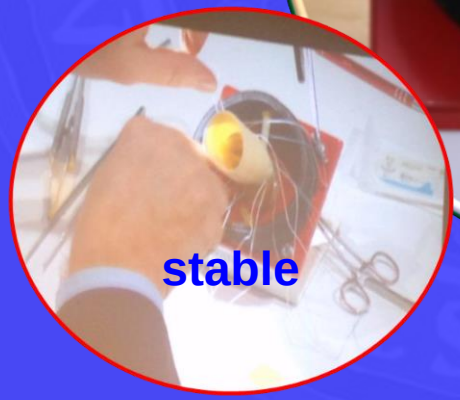
Our simulator allows the following procedures:

- David procedure
- Yacoub procedure
- Plastic aortic cusps
- Bentall procedure
- Florida sleeve procedure
- ...of course substitution of the aortic valve and annulus widening
  (Nicks and Manoughian techniques)

Simulator Aortic Root - today

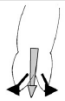


Features of the Aortic simulator

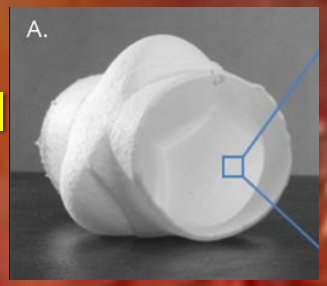


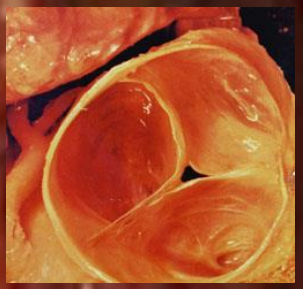
What I would like for the future .....?

- Produce molds aortic root according to the various forms of aortic regurgitation (classification of El Khoury)

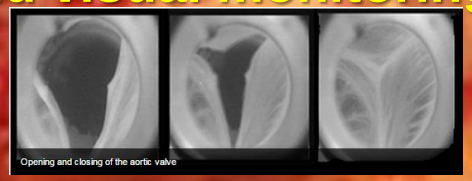
AI Class	Type I Normal cusp motion with FAA dilatation or cusp perforation				Type II Cusp Prolapse	Type III Cusp Restriction
	Ia	Ib	Ic	Id		
Mechanism						
Repair Techniques (Primary)	STJ remodeling *Ascending Aortic Graft*	Aortic Valve sparing: *Reimplantation or Remodeling with SCA*	SCA	Patch Repair *Autologous or bovine pericardium*	Prolapse Repair *Free Margin Plication Triangular Resection Free Margin Resuspension*	Leaflet Repair *Shaving Decalcification Patch*
(Secondary)	SCA		STJ Annuloplasty	SCA	SCA	SCA

- Use molds as scaffold for seeding stem cell
- Create a root pathological entirely organic





- Create a box to verify via a pulse duplicator with a true Δ pressure set to ECG and visual monitoring, pressure and echocardiographic



- Increasing the degree of confidence and success regarding the procedures of conservative surgery of the aortic valve

Using simulation for high impact training

Thanks for your attention

University Division of Cardiac Surgery – Città della Salute e della Scienza - Torino

behind a simple idea it is hidden a more complex project that arises from the consideration anatomic aortic root as the set of

four distinct components:

Our simulator allows the following procedures:

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- Plastic aortic cusps
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- Florida sleeve
- …of course substitution of the aortic valve and annulus widening (Nicks and Manoughian techniques)

It allows to improve the understanding of conservative surgery on the aortic valve

Increase the skills in surgical sutures such as the sutures of coronary tokens

Costo per 1 simulatore

Costo per il supporto = 20 €
Costo per la radice aortica + aorta = 0,21 € (ricaricabile)
