Scientific Research Publishing

Forensic Medicine and Anatomy Research, 2024, 12, 41-49
https://www.scirp.org/journal/fmar
ISSN Online: 2327-4107
ISSN Print: 2327-4115

3D Vector Reconstruction of Coronary Arteries from Korean Visible Woman Sections at the Clinical and Numerical Anatomy Laboratory of the Faculty of Medicine and Odontostomatology in Bamako

Abdoulaye Kanté[1*], Tata Touré[1], Ousmane Toumany Chérif Haidara[1], Mariam Daou[2], Uhl Jean François[3], Mamadou A. Keita[4], Bakary Keïta[5], Adégné Togo[6], Nouhoum Ongoïba[1], Abdel Karim Koumaré[7]

[1]Faculty of Medicine and Odontostomatology of Bamako, Bamako, Mali
[2]Department of Neurology, The Gabriel Touré University Hospital, Bamako, Mali
[3]University of Paris Descartes, Paris, France
[4]Department of General Surgery, The Kati Health Center, Bamako, Mali
[5]Anesthesia-Resuscitation Service, Commune I Reference Health Center, Bamako, Mali
[6]Department of General Surgery, The Gabriel Touré University Hospital, Bamako, Mali
[7]African Institute for Training in Pedagogy, Research, Evaluation in Health Sciences, Bamako, Mali
Email: *kanteim@yahoo.fr

How to cite this paper: Kanté, A., Touré, T., Haidara, O.T.C., Daou, M., François, U.J., Keita, M.A., Keïta, B., Togo, A., Ongoïba, N. and Koumaré, A.K. (2024) 3D Vector Reconstruction of Coronary Arteries from Korean Visible Woman Sections at the Clinical and Numerical Anatomy Laboratory of the Faculty of Medicine and Odontostomatology in Bamako. *Forensic Medicine and Anatomy Research*, **12**, 41-49.
https://doi.org/10.4236/fmar.2024.124004

Received: January 16, 2024
Accepted: October 28, 2024
Published: October 31, 2024

Abstract

Aim: To carry out a 3D reconstruction of the coronary arteries from the anatomical sections of the "Korean Visible Woman" for educational purposes. **Material and Methods:** The anatomical sections of a 26-year-old Korean woman who died of stomach cancer and donated her body were made in 2010 after an MRI and CT scan. A special saw made it possible to make cuts of 0.2 mm thickness on the frozen body, *i.e.* 5960 cuts. Only sections numbered from 1500 to 2000 (*i.e.* 500 sections of the thorax) were used for our study. A segmentation by manual contouring of each vascular structure was done using Winsurf software version 3.5 on a laptop running Windows 7 with a RAM of 8 gigabytes. **Results:** Our vector 3D model of the coronary arteries includes the following: the left coronary artery and its branches, the right coronary artery and its branches, the coronary sinus, the anterior veins of the heart, and the minimal veins of the heart. This model is easy to manipulate using the Acrobat 3Dpdf interface. Each vessel accessible in a menu can be shown, hidden or made transparent, and 3D labels are available as well as educational menus for learning about the vascularization of the heart. **Con-**

clusion: Vascularization of the heart is a prerequisite for understanding the physiology and semiology of coronary heart failure. This reconstruction of the vessels of the heart is an educational tool that allows us to teach the vascularization of the heart. It could also be used as a 3D atlas for simulation purposes for training in coronary angioplasty and coronary artery bypass grafting procedures.

Keywords

Coronary Arteries, Korean Visible Woman, Vector 3D Modeling

1. Introduction

The two coronary arteries of the heart are the first branches of the ascending aorta. They are located under the epicardy. Their caliber is 3 to 5 mm; that of the left coronary artery is usually larger (60% of cases) [1].

Their terminal branches have subepicardial and myocardial anastomoses whose functional value is reduced, as shown by their thromboses in the clinic.

The right coronary artery originates above the right semilunar valve of the aorta. It passe between the pulmonary trunk and the right atriolic, travels along the right coronary sulcus bypassing the right edge of the heart, then reaches the posterior interventricular sulcus where it becomes the posterior interventricular artery, to anastomosis with the left coronary artery.

