

Intra-operative angiographic images for Transcatheter Aortic Valve Implantation: extraction of quantitative data to support computer-based simulations

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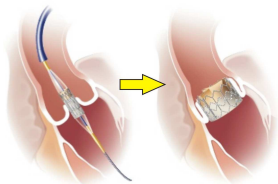
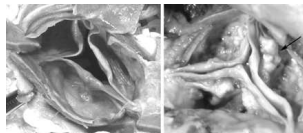
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Outline

- 1 Transcatheter Aortic Valve Implantation (TAVI)
 - procedure description
- 2 Intra-operative angiography
 - technical aspects
 - employment for TAVI
 - angiographic aspect of aortic root
- 3 Matlab program to support computer-based simulations
 - data extraction form angiographic images
 - program description

► **Transcatheter Aortic Valve Implantation (TAVI):** innovative and promising technique for the treatment of **aortic stenosis**

- **calcified** leaflets with reduced motion
- death within 2 years from diagnosis
- **replacement** of the valve required



► Features of the procedure:

- biological valve mounted onto a stent
- stent crimped into a sheath
- self/balloon-expandable device
- **minimally invasive**
- alternative to surgery
- over 50.000 cases since 2002

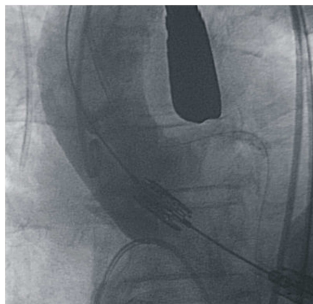
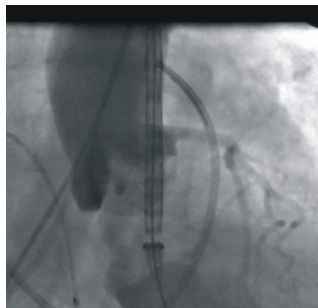
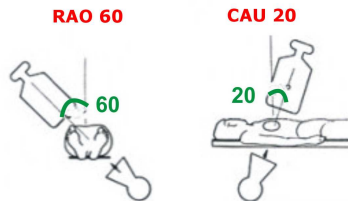
► **Angiography** is employed to guide the whole procedure

Aims of the thesis:

- 1 full understanding of **angiography** employed to perform TAVI
 - ▶ review of the literature
 - ▶ collaboration with **Istituto Clinico Sant' Ambrogio** (ICSA)
 - two interventions attended and angiographic images provided
- 2 use of angiographic images to **support** computer-based **simulations** of TAVI
 - ▶ *pre-processing*: realistic reproduction of the specific intervention
 - ▶ *post-processing*: validation to test predictive accuracy
- 3 development of a **program** within **Matlab** environment
 - ▶ semi-automatic **data extraction** from angiographic images

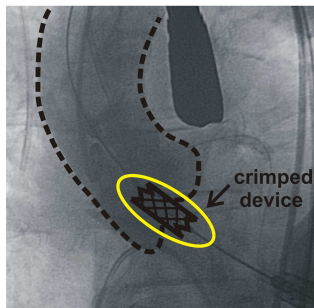
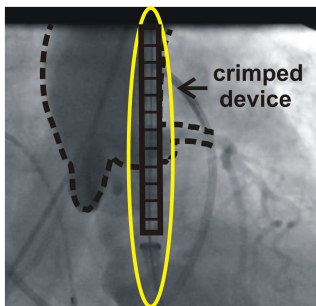
Angiography: principles

- ▶ Standard imaging technique to visualize **blood vessels** and heart chambers
- ▶ Technical aspects:
 - interaction **Xrays-body** forms the image
 - **2D image** of a 3D object
 - **projection** of the structures crossed by the beam
 - **different angles** available
 - contrast agent required



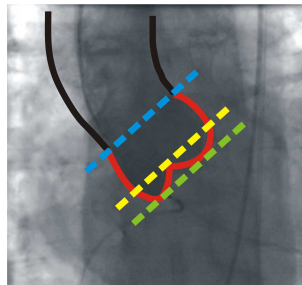
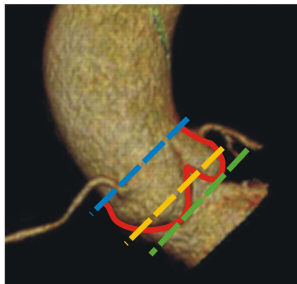
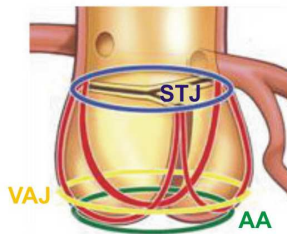
Angiography: support to TAVI

