H-S01

The Utility of Non-invasive Myocardial Work Analysis in Clinical Practice

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Cardiac pressure volume loop analysis provides detailed information of cardiac function and is the gold standard for assessment of cardiac function. However, pressure volume loop analysis is an invasive and time-consuming method, preventing it from widely use in clinical practice. Left ventricular ejection fraction and global longitudinal strain are two commonly measures for of left ventricular systolic function, do not take dynamic LV pressure change during systole into account and hence fail to describe LV function as a hydraulic pump. Recently, LV pressure-strain analysis has been introduced as a new technique to assess myocardial work non-invasively based on two-dimensional speckle tracking strain analysis. This new method displays novel insights in comparison to invasive methods and has been validated in different cardiac pathologies. Non-invasive assessment of myocardial work may play a major role in diagnosis, guiding therapies, and predicting prognosis. However, its incremental value in comparison to traditional echocardiographic parameters remains uncertain. This review aims to provide an overview of current applications and potential use of non-invasive myocardial work assessment by pressure-strain analysis.

H-S02

Predicting Cardiovascular Disease Prognosis from Echocardiography Big Datasets by Machine Learning

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Using machine learning algorithms for big medical record data analysis by machine learning and deep learning is a logical step to predict patient's clinical prognosis and outcomes. In this study, we analysis of aortic stenosis patients during 2014 to 2016. Echocardiography measurement data were retrieved from the structure reports server. Matched laboratory data were also collected. These patients were divided into four groups, namely Group 1: Transcatheter aortic valve implantation (TAVI); Group 2: Conservative treatment with medication control; Group 3: Surgical aortic valve replacement (SAVR); Group 4: No treatment was performed. Evaluation and optimization of models to predict which types of patients receive which valve interventions are most beneficial to the overall structure, function and prognosis of the patient's heart. After the clinical data is divided into 9 categories, both unsupervised and supervised learnings are uses to train the best feasible model based on training data. Unsupervised and supervised learnings use 7 and 2 algorithms, respectively, through recursive features to eliminate and filter important features out. The judgement based on the model accuracy for supervised learning and the comparison of four different features' impact on accuracy for unsupervised learning. The highest accuracy for supervised learning is 1, while the highest accuracy of the unsupervised model is about 0.44. The accuracy of feature selection is not much different from the original data. This study shows the XG Boost algorithm possess the highest accuracy.

H-S03

The Performance of Transesophageal Echocardiographic Screening for Structural Heart Intervention

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Transcatheter intervention for structural heart diseases is one of the most important era in the modern cardiology. Traditionally, we could only treat such patients by open-heart surgery. Despite

surgical treatment is direct and effective, peri-operative risks of complications are relatively high, and some patients are too fragile to receive that. To reduce the incidence of the adverse events, transcatheter intervention for the structural heart diseases is developed.

Generally, treating patients with structural heart diseases by transcatheter techniques has some strengths: safer, less operating time, and faster post-procedural recovery. With the improvement of medical technology, some transcatheter interventions are equally effective to the traditional surgeries. However, to perform the interventions, we need accurate cardiac images for comprehensive pre-procedural plans. Echocardiography is one the most important tools.

Transthoracic echocardiography is a convenient, non-invasive, safe, and effective imaging tool. Transesophageal echocardiography is invasive, but possesses greater power in evaluating the left-heart structures, and is the main guidance during the procedures. In the recent decades, the advances of echocardiography beyond the imagination of the most physicians. Three-dimensional echocardiography plays the essential role in the interventions, and all interventional echocardiographers need to be familiar with this technique.

In today's speech, we'll review the importance points of echocardiography in the pre-procedural evaluation for the often-seen transcatheter interventions, such as left atrial appendage closure, edge-to-edge mitral valve repair, and aortic valve replacement.

H-S04

Practical Echocardiography for Patients with Ventricular Assist Device

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In patients with advanced heart failure (HF) refractory to medical therapy, LVADs have been used as a bridge to transplantation (BTT), as destination therapy (DT), as a bridge to transplant candidacy, or as abridge to recovery. Recent guidelines endorse the important role of echocardiography in the clinical care of LVAD patients at several stages, including preoperative patient selection, perioperative imaging, postoperative surveillance, optimization of LVAD function, troubleshooting of LVAD alarms, and evaluation of native myocardial recovery.