The left coronary artery originates above the left semilunar valve of the aorta. It is carried forward, goes back and forth and to the left of the pulmonary trunk, and passes under the left auricle. It travels to the anterior interventricular sulcus and becomes the anterior interventricular artery, which bypasses the incisure of the heart and ends in the posterior interventricular sulcus, where it anastomoses with the right coronary artery.

Coronary arteries can be affected by several pathologies such as coronary strictures, coronary aneurysms and coronary malformations, etc.

These pathologies can significantly affect patients' lives. They can be diagnosed by stress testing (brisk walking on a treadmill with ECG monitoring), nuclear imaging tests such as single-photon emission tomography (SPECT) or positron emission tomography (PET), stress echocardiography, computed tomography (CT) angiography, and angiography.

In-depth knowledge of the vascular structures of the heart is the basis for the prevention and/or treatment of these pathologies.

Certainly, cadaveric dissection is the gold standard for the acquisition of this knowledge, on the other hand, it has significant disadvantages: the lack of cadavers that cannot cover the demand of medical schools, the limited location of the activity (anatomical theater) and the fact that dissection is unique because it is based on a destructive and irreversible process on human tissues, and ethical and religious problems [2] [3].

For all these reasons, the 3D reconstruction of anatomical structures promotes new pedagogical methods widely used around the world, for their new realistic and interactive interfaces.

It is a wonderful tool for students interested in learning about the human body, but also for anatomy teachers and for interactive clinical simulation for practitioners [4] [5]. Finally, it is a revolution for surgeons: assistance with pre-operative planning, simulation and augmented reality to guide the surgical procedure.

We initiated this work in order to have a 3D educational tool to facilitate the teaching of the vascularization of the heart.

2. Materials and Methods

This was an experimental study carried out from November 1 to December 30, 2023 at the Clinical and Morphological Anatomy Laboratory of the Faculty of Medicine and Odontostomatology of Bamako.

The anatomical sections of a 26-year-old Korean woman who died of stomach cancer and donated her body were made in 2010 after an MRI and CT scan.

A special saw made it possible to make cuts of 0.2 mm thickness on the frozen body, *i.e.* 5960 cuts. Only sections numbered from 1500 to 2000 (*i.e.* 500 sections of the thorax) were used for our study. A segmentation by manual contouring of each anatomical element was done using Winsurf software version 3.5 on a laptop running Windows 7 with a RAM of 8 gigabytes.

3. Results

In this study, we reconstructed the left coronary artery and its branches, the right coronary artery and its branches, the coronary sinus, the anterior veins of the heart, and the minimal veins of the heart. (**Figures 1-8**)

4. Discussion

Our work consisted of a recognition of the coronary arteries on the sections and a more tedious work of contouring in order to obtain the most realistic models possible.

The advantage of this work is essentially based on the fact that the entire contouring work, and consequently the entire 3D reconstruction of the coronary arteries, was carried out using real sections of the human body.

This results in a major increase in the accuracy and reliability inherent in the results presented above.

This contouring work was based on a manual segmentation process, which reduces the risk of anatomical errors in the reconstruction of the organ.

The second advantage lies in the fact that a better precision as well as the possibility of individualization of the different vascular entities favors a massive application in the academic field, thus contributing to a better understanding by medical students and other fields.

