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Risk Analysis For Catheter Guided Aortic Valve Implantation

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Abstract

The assessment process of the risks which could face the surgeons during the replacement of the severe stenotic aortic valve still needs a lot of research and studies. In order to achieve this assessment the amount of available data and information (X-Ray and CT-Images) has to be classified and read on the light of its influence on the success percentage of the operation.

In this paper, about 32 cases of catheter guided heart valve implantations were analyzed, which are almost 13% from the total number of operations per year (250 operations annually). Some parameters which were considered to be very important in predicting the occurred risks in case of the incorrect estimation were further analyzed. These parameters were the size and the type of the suitable implanted valve for each patient, in addition to the volume of the total calcification in the level of the aortic valve besides the calcification's volume of each cusp.

This study was conducted by the use of three different medical viewing programs. ITK-SNAP software was used for segmenting the aortic valve and its calcification, where Aeskulap software was used for analyzing the X-Ray images of each operation and Paraview software was used for visualizing the obtained segmentation. Some of the extracted results in this thesis could explain the reasons of some complications and risks.

1 Introduction

The procedures followed in the heart valve implantations, especially in the domain of aortic valve implantations witnessed a rapid progress from the traditional open heart surgery (full chest cut) to the minimal invasive surgeries (minimal chest cut). Out of this the so-called catheter guided aortic valve implantation appeared.

The catheter guided aortic valve implantation is performed either transapically (through the apex of the heart) or transfemorally (through the femoral artery). A new tissue implanted valve confined within a metal mesh is then released over the old stenotic one. The biggest challenge which faces the surgeon during the operation is to choose the right size and type of the implanted valve. Another challenge is knowing the effect a chosen valve has on the patient as well as the reasons behind eventual complications which might occur.

Clinical Data such as CT-images or TEE-images support the surgeon in getting direct visualization on the calcification area and approximate values for the size of the implantable valve. The estimation of these parameters (size of valve etc.) is still improvable with respect to accurate numbers.

This thesis therefore deals primarily with the identification and analysis of the most important parameters that could be extracted from the amount of the available data. It was structured as follows:

1- Literature research for complication analysis (stenosis degrees and types, diseases of aortic valve, et cetera).

2- Screening of pre-operative and intra-operative CT-images and X-ray images, selecting the parameters of interest for further analyzing.
3- General statistical evaluation of derived parameters.

2 Software & Methods

Basically three computer programs were used for segmenting and visualizing the aortic valve and the calcification:

ITK-SNAP software: which was used for the segmentation; AESKULAP software, which was used for analyzing the videos of the operation; PARAVIEW software, which was used for the final visualization of the segmented structures (the aortic valve and the calcification).

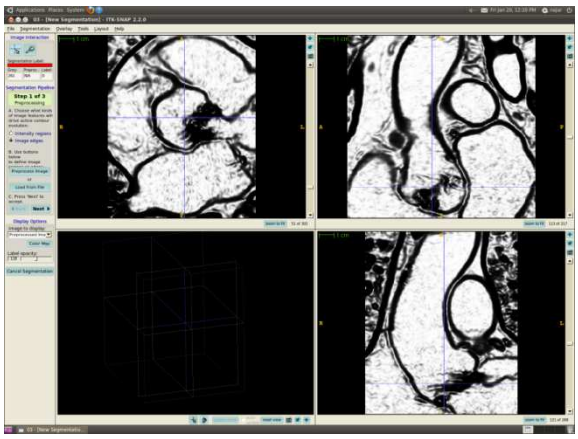

Figure 1: Shows the segmentation process of the aortic valve by ITK-SNAP software. The aortic valve is seen from three different planes shown in three different windows; "the orthogonal axial plane "(top left); "the sagittal plane"(top right) and "the coronal plane"(bottom right). The result of the segmentation is then seen in the fourth window (bottom left) which gives 3D view.

After segmenting the aortic valve, the calcification on each cusp had to be additionally segmented. In order to do so the location of each cusp was distinguished by the left and right coronary arteries.

