Biomedical Imaging Technologies for Cardiovascular Disease - Volume II

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1. Introduction

Biomedical imaging innovation facilitates a better understanding of the heart’s physiology, performance, function, and structure. Furthermore, each imaging technique provides specific benefits for the diagnosis, treatment, and follow-up of cardiovascular diseases. Technological progress improves the precision, sensitivity, and accuracy of the specialized measurements needed for the assessment of complex conditions. This Editorial refers to the Special Issue, “Biomedical Imaging Technologies for Cardiovascular Disease–Volume II”. Seventeen manuscripts were taken into consideration for this Special Issue, all of which underwent a rigorous peer-review process. A total of eleven original articles and six reviews were published.

2. Overview of Original Articles

Transcatheter interventions have become a valuable therapeutic alternative for the treatment of valvular diseases and are often preferred over surgical replacement by patients with severe symptomatic valve disease. Transcatheter aortic valve replacement has emerged, has been widely assessed, and has become a well-established option [1]. As the procedure has gained maturity, it has been assessed for mitral and pulmonary valve replacement. In this Special Issue, Contribution #1 aimed to demonstrate the feasibility and accuracy of 4D cardiac computed tomography (CT) segmentations to conduct a landing zone analysis for the perioperative evaluation of transcatheter pulmonary valve replacement. Determining the optimal delivery is especially important for patients with a history of congenital heart defects, as their anatomy is often altered due to the multiple surgeries they undergo during infancy. One major innovation of transcatheter procedures was their minimally invasive nature. The surgical management of the mitral valve has also evolved into minimally invasive strategies. The authors of Contribution #2 aimed to analyze and report their experience in treating mitral annular calcification via minimally invasive mini-thoracotomy. This study also suggests widening the inclusion selection to include mild-to-severe mitral calcification patients, instead of only severe cases, given the low perioperative mortality reported. However, a recent study performed a risk analysis for this procedure on the mitral valve. The authors highlighted the need for safety surveillance during the learning curve of the surgery program [2]. CT angiography has also demonstrated success for peripherical arterial disease detection and diagnosis. Contribution #3 assessed this approach in 40 patients. The authors’ findings demonstrated good reliability for the detection and diagnosis of peripherical arterial disease. Multi-imaging approaches have been demonstrated to facilitate complex cardiovascular surgical procedures. In many situations, previous animal testing is required to assess the effectiveness of the...
procedure. Contribution #4 aimed to demonstrate the safety, reproducibility, and accuracy of a real-time cross-imaging fusion guide–image to minimize the risk of transjugular intrahepatic portosystemic shunts in an animal protocol. The authors suggested the potential usefulness of this approach in both emergency and non-emergency clinical contexts.

Cardiac magnetic resonance (CMR) is widely used for a more detailed assessment of cardiovascular diseases. Its non-ionizing nature facilitates the clinical follow-up of patients without radiation and can often overcome limitations of Doppler ultrasound. More recently, CMR has been used for the imaging of atrial fibrillation (AF) prior to cardiac ablation [3]. Several comorbidities have been associated with the redevelopment and persistence of AF after an ablation procedure. Obesity has been identified as a well-established risk factor for AF. Contribution #5 aimed to determine the factors influencing cardiac fat deposition and its impact on heart function and AF recurrence. Obesity was associated with increased cardiac fat deposition. Biological sex was a determinant of fat deposition locations in the heart, leading to reduced cardiac function. Several questions remained open regarding the association of obesity and cardiac fat deposition with electrical remodeling, left atrial scar location, and impaired hemodynamics. CMR allows for the comprehensive evaluation of blood hemodynamics using 4D flow MRI [4]. This advanced flow imaging technique is typically acquired using a single range of velocities, which is also referred to as single velocity encoding. Recently, dual- and multi-velocity encoding sequences were developed to increase the sampling accuracy range of 4D flow [5,6]. Contribution #6 aimed to investigate the feasibility and added value of dual-velocity 4D flow encoding to assess complex flow patterns in patients with type B aortic dissection. The authors recommended the use of highly accelerated approaches, using compressed sensing instead of accelerated parallel imaging, given the time cost of the acquisition. The usefulness of 4D flow MRI in congenital cases has been demonstrated in multiple studies. The 4D flow recommendations for congenital diseases highlight several of its applications [4]. Contribution #7 explored the capacity of 4D flow MRI for quantifying blood flow turbulence in Tetralogy of Fallot patients, a common congenital disease. The authors aimed to compare the level of turbulence in repaired Tetralogy of Fallot patients versus healthy controls. Turbulence was found to be abnormally elevated in these patients. However, the clinical value of this turbulence remains to be demonstrated.

Myocardial perfusion imaging has been proven useful in identifying coronary artery disease [7]. Contribution #8 proposed an attention-based feature-fusion VGG19 network for the detection of coronary artery disease using 486 patient records. This network demonstrated a high agreement with expert diagnosis and illustrated the potential of artificial intelligence tools in supporting clinical diagnosis. Similarly, Contribution #9 introduced a deep learning approach based on deep fuzzy cognitive maps to diagnose coronary artery disease. These innovative works illustrate the practical applications and the potential impact on daily clinical practice.

Doppler ultrasound is by far the most accessible imaging tool used in clinical practice. Contribution #10 used Doppler echocardiography to conduct a serial study monitoring the performance of dexamethasone therapy in premature neonates. Their findings demonstrated that the therapeutic strategy improved the respiratory status of patients as well as their heart function. Device innovation is also an important component of the health care system in improving patient management. Contribution #11 highlights a dedicated device development for arterial embolization. The caterpillar device was demonstrated to be safe and efficient in performing arterial occlusions in this pilot study.

3. Overview of Review Articles

Review articles effectively summarize and contextualize the state-of-the-art in a specialized topic. In this Special Issue, six review articles were included. Contribution #12 provides a comprehensive review for understanding the role of CT in the planning of transcatheter structural heart interventions. It highlights the most important benefits and drawbacks of CT for this procedure. Contribution #13 also provides an important overview
of the use of calcium scores obtained by CT. This manuscript also illustrates other useful aspects of CT for the assessment of cardiovascular risk. Animal models are often used to test multiple scenarios that cannot be tested in humans. Contribution #14 emphasizes the relevance of canine models to assess cardiac dysfunction. It also highlights the importance of translational research in both veterinary and human studies. Late gadolinium enhancement can facilitate the assessment of fibrosis in the left atrium. Contribution #15 provides a complete revision of the current strategies for the assessment of cardiac arrhythmias and ablation procedures, along with fibrosis quantification. Takotsubo cardiomyopathy is a temporary heart condition that develops in response to an intense emotional or physical event. Contribution #16 revisits the strategies from cardiac nuclear imaging in identifying atypical variants of Takotsubo cardiomyopathy. Finally, Contribution #17 reviews the assessment of cardiovascular disease and progressive kidney failure.

Conflicts of Interest: The authors declare no conflicts of interest.

List of Contributions


References


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