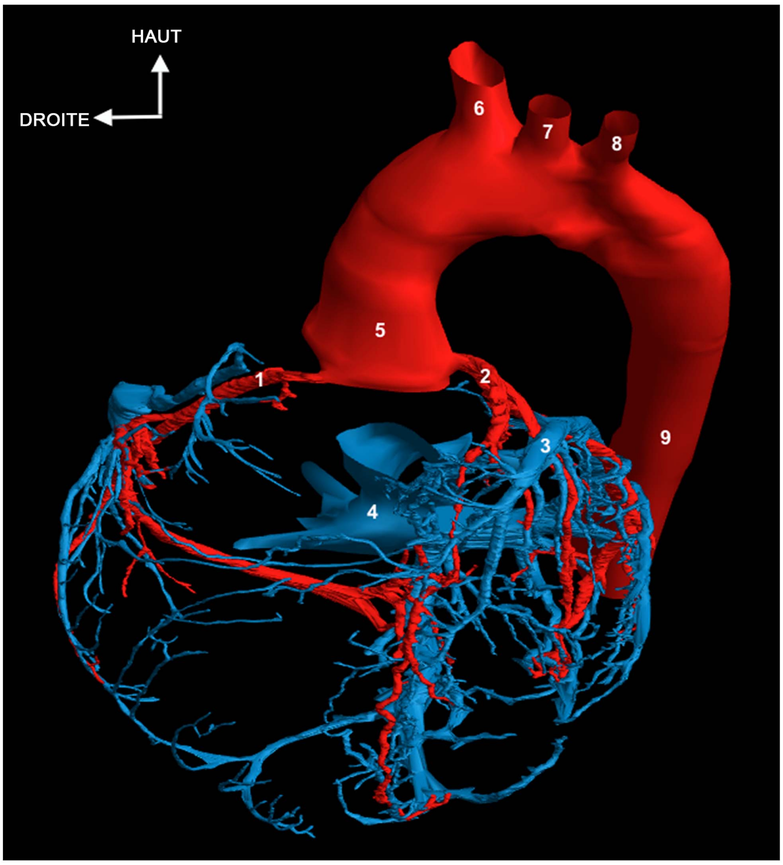

Figure 1. 3D reconstruction of the cardiac vasculature with Winsurf software. 1: Right coronary artery; 2: Left coronary artery; 3: Large vein of the heart; 4: Inferior vena cava; 5: Ascending thoracic aorta, 6: Brachiocephalic truncus arteriosus (TABC), 7: Left common carotid artery, 8: Left subclavian artery; 9: Descending thoracic aorta.

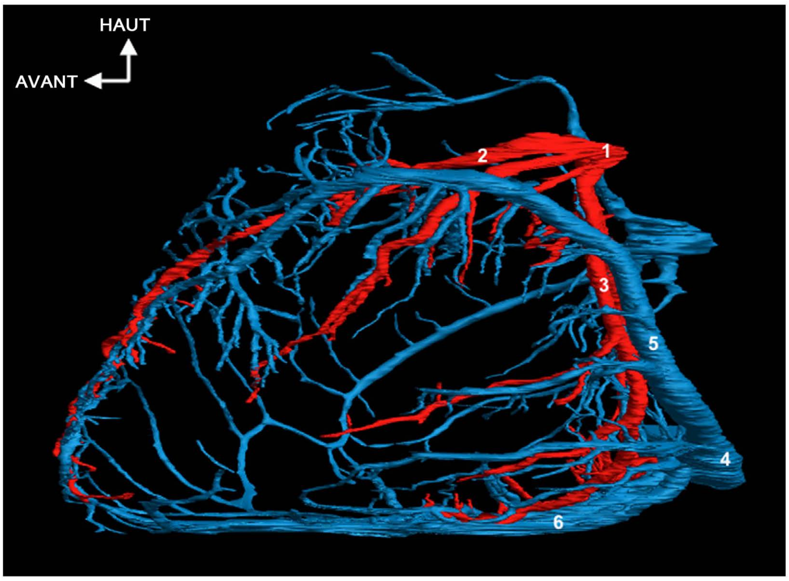

Figure 2. 3D reconstruction of the cardiac vasculature with Winsurf software. 1: Common trunk of the left coronary artery; 2: Anterior interventricular artery; 3: Circumflex artery; 4: Coronary sinus; 5: Large vein of the heart; 6: Middle vein of the heart.