Despite increasing clinical use of LVADs, recognition of the central role of echocardiography in their management, and presentation of an exponentially expanding outpatient LVAD population to healthcare facilities not directly associated with implantation centers, there is a lack of published guidelines for echocardiography of LVAD recipients. Although numerous types of LVADs are in clinical use or under development, the scope of this document is primarily limited to current surgically implanted CF-LVADs that have been approved by the United States Food and Drug Administration (FDA) for extended use in adults. Surgically implanted LVADs for short-term use, percutaneously implanted LVADs, right ventricular (RV) assist devices (RVADs), and/or biventricular assist devices (BiVADs) may also be encountered by echocardiographers.

Echocardiography is important in the management of LVAD patients. Guidance about when and how to perform echocardiography in these patients has previously been lacking. In the literature, there is growing support for specific echocardiography parameters that may constitute contraindications or precautions before LVAD surgery. During and after LVAD implantation, one may use perioperative TEE and TTE/TEE, respectively, to confirm normal versus abnormal device function and to determine whether or not the native heart is responding to LVAD support as expected. For organizing these recommendations, we have used a phase of care approach, which includes (1) preoperative assessment, (2) perioperative TEE, (3) postoperative surveillance echocardiography, (4) postoperative problem-focused echocardiography, and (5) recovery protocols.

H-S05

AI in Echocardiography: Human Learning vs Machine Learning

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Artificial Intelligence (AI) is now an emerging technology. Since its initial appearance in 1950's, current AI technology is still advancing gradually. The bioinformatic technology usually involves. From the developmental milestone of AI, it could be deducted that machine learning is no double the core content of current AI technology. With machine learning, the diverse technologies such as computer science, probability, and statistics…. etc. is incorporated into a complex process. It is this complex process that machine can learn.

With more development of machine learning, a multi-layer convolutional machine learning mechanism – Neuronet -- was developed and was further considered to be "Deep Learning".

At present time, machine learning including deep learning may be considered to mimic conventional human learning. Although the actual process may be different.

However, the output of machine learning may be like conventional human learning. This is an interesting deduction because philosophically, people may double that whether the machine-learning derived AI will override human experience? Although currently, there is no evidence that AI may surpass conventional human learning. We may use an intermediate attitude to view the potential role pf AI in the present and in the future time. We, as human beings, are still the teacher of machine and thus machine learning is under the instruction of human beings. However, this attitude may be changed in the future and we should be aware of it.

In the past several years, I have been developed myself to the development of AI application in sonography including echocardiography. In the process of development of AI application in sonography and echocardiography, my experience is that in this stage of AI development, human participation is un-avoidably involved in the process. Not only the heavy involvement of human participation, but also frequent participation is devoted to its development. My experience is as the old proverb "Only root down will bring up fruits"!

H-S06

Clinical Applications of Contrast Echocardiography

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Ultrasonic contrast agent is a kind of microbubble that can be covered by a shell of biodegradable material. The diameter of the microbubble is several microns. It is coated with fluorocarbons, which can be decomposed by organisms and is non-toxic and not easy to cause immune reactions. It has high biocompatibility, and the coated fluorocarbons are more stable than other gases, and can prolong time of microbubbles decomposition to achieve the effect of prolonging the contrast enhancement of the image.

Because its diameter is less than 10 microns, it can flow through the pulmonary circulation into the left atrium and left ventricle to achieve the purpose of cardiac imaging. The current applications of ultrasound contrast agents in the cardiac field include ventricular imaging, differential diagnosis of cardiac structural abnormalities, enhanced Doppler signal, and myocardial imaging. Cathay General Hospital has introduced ultrasound contrast agent as an auxiliary tool for cardiac ultrasound examination to provide solutions for patients with poor cardiac ultrasound images. The use of ultrasound contrast agent can more accurately assess the function of the heart and whether there is a myocardial contractility abnormality. The differential diagnosis of cardiac tumors and ventricular thrombus is the strength of ultrasound contrast agents. At the same time, it also provides a good reference for the evaluation of

ventricular rupture, ventricular aneurysm and ventricular pseudoaneurysm formation in patients after myocardial infarction. It can also improve the detection rate of coronary artery disease during the examination. At present, the indications opened by the Ministry of Health and Welfare are that for adult patients with poor cardiac ultrasound imaging, the left ventricular cavity can be visualized and the contour of the left ventricular endocardium can be improved. This examination is a self-funded project and is currently actively applying for health insurance benefits.