The left cusp was known by the left coronary artery, where the right cusp was known by the right coronary artery. After the left and right cusps were differentiated from each other, the non- cusp was easily distinguished.

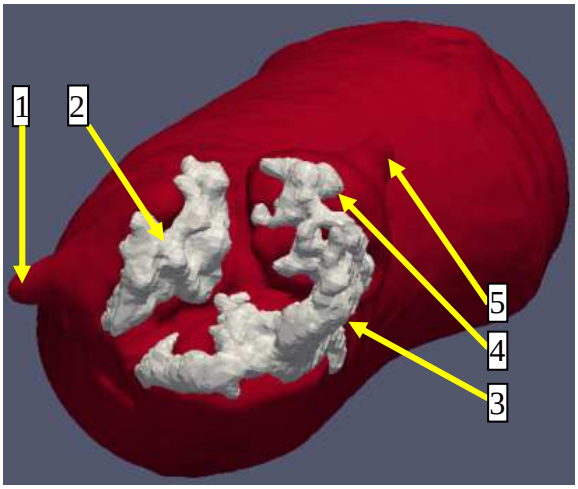

Figure 2: The segmented aortic valve and the calcification on each cusp visualized by Paraview software. 1:Right coronary artery,2: Right cusp, 3:Non-cusp, 4:Left cusp 5: Left coronary artery.

Also the diameter of the valve's annulus was measured by using the measurement's tools provided by Paraview software (line method and ruler method). The gained values were compared then with the estimated diameters used by the physicians, this was done to improve the estimation of the valve' size (implantable new valve).

3 Results & Discussion

The results in this study showed much important information that could help in the pre-operative risk analysis. They are mentioned as follows:

1- The calcification on the non-cusp was in most cases the highest; compared with the other two cusps. This can be also observed by calculating the average of this volume (51%). In contrast, the calcifications on the left and right cusps were so close to each other (26% & 24% respectively)

2- The amount of the calcification on the three cusps range between 359 [mm³] and 1940 [mm³] except in one case where this amount was very high 2463 [mm³]. In this case not the amount of the calcification was the only unique observation, also its shape and distribution. The calcification had sharp edges and extended in the LVOT (left ventricle outflow tract). Using the balloon-based valve was not a good choice for this case because of the high pressure; it led to severe complications during the operation. The self-expandable valve was the suitable one. This indicates that the type of the implanted valve has a big effect on the success or the failure of the Operation; moreover it has to be related to the volume of the calcification, shape and distribution.

3- Combining the estimated diameters measured by the ruler method and the estimated diameters used by the surgeons gave a better estimation of the suitable valve's size, rather giving a very accurate number of the new implanted valve is still very difficult to be achieved despite the efforts exerted by the mathematicians and engineers.

4 Conclusion

After the theoretical and computational study of the important parameters (volume of the calcification, the size and the type of the valve), it was found that a lot of complications can be avoided by the correct choosing of these parameters, moreover the life of the patient can be saved.

Overall it can be said that this study could pay attention of the surgeons for other important factors which influence the result of the operation and it could open more doors in further analyzing the risks in catheter guided aortic valve implantation.

5 References

[1] C.Lewerence, H. (2008). Cardiac Surgery in the Adult / Minimally Invasive Aortic Valve Surgery. New York: NcGraw-Hill.

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Reem Rosen,

vom Institut für Technische Medizin (ITeM), der Hochschule Furtwangen University (HFU) Villingen-Schwenningen Campus am Studierendenwettbewerb der BMT 2012 unterstütze ich nachdrücklich. Die Masterarbeit mit dem Titel

Risk Analysis For Catheter Guided Aortic Valve Implantation

wurde unter meiner Mit-Betreuung angefertigt.

Mit freundlichen Grüßen

VS, 27.03.2012 Prof. Dr. Knut Möller
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Erstautor/in (Name, Vorname):	Rosen, Reem
Titel des Beitrags:	Risk Analysis in catheter guided Heart valve implantation
Abgabetermin der Abschlussarbeit zur eingereichten Thematik: (bis zu maximal 1 Jahr vor Einreichtermin abgeschlossen)	31. März 2012
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