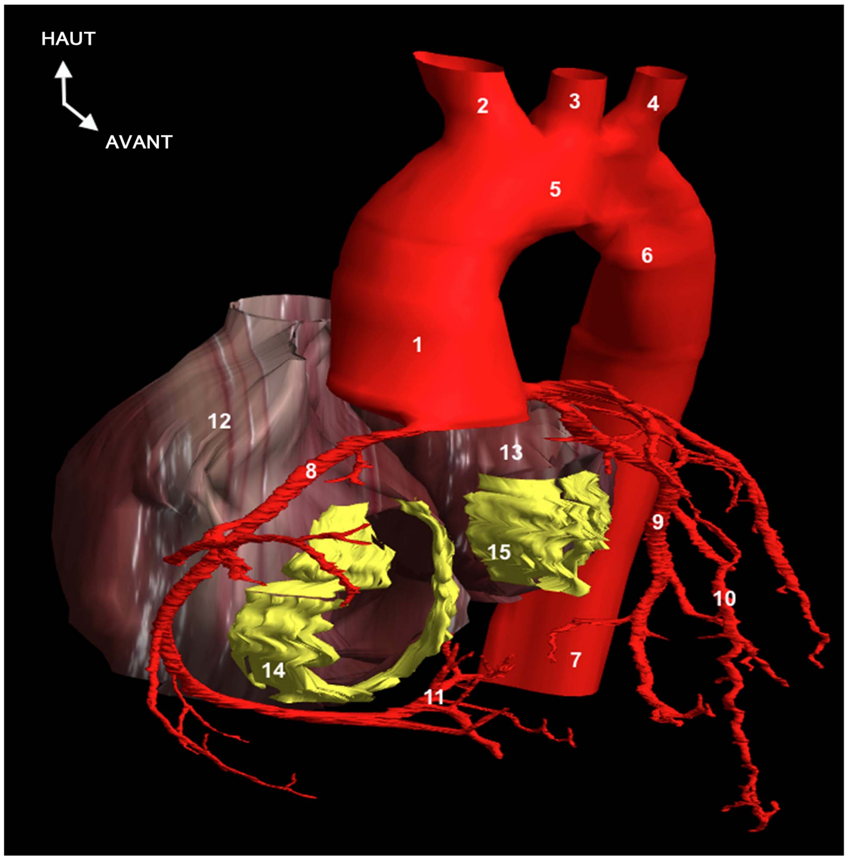

Figure 3. 3D reconstruction of the cardiac vasculature with Winsurf software. 1: Common trunk of the left coronary artery; 2: Anterior interventricular artery; 3: Circumflex artery; 4: Coronary sinus; 5: Large vein of the heart; 6: Middle vein of the heart.

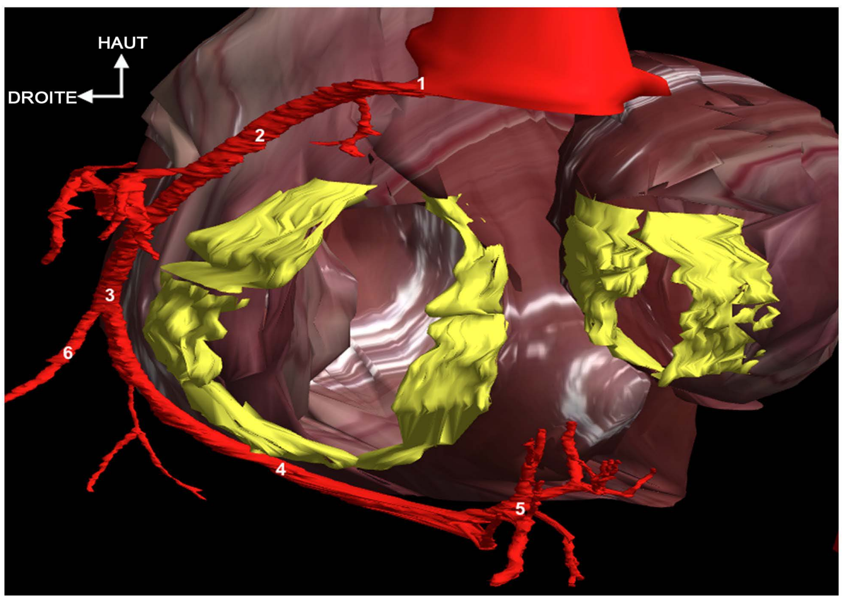

Figure 4. 3D reconstruction of the right coronary artery with Winsurf software. 1: Anterior Valsalva sinus (aortic root); 2: D1 (short, horizontal segment) of the right coronary artery; 3: D2 (long and vertical segment) of the right coronary artery; 4: D3 (long and horizontal segment) of the right coronary artery; 5: Cross of the Heart; 6: Marginal Artery.