The consensus on ultrasound contrast agents is that ultrasound contrast agents are quite safe dosage forms in the world, with an allergic reaction rate of about 1 in 10,000, and ultrasound contrast agents have no nephrotoxicity, and are used in patients with poor renal function. can also be used.

H-F01

The Role of Exclusive Trans-Esophageal Echocardiography to guide Minimal-Fluoroscopic Catheter Visualization & Trans-Septal Puncture during Cardiac Ablation

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Background: Efforts to reduce radiation exposure during cardiac intervention can benefit patients & physicians tremendously. Nowadays the combination of intra-cardiac echocardiography (ICE) and 3D electro-anatomical mapping can aid minimal/non-fluroscopic cathter ablation effectively. However, ICE has the main disadvantage of higher cost due to non-reusable and hence it's not available for patients without healthy insurance coverage. To our knowledge, there is no specific alternatives reported. Therefore, we aim to investigated the role of trans-esophageal echocardiography(TEE) on non-fluoroscopic method of cardiac intervention.

Methods: Between Aug. 2019 and Feb. 2021, a total of 11 patients underwent TEE for guiding non-fluoroscopic atrial fibrillation catheter ablation were included. Under general anesthesia, TEE was performed for pre-ablation LAA thrombus and evaluation of the feasibility of catheter position and trans-septal puncture guiding. In this cohort (60.9 ± 10.39years; 4 men 7 women; left ventricular ejection fraction 66.5 ± 12.9%). We designed a step-by-step TEE acquisition protocol compatible with the need of catheter ablation procedure.

Complication events were recorded as pericardial effusion post procedure, IAS dissection, aorta puncture through, and LA posterior wall puncture through.

Results: The acquisition steps and its successful rate was as following: The corresponding TEE probe level and angle was summerized in tables and presenting as figures.

Step 1: Preablation LAA thrombus detection, LAA empty velocity (11/11)

Step 2: CS orifice (for CS catheter advancement) (6/6)

Step 3: Sheath introduction along with guidewire into SVC (avoid wire into RAA) (11/11)

Step 4: Sheath pulldown from SVC after Brockenbrough needle insertion (11/11)

Step 5: Transseptal tenting at inferior, toward anterior (11/11)

Step 6: Advanced transseptal sheath into LA (toward LSPV, avoid into LAA) (10/11)

Step 7: J-tip wire into LSPV (8/11)

Step 8: Cryoballoon engagement of 4 pulmonary veins (0/1)

Total Fluoroscopic time: 0 mins . Complication event was 0/11.

Conclusion: The application of TEE-guided minimal/non -fluoroscopic catheter ablation enables safe, consistent and successful outcome in routine clinical practice. The pre-existing septal occluder in situ may interfere with trans-septal needle tip visualization. By now, we still need more practice using exclusive TEE-guide for cryoballoon ablation.

H-F02

Phenotypes of Functional Mitral Regurgitation Using a Novel Morphological Definition and Determinants of Outcomes

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Background: Conflict results from large MitraClip randomized trials in France and US had sparked interests on studies of functional mitral regurgitation (FMR), challenged our preconceived perspectives of FMR and suggested that we knew little about FMR. Yogesh et al therefore proposed a new classification of 3 FMR-phenotypes based on morphological characteristics: ventricular FMR (VFMR), atrial FMR (AFMR) and ischemic FMR (IFMR); yet, outcome data and treatment implications are lacking. Therefore, we aim to examine the presentation and outcomes of 3 phenotypes of FMR herein.

Method: We included 169 consecutive patients with isolated chronic moderate-to-severe and severe FMR without other ≥moderate left-sided valvular heart disease or prior mitral-valve (MV) surgery between 2012-2014 from a tertiary referral center. All transthoracic echocardiograms were de novo reviewed and FMR classified into 3 phenotypes proposed by Yogesh et al.