- ▶ **Gold standard** to support the whole procedure
 - *pre-operative*: anatomical measurements
 - *intra-operative*: placement and deployment of the valve
 - *post-operative*: register early outcomes
- ▶ Most crucial step: **positioning**
 - angiography mandatory to achieve suitable implantation



Angiography: anatomical landmarks

- ▶ **Constitutive elements** of the aortic root are used as **anatomical markers** to guide the implantation of the device
 - **sinuses of Valsalva**
 - **sinotubular junction**
 - **ventriculo-arterial junction**
 - **aortic annulus**
- ▶ *Assessment of aortic root under angiography important for data extraction*



Computer-based simulation of TAVI

- ▶ Computer-based models are engineering tools for simulation of TAVI procedure
 - **case specific**: patient, device, position of implantation
 - future employment in the field of **predictive medicine**
- ▶ Intra-operative angiographic images can support the development of the simulations
 - several images available for each intervention
 - possibility to gain information about the implantation

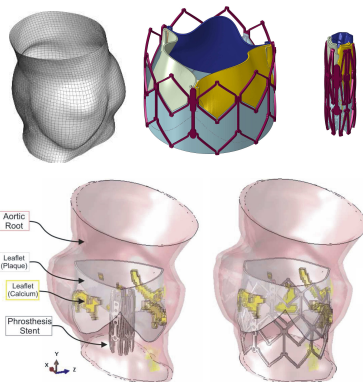


Figure: computational simulation developed by Morganti et al.

▶ Applications:

- 1 **pre – processing** to gain realistic reproduction of the specific case
- 2 **post – processing** to test the predictive accuracy

► Program developed within Matlab environment

- support to the **pre-processing** phase of the **simulations**
 - provide position of the implanted valve within the root
 - simulated device implanted in the same position of the real
- **semi-automatic tool** to gain **quantitative information** about implantation
- data extraction from intra-operative angiographic **images** provided by **ICSA**

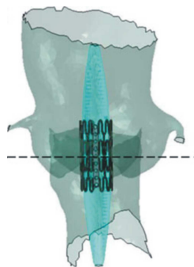
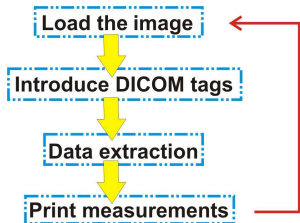


Figure: placement of the device simulated by Capelli et al.



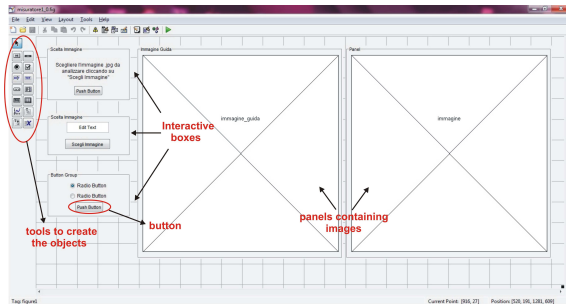
► Features of the program:

- intuitive Graphical User **Interface** (GUI)
- minimal interaction with the user
- user not required to be familiar with angiography
- guided procedure
- measurements semi-automatically arranged
- two device configurations implemented

Program: loading step

► Graphical User Interface (GUI):

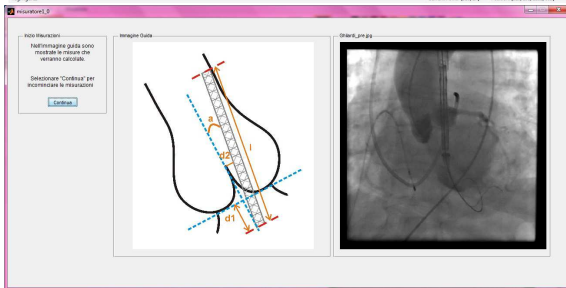
- interactive window
- buttons and panels for the images
- Matlab code is executed when the button is pressed