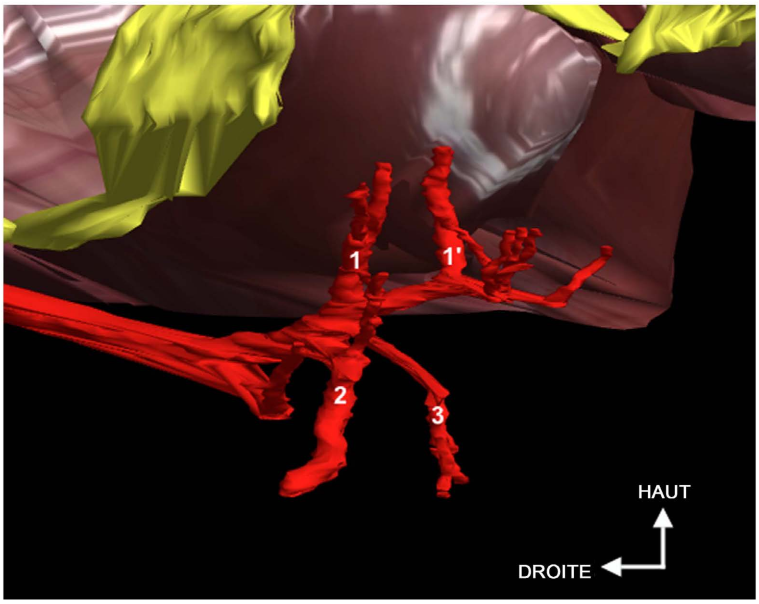

Figure 5. 3D reconstruction of the cross of the heart with Winsurf software. 1 + 1': Septal branches of the right coronary artery (vascularization of the sinus node; may be causing atrioventricular block if ischemic necrosis); 2: Posterior interventricular artery (PVI); 3: Left retroventricular artery (LVR).

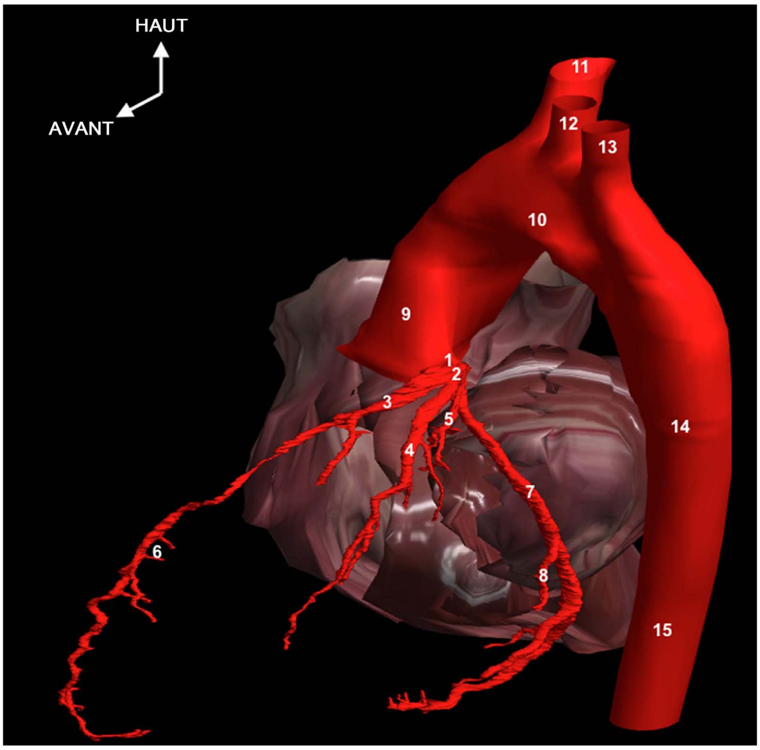

Figure 6. 3D reconstruction of the left coronary artery with Winsurf software. 1: Antero-left Valsalva sinus (aortic root); 2: Common trunk of the left coronary artery (short, 3 - 4 cm); 3: Anterior interventricular artery; 4: Diagonal Artery; 5: Bisector artery; 6: Septal branch; 7: Circumflex artery; 8: Marginal artery; 9: Ascending thoracic aorta; 10: Aortic Arch. 11; Brachiocephalic trunk arteriosus. 12: Left common carotid artery. 13: Left subclavian artery; 14: Isthmus de Staël; 15: Descending thoracic aorta.