Results: There were 100 VFMR (59%, 68±15 years, 41% female), 42 AFMR (25%, 73±11 years, 71% female) and 27 IFMR (16%, 68±15 years, 44% female) patients. As compared to VFMR and IFMR, AFMR-patients were female-predominant, had more atrial-fibrillation, smaller left ventricular (LV) end-diastolic dimension and LV end-systolic dimension, larger LV ejection fraction (LVEF), larger left atrial volume, larger mitral annulus and higher right-ventricular fractional area change (RV-FAC) (all $P \leq 0.05$). After a median follow-up of 2.6 (interquartile-range: 0.4-7.6) years, 54 (32%) patients died and 23 (14%) had MV-surgery or heart transplantation. Univariately, older age, larger MR vena-contracta (VC), lower LVEF, lower RV-FAC and female-sex were predictive of death (all $P \leq 0.03$). In multivariate analysis, older age, larger VC and lower RVFAC were independently predicted of death (all $P \leq 0.03$). Kaplan-Meier survival curves showed that AFMR had a trend toward better survival while IFMR had worse survival ($P = 0.11$). MV-surgery seems to be protective (hazard-ratio, 0.63; $P = 0.11$).

Conclusion: To the best of our knowledge, this is the first FMR study in the world using a newly-proposed classification with outcome-data. It seems that AFMR had the best survival; yet IFMR had worse survival. Interestingly, RV-function and the severity of FMR played an important role in prognosis rather than LVEF per se. These results suggest that FMR quantification and RV function evaluation merit re-emphasizing and may have potential therapeutic implications regarding selection of appropriate candidates for MitraClip.

H-F03

Association of Echocardiographic Parameter E/e' with Cardiovascular Events in A Diverse Population of Inpatients and Outpatients with and without Cardiac Diseases and Risk Factors

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Background: The echocardiographic parameter E/e' has been associated with cardiovascular (CV) events. However, few studies have analyzed multiple associated CV outcomes using E/e' in a diverse population of both inpatients and outpatients with and without cardiac diseases and risk factors.

Methods: Medical records of 75,393 patients without atrial fibrillation (AF) with first available E/e' were retrieved from our hospital database. Patients with mitral valve disease were excluded and the remainder were studied in Protocol 1 (70,819 patients). Patients with hypertension, diabetes mellitus, hyperlipidemia, CV diseases, prior CV events, CV surgeries, and left ventricular ejection fraction (LVEF) <50% or missing LVEF were further excluded and the remaining patients were studied in Protocol 2 (14,665 patients). The study outcomes are major adverse cardiovascular events (MACE), which included myocardial infarction (MI), atrial fibrillation (AF), ischemic and hemorrhagic stroke (IHS), hospitalization for heart failure (HHF) and cardiac death. The primary outcome were MACE and each of the MACE components.

Results: At the end of maximal 5-year follow-up (median 22.18 months with interquartile range [IQR] 7.20-49.08 months for MACE in Protocol 1, and 23.46 months with IQR 8.15-49.02 months for MACE in Protocol 2), compared with an E/e' value of <8, an intermediate value of E/e' 8-15 and a high value of E/e' >15 were significantly associated with MACE, MI, AF, IHS, HHF, and cardiac death in Protocol 1 (all p <.0001). In Protocol 2, an intermediate E/e' value of 8-15 and a high value of E/e' value >15 were significantly associated with MACE, MI, AF, IHS, HHF, and CV death (all p <.05), except an intermediate value E/e' 8-15 was not associated with AF.

Conclusion: In a diverse population of inpatients and outpatients with and without cardiac diseases and risk factors, the echocardiographic parameter E/e' was associated with cardiovascular events and a useful a marker of risk.

H-F04

Effects of Post-systolic Shortening and Diastolic Dyssynchrony on Myocardial Work in Untreated Early Hypertension Patients

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Background: Myocardial work is estimated from non-invasive pressure-strain loop for advanced assessment of left ventricular function. Post-systolic shortening and diastolic dyssynchrony of left ventricle were noted early in hypertension. Their novel effects on myocardial work will be illustrated in this study.

Material and Methods: We recruited 43 consecutive patients (mean age 51.3 ± 11.5 years, 55.8% men) with newly diagnosed hypertension. Pressure-strain loop derived myocardial work incorporated global longitudinal strain from speckle tracking echocardiography with brachial artery cuff pressure. Post-systolic strain index (PSI) was defined by the percentage of post-systolic shortening over peak strain. Diastolic dyssynchrony was assessed by standard deviation of time to peak early diastolic strain rate (TDSr-SD) of 18 segments, and maximal difference of time to peak early diastolic strain rate (TDSr-MD) between any 2 segments.

