Journal of Clinical Trials
ISSN: 2167-0870

Alotaibi et al., J Clin Trials 2019, 9:6

Research Article Open Access

Cardioscope: A New Innovation for Visualization of Intracardiac Pathology

Amal Alotaibi, Ghannam Al Dossari and Patrick T Roughneen*

Department of Cardiovascular and Thoracic Surgery, University of Texas Medical Branch, Galveston, USA

***Corresponding author**: Patrick T Roughneen, Department of Cardiovascular and Thoracic Surgery, University of Texas Medical Branch, Galveston, USA, Tel: +14097721203; E-mail: ptroughn@utmb.edu

Received date: September 26, 2019; **Accepted date:** October 5, 2019 ; **Published date:** October 12, 2019

Abstract

Background: Since the conception of cardioscopy in the early 20th century, several attempts have been made to design the ideal cardioscope. We present a novel endoscopic technique providing direct visualization of intracardiac anatomy in a porcine heart and describe the use of cardioscopy as a diagnostic and therapeutic treatment to advance the treatment of cardiovascular disease.

Materials and Methods: Our model involves cardioscope access in a porcine heart utilizing carbon dioxide and normal saline, using a flexible endoscopy to visualize intracardiac anatomy. Purse strings were applied on both the right (right atrium and pulmonary artery) and left (aorta and left atrium) sides. The pulmonary veins, superior vena cava, and inferior vena cava were closed with 3-0 prolene sutures allowing the heart to fill with the normal saline and carbon dioxide. A flexible Olympus (Center Valley, PA, USA) bronchoscope was used, measuring approximately 5-6 mm in outside diameter, with the ability to flex 180 degrees and extend 120 degrees. The endoscope was inserted through the harvested porcine aorta and atrium, and carbon dioxide was utilized to inflate the heart.

Results: Transaortic approach: we were able to view the aortic valve, coronary orifices, papillary muscles, mitral valve, and left ventricle. Right atrial approach: the right atrial, tricuspid valve, papillary muscle, pulmonary valve, and right ventricle were visualized.

Conclusions: Cardioscopy has potential as a diagnostic and therapeutic technique. However, the design of the cardioscope needs innovation, including 360 degrees of rotational capacity, capability for therapeutic intervention, and improved optic visualization through blood utilizing digital subtraction technology.

Keywords: Biosimulator; Cardioscopy; Diagnostic technique; Therapeutic technique; Intracardiac anatomy

Introduction

The concept of cardioscopy, or endoscopy of the heart, dates back to the early 20th century with the development of the first cardioscope by Drs. Rhea and Walker in 1913 [1] and the first published article in 1922 by Drs. Allen and Graham [2] Since then, several attempts have been made to design the ideal cardioscope. However, cardioscopy has not advanced as rapidly as other forms of endoscopic surgery because of problems with visualization through blood within the beating heart [3].

During the last several years, there has been a revival of interest in cardioscopy, with increased interest in performing less invasive forms of cardiac surgery [4]. Despite early technological advancements in cardioscope visualization and flexibility, including the ability to see through blood in the beating heart, these advancements have yet to be refined and developed enough to make the cardioscope a viable diagnostic and therapeutic technology.

Previously, cardiologists and cardiac surgeons first learned the technical aspects of new devices in the operating room and/or catheterization laboratory. Now, with the development of new techniques in the rapid evolution of trans-catheter aortic valve replacement (TAVR) and aortic vascular stent grafts, it has become obvious that these new technological advancements would be aided by technology of real-time visualization such as cardioscopy and angioscopy.

In 2016 we began trials using a flexible endoscopy machine to visualize intracardiac anatomy. Our preliminary observations reported herein demonstrate the need for further technological innovations in cardioscopy and describe what such innovations should encompass.

Materials and Methods

Porcine hearts were harvested and utilized in the study. Purse strings were applied on both the right heart side (right atrium and pulmonary artery) and left heart side (aorta and left atrium). The pulmonary veins, the superior vena cava, and the inferior vena cava were closed with 3-0 prolene sutures to allow the heart to fill with the normal saline and carbon dioxide (CO2) (Figure 1). A flexible Olympus (Center Valley, PA, USA) bronchoscope was used. This endoscope had an outside diameter of approximately 5-6 mm, with the ability to flex 180 degrees and extend 120 degrees.