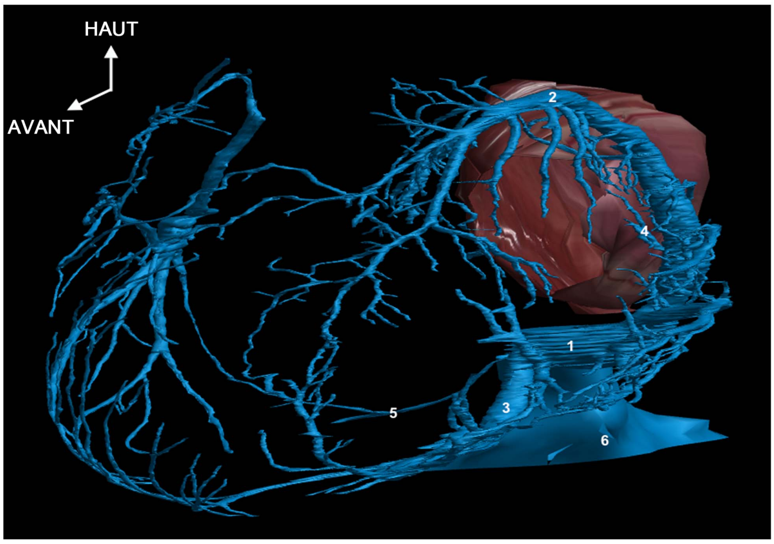

Figure 7. 3D reconstruction of the cardiac venous system with Winsurf software. 1: Coronary sinus; 2: Large vein of the heart; 3: Middle vein of the heart; 4: Oblique vein of the heart (Marshall's); 5: Small medium of the heart; 6: Inferior vena cava.

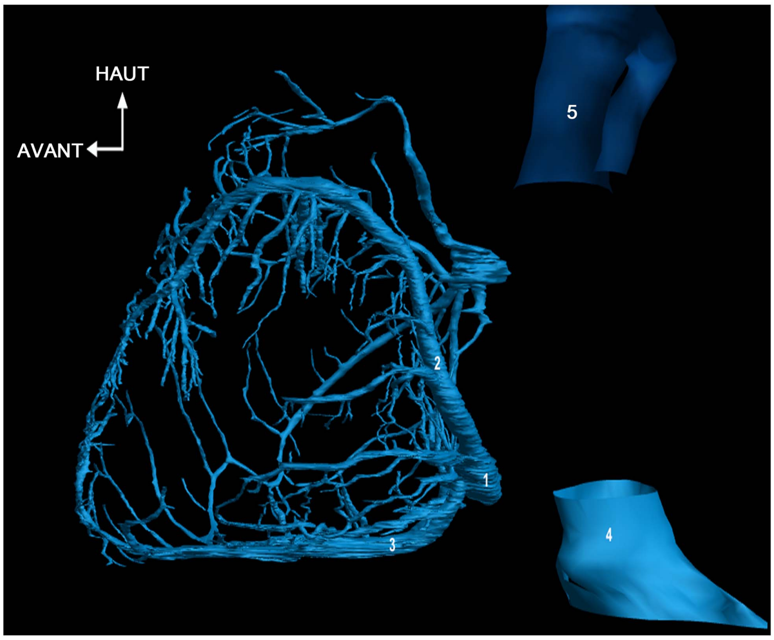

Figure 8. 3D reconstruction of the cardiac venous system with Winsurf software. 1: Coronary sinus; 2: Large vein of the heart; 3: Middle vein of the heart; 4: Inferior vena cava; 5: Superior vena cava.

In addition, it is fundamental to emphasize that this application is not restricted to the academic field but can also be the support of a "surgical training" thus allowing a continuous training of cardiovascular surgeons and a fortiori improvement of their skills in their daily practices.

The "Winsurf" and Acrobat 3D PDF software are easy to use, which is not the case with other 3D modeling and manual segmentation software. In addition, they offer quite a wide range of textures, which increases the realism that we can bring to our final work.

The main disadvantage of this software is the amount of work required to achieve the desired result. Indeed, this is a tedious contouring work of several days on more than 500 anatomical sections where sometimes only the analysis cut by section was possible.

In addition, there were the different objects that had to be created in order to be able to individualize the vascular apparatus, which increased tenfold the number of sections that had to be returned to each time; Not to mention the multiple collaterals and ramifications of the entire cardiovascular system, which together accounts for more than 50% of the time spent doing this work.