- The selected angiographic image is loaded to perform measurements

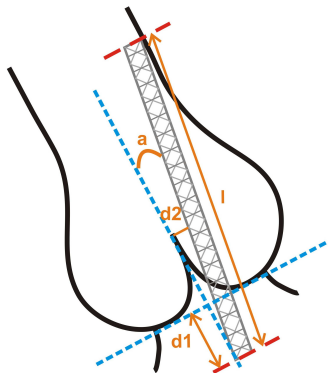
► Sketch of aortic root with device

- guide the user in all the step of the procedure



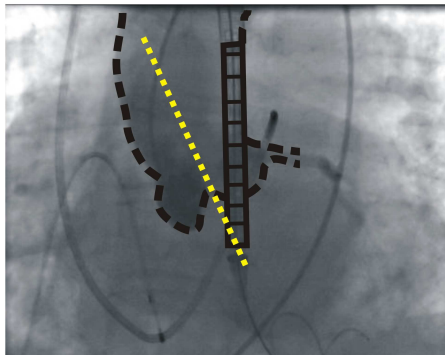
Program: support to pre-processing

- ▶ The program is developed to **support** **pre-processing** phase of TAVI simulations
- ▶ **Data extracted** from the images used to **set-up the simulations**
 - realistic placement of the crimped device within the root



▶ Required information:

- quantitative
- easily implemented in the simulations
- univocally identify device position
- not redundant



Program: data extraction

► Data extraction in semi-automatic fashion

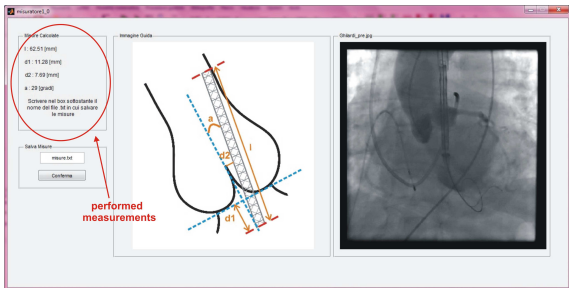
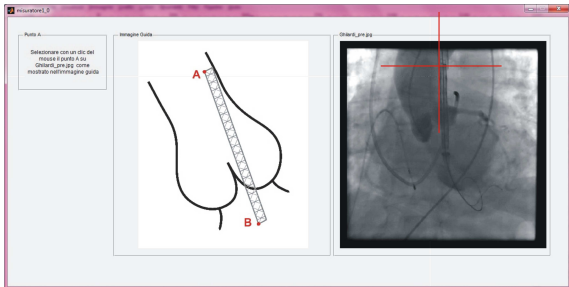
- measurements arranged by the program

► Matlab Image Processing Toolbox

- cross-hair on the image
- user picks the required points
- selected points appears on the image
- possibility of repositioning
- coordinates of each point

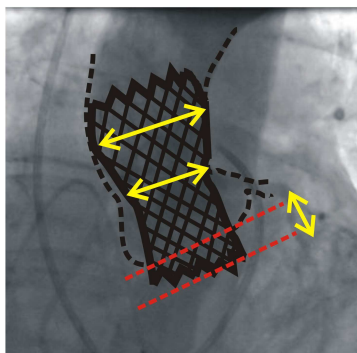
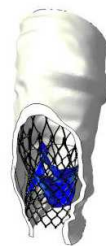
► Calculations

- measurements performed using algebraic considerations
- extracted data stored in a text file



Support to post-processing

- ▶ **Post-processing phase** : validation of the simulation to test **predictive accuracy**
- ▶ Data extracted from angiographic images of expanded device
 - stent profile
 - depth of implantation
 - stent diameters at different heights



► Conclusions

- Intra-operative angiography **gold standard** to guide TAVI
- **Data extraction** from angiographic images **to support** computer-based **simulations**
 - ▶ *pre-processing* phase
 - ▶ *post-processing*-phase
- **Matlab program** for data extraction
 - ▶ images provided by ICSA
 - ▶ 2 device configurations implemented
 - ▶ analysis performed on 4 patient
- The program is just one step towards **predictive medicine**

► Future developments

- **Extracted data** have to be **implemented** to set-up the simulation
- **Validation** of the simulations has to be performed