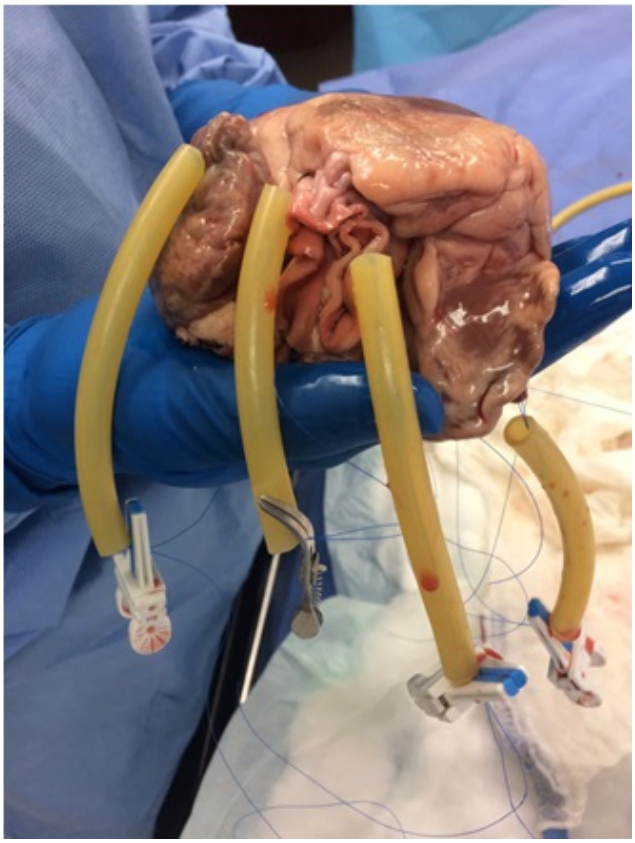

Figure 1: Purse strings were applied on both the right heart side (right atrium, pulmonary artery) and left heart side (aorta and left atrium). The pulmonary veins, SVC, and IVC were closed with 3-0 prolene sutures.

Results

Left Heart Axis Visualization

First Axis View: The endoscope was inserted through a purse string suture in the aortic artery, and CO2 was utilized to inflate the heart. Inflation pressure was kept between 12-20 mmHg. After insufflation, the aortic valve (AV) was visualized (Figure 2A, B) along with the left aortic cusp, the opening of the left main coronary artery, and division of the left anterior descending artery (LAD) and left circumflex artery (LCX) (Figure 2C, D, E, F). The right aortic cusp was visualized, but we could not visualize the right coronary artery (RCA).

The endoscope was advanced through the aortic valve to visualize the high trabeculations of the left ventricle (LV) with full flexion. Despite rotation and flexion of the 180-degree endoscope, it was not possible to see mitral valve (MV), although other areas in the LV were visualized.

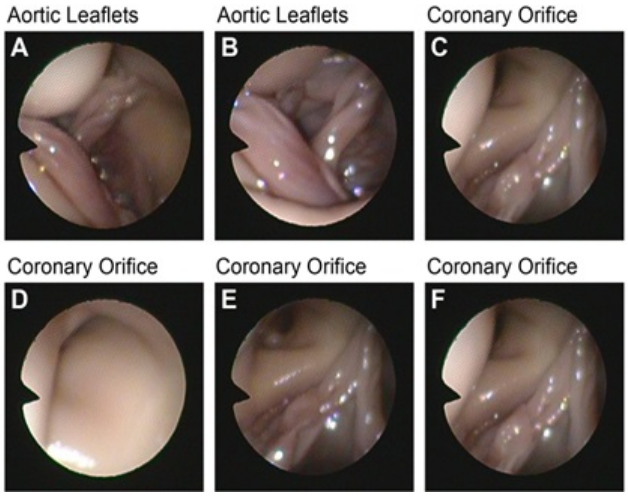

Figure 2: Visualization of the aortic valve: A-B aortic leaflets; C-F coronary orifice: left aortic cusp, the opening of the left main coronary artery, and division of the LAD and LCX.

Second Axis View: The endoscope camera was inserted into the left atrial appendage to visualize the left atrium (LA) and advanced to better visualize the mitral valve (MV) from this view (Figure 3A, B, C, D, E, F). Passing through the MV the high trabeculations (Figure 3A, C) of the LV were seen and the MV papillary muscles were visualized (Figure 3E).