The second disadvantage relates to the contouring work itself: Indeed, the 3D reproduction of certain small anatomical entities was particularly complicated, and in particular that of the coronary vessels (especially the coronary arteries and their collaterals).

Indeed, the coronary arteries turned out to be of a smaller caliber than the veins and consequently despite the very high resolution of the sections, it was sometimes very difficult to follow them, especially during their journey through the thickness of the myocardium (septal branches +++).

It was also very difficult to obtain the final resolution as presented in the "RESULTS" section. Indeed, when contouring the coronary vessels is cut by section, for example, or when the number of points allocated to the object of interest is too large, the final result may be disappointing.

Indeed, the anatomical entities will have the appearance of a "pile of plates", which decreases the final resolution and would therefore call into question our goal of creating a 3D atlas for application in the academic and surgical fields.

Finally, it is necessary to point out that "Winsurf" offers a color palette containing 16 colors. When segmenting manually, it is imperative to change color each time a new collateral of a vessel appears, for example. This is clearly disabling when you are faced with a coronary artery or vein where the number of collaterals is considerable (which makes sense because they ensure the vascularization of the entire heart).

The main limitation of this study, which unfortunately is recurrent in any scientific study, is the great inter-individual variability. In the context of the cardiac system, this is essentially illustrated by the notion of coronary dominance.

In the general population, an average of 15% of cores are right-dominated, 15% left-dominated, and 70% have a balanced network.

This notion is fundamental to assimilate because in the context of ischemic necrosis such as an infarction affecting a particular area of the heart, the consequences will not be the same depending on the coronary dominance.

Indeed, from this point of view, the notion of infarction should be put into perspective: For example, left dominance with stenosis of the common trunk of the left coronary artery constitutes a surgical emergency, whereas for the same patient with right coronary stenosis, this stenosis would not be so urgent.

Our patient has a balanced coronary network but the ideal would be to take into account all possible scenarios, *i.e.* by modeling two other hearts in 3D, one predominantly left coronary and the other predominantly right. This would make it possible to scan all cardiac configurations that may be encountered in surgical practice.

As mentioned above, this concept is particularly useful in the context of surgical training. However, personalization for each patient is not possible.

The aim of this work is not to create a diagnostic or therapeutic tool (whose role of coronary angiography is indisputable) but to propose a 3D atlas for practical learning of medicine.

So, in a sense, it's a disadvantage without really being a disadvantage given the original purpose of this study.

Our 3D reconstruction of the coronary arteries is comparable to that performed by Uhl and collaborators at the Paris Descartes Laboratory of Computational and Clinical Anatomy [6].

5. Conclusion

Vascularization of the heart is a prerequisite for understanding the physiology and semiology of coronary heart failure. This reconstruction of the vessels of the heart is an educational tool that allows us to teach the vascularization of the heart. It could also be used as a 3D atlas for simulation purposes for training in coronary angioplasty and coronary artery bypass grafting procedures.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Rein, K.P. (2014) In Clinical Anatomy: Thorax-Abdomen. Maloine.

[2] Uhl, J.F., Mogorron, J., Chahim, M. (2021) The Virtual Dissection Table: A 3D Atlas of the Human Body Using Vectorial Modeling from Anatomical Slices. In: Uhl, J.F., Jorge, J., Lopes, D.S. and Campos, P.F., Eds., *Digital Anatomy. Human-Computer Interaction Series*, Springer, 103-120. https://doi.org/10.1007/978-3-030-61905-3_6

[3] Abdoulaye, K. (2019) 3D Reconstruction of the Anterior Region of the Neck from the Anatomical Sections of the Korean Visible Human at the Clinical and Digital Anatomy Laboratory of Paris Descartes. Science Thesis, 12.

[4] Ackerman, M.J. (1999) The Visible Human Project. *Academic Medicine*, **74**, 667-670. https://doi.org/10.1097/00001888-199906000-00012

[5] Cho, Z.H. (2009) 7.0 Tesla MRI Brain Atlas, *in Vivo* Atlas with Cryomacrotome Correlation. Springer.

[6] Uhl, J.F. (2016) Reconstruction Vectorielle 3D de Korean Visible Woman: Coeur et Coronaires. Paris Descartes, 29-36.