Results: After multivariate regression analysis, global myocardial work index was independently correlated with TDSr-SD (B = -0.498, p = 0.001) and

TDSr-MD (B = -0.513, p = 0.001). Global myocardial work efficiency was independently correlated with glucose (B = -0.494, p<0.001) and PSI (B = -0.315, p = 0.009). Global myocardial constructive work was independently correlated with TDSr-SD (B = -0.334, p = 0.025) and TDSr-MD (B = -0.397, p = 0.007). Global myocardial wasted work was independently correlated with glucose (B = 0.419, p = 0.006) and PSI (B = 0.358, p = 0.019).

Conclusions: In conclusion, the effect of diastolic dyssynchrony mainly influenced constructive work, while post-systolic shortening affected wasted work in early untreated hypertension.

H-F05

Mid-term Outcome of Left Ventricular Myocardial Work in Bradycardia Patients with Left Bundle Branch Pacing

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Background: Right ventricular pacing (RVP) caused left ventricular (LV) mechanical dyssynchrony. Left bundle branch pacing (LBBP) is an emerging physiological pacing modality. LV myocardial work (MW) incorporates afterload and LV global longitudinal strain to estimate global and segmental myocardial contractility. However, LBBP on LV MW remains unknown. This study aimed to evaluate the impact of LBBP on LV MW in patients receiving pacemaker for bradyarrhythmia.

Methods: We prospectively enrolled 70 bradycardia patients with normal LV systolic function receiving LBBP (n = 46) and His-bundle pacing (HBP) (n = 24). For comparative analysis, patients receiving RVP (n = 16) and control subjects (n = 10) were enrolled. Two-dimensional speckle tracking echocardiography was performed. The LV pressure-strain loop was non-invasively obtained to assess global LV MW.

Results: After 6-month follow-up, during synchronized ventricular pacing, LBBP group (with >40% ventricular pacing during 6 months) had shorter septal-to-posterior wall motion delay, shorter peak strain dispersion, shorter difference of tissue Doppler between LV and interventricular septum, and higher LV global longitudinal strain compared with RVP group, but had no difference in left intraventricular mechanical dyssynchrony compared to HBP group. During ventricular pacing, LBBP group had shorter LV pre-ejection period and shorter interventricular mechanical delay compared with RVP group. During ventricular pacing, LBBP group had higher global MW index (GWI), higher global constructive work (GCW), lower global wasted work (GWW) and higher global MW efficiency (GWE) compared with RVP group, and had lower GWW and higher GWE compared with HBP group.

Conclusions: After 6-month of >40% ventricular pacing burden, LBBP had less left intraventricular mechanical dyssynchrony during ventricular pacing compared with RVP, had better LV MW parameters (GWI, GWW and GWE) during ventricular pacing compared with RVP, and had better LV MW parameters (GWW and GWE) during ventricular pacing compared with HBP.

H-F06

Deep Learning with Long Short-term Memory Networks for Predicting Response to Cardiac Resynchronization Therapy

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Background: We tested the hypothesis that a deep learning algorithm with long short-term memory (LSTM) networks utilizing left ventricular (LV) strain would be able to identify cardiac resynchronization therapy (CRT) responders.

Methods: We studied 131 patients receiving CRT. LV longitudinal speckle-tracking strain traces from apical four-chamber (A4CH), apical two-chamber, and apical long-axis views were used for data preprocessing. Data were split into training (n=100) and testing (n=31) samples. We first constructed four LSTM scoring models for producing the confidence score. To optimize prediction accuracy-specifically, to improve the accuracy of the confidence score-we combined the stacking ensemble learning (EL) method with LSTM (here after referred to as the EL-LSTM method).

The EL-LSTM model was compared with LSTM models established using traditional machine learning (ML) methods in terms of their power to predict CRT response. This response was defined as a reduction in the LV end-systolic volume of ≥15% after 6monthsof CRT.

Results: The A4CH LSTM scoring model outperformed the other LSTM scoring models in prediction performance. The EL-LSTM model not only outscored the five representative ML methods on the nine evaluation indices but also exhibited the highest prediction accuracy (>90%) of all the LSTM scoring models.

Conclusions: Modeling under the EL-LSTM method, involving the use of longitudinal strain traces from the three apical views, enables the identification of CRT responders.