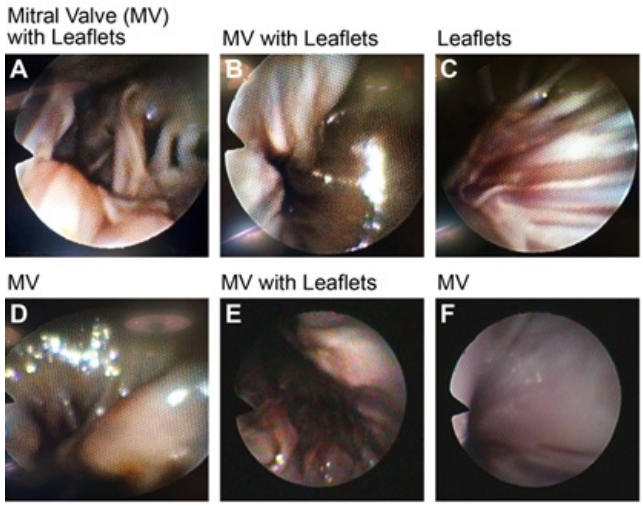

Figure 3: Visualization of the left atrium and mitral valve: A-B mitral valve with leaflets; C left ventricular high trabeculations; D, F mitral valve; E mitral valve papillary muscles.

Right Heart Axis Visualization

Third Axis View: The endoscope was advanced through the right atrium (RA) visualizing the right atrial appendage, RA, and the tricuspid valve (TV) (Figure 4A, B, C, D, E). Upon advancement through the TV, the trabeculations (Figure 4C, E) of the right ventricle

(RV) were seen, but limited flexibility of the camera resulted in difficulty visualizing the pulmonary artery from the RA.

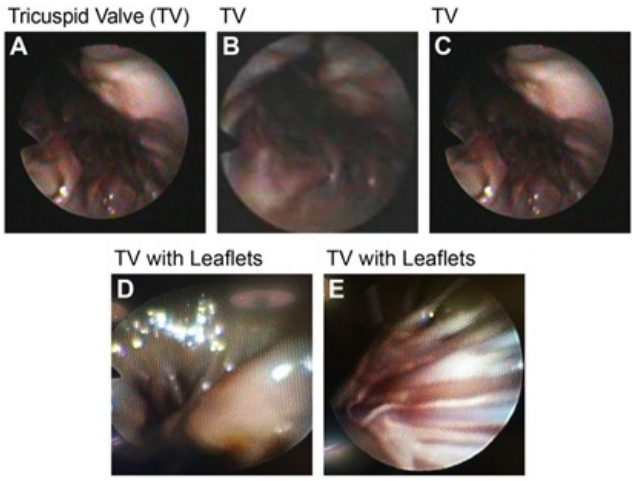

Figure 4: Visualization through the right atrium: A-E right aterial appendage, atrium, and tricuspid valve; C, E trabeculations of the right ventricle.

Fourth Axis View: The endoscope was advanced through the pulmonary artery to visualize the pulmonary valve (PV) and its cusps, and then advance through the PV to visualize the RV and its trabeculations. With flexion of the endoscope, the TV, chordae tendineae (Figure 5A, B), and leaflets were seen (Figure 5C).

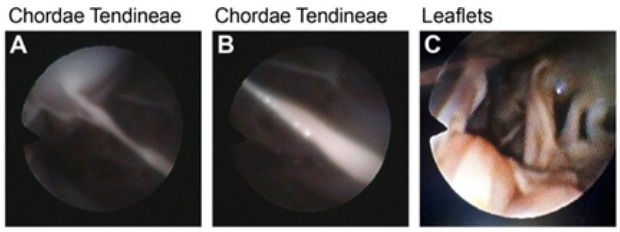

Figure 5: Visualization through the pulmonary artery: A-B tricuspid valve, chordae tendineae; C leaflets.

Discussion

Our preliminary studies demonstrated that the cardioscope can provide good visualization of intracardiac anatomy in a porcine heart. The study also demonstrated the need for specific design evaluated as necessary in the cardioscope in order to adequately and fully visualize intracardiac anatomy. The problem of visualization is the flexibility of the scope, especially when advanced through the right and left ventricles and associated great vessels, with the current limited rotation of 180 degrees. From our experience, this also conveys the need to develop an endoscope with 360 degrees of rotational capacity.

Researchers at the Georgia Institute of Technology have developed a mini camera with real-time, three-dimensional direct imaging of intracardiac anatomy with the capacity to produce 60 frames per second [5,6]. Other researchers developed a tiny camera-no bigger than a grain of salt-that can be fixed at the end of a catheter and inserted into a coronary artery to visualize plaque to be removed. In addition, 3-D printing was utilized to produce a complex optical lens system for medical imaging and real-time assessment of intravascular structure. The Avinger's Pantheris™ lumivascular atherectomy system device (San Diego, CA, USA) further expanded on these ideas to develop a therapeutic and diagnostic tool with direct visualization of intracardiac anatomy [5,7]. Additionally, Cardio-Optics Inc. (Wilmington, MA, USA) developed the Trans Blood Vision, an infrared endoscopic imaging system capable of visualizing cardiac structures through blood. This system utilizes pulsed laser emission from diodes operating at 1550 nm or 1820 nm and provides real-time images of blood flow and intravascular anatomy. However, as indicated earlier, results with visualization are preliminary at this time [7,8].

Some surgeons have reported on the clinical used of the cardioscopy technique to perform right heart surgery, especially with TV repair with cardiopulmonary bypass in a beating ovine heart model [9]. Other studies further evaluated a visualization technique for beating-heart intracardiac procedures by evaluating a novel cardioscope in the context of aortic paravalvular leaks (PVLs) localization and closure. The study showed limitations, including some variability in the PVL model and compatibility between PVL and the device itself [10].

Multiple surgeons have assessed the use of this biosimulator during artificial chordae implantations. This simulation platform recapitulates normal and pathological mitral valve function with associated hemodynamic changes. Clinical situations were replicated in the simulation with echocardiography used for navigation, followed by videoscopic confirmation, to help surgeons and cardiologists be trained on many transcatheter and beating heart procedures [11,12].

Conclusions

Cardioscopy has promise as a diagnostic and therapeutic technique. However, new innovations in the design of the cardioscope are needed. These innovations should include 360 degrees of rotational capacity and a side arm, capability for therapeutic intervention, and improved optic visualization through blood utilizing digital subtraction technology.

Ethical Statement

No ethical approval was required for this study. Porcine hearts were obtained from a local abattoir after slaughter. No living animals were used. No human data were collected and no patients were involved in the study.

References

1. Cutler E, Levine S, Beck C (1924) The surgical treatment of mitral stenosis: Experimental and clinical studies. Arch Surg 9:689-821.
2. Allen D, Graham E (1922) Intracardiac surgery-A new method: Preliminary report. Jama 79:1028-1030.
3. Murray G. A cardioscope (1950) Angiology 1:334-336.
4. Reuthebuch O, Roth M, Skwara W, Klovekorn WP, Bauer EP (1999) Cardioscopy: Potential applications and benefit in cardiac surgery. Eur J Cardiothorac Surg 15:824-829.
5. Gurun G, Tekes C, Zahorian J, Toby Xu, Sarp Satir et al.(2014) Single-chip CMUT-on-CMOS front-end system for real-time volumetric IVUS and ICE imaging. IEEE Trans Ultrason Ferroelectr Freq Control 61:239-250.

6. Mini camera films live 3D images from inside human blood vessels and heart. International Business Times, 2014
7. Camera-loaded catheter streams live from inside arteries, removes plaque at same time. New Atlas, 2016.
8. Tiny camera sees inside blood vessels. VOA News, 2015.
9. Umakanthan R, Ghanta RK, Rangaraj AT, Lawrence S. Lee, Rita G et al. (2009) Cardioscopic tricuspid valve repair in a beating ovine heart. Heart Surg Forum 12:90-94.
10. Rosa B, Machaidze Z, Mencattelli M, Sunil Manjila, Borami Shin et al. (2017) Cardioscopically Guided Beating Heart Surgery: Paravalvular Leak Repair. Ann Thorac Surg 104:1074-1079.
11. Conti V, Perez A (2018) When a simulation laboratory becomes essential. J Thorac Cardiovasc Surg 155:156.
12. Leopaldi AM, Wrobel K, Speziali G, van Tuijl S, Drasutiene A et al. (2018) The dynamic cardiac biosimulator: A method for training physicians in beating-heart mitral valve repair procedures. J Thorac Cardiovasc Surg 155:147-55.