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Cardiovascular Imaging for Investigation of Cardiovascular Diseases

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Abstract

Recent research in functional magnetic resonance imaging (fMRI) and nuclear imaging techniques have become quite important in the diagnosis of neurological diseases, psychological disorders, apart from pathophysiology of atherosclerosis processes and vulnerable plaques. Further research indicate that 3-dimensional echocardiography (3D-Echo) and multi-detector-row computed tomography have improved our capability to know more about heart disease in the valves as well as athero-thrombotic plaque in acute coronary syndrome (ACS). Recently, several studies have demonstrated that chronic anxiety disorders may be risk factors of cardiovascular diseases (CVDs) and diabetes which is associated tremors in the amygdala. Physiological imaging of brain by functional magnetic resonance imaging (fMRI) allows us to examine brain structures in presence of CVDs and behavioral risk factors. Most of the behavioral risk factors may have autonomic nervous system dysfunction with rise in the sympathetic activity, which brings about increased catecholamines and cortisol, oxidative stress, and hyperglycemia, and may be pro-inflammatory. Rise in parasympathetic activity related to vagal nerve stimulation may be associated with increased release of acetylcholine, a precursor of nitric oxide which is anti-inflammatory. Yoga therapy, meditation, and active prayer can reduce the severity of sympathetic activity and increase the parasympathetic activity leading to decline in risk of metabolic syndrome, high blood pressure and blood glucose, as well as pro-inflammatory cytokines.

Keywords: *Echocardiography; Acute Myocardial Infarction; Coronary Diseases; Early Diagnosis*

There is evidence that fMRI and Positron emission tomography (PET) are important modalities for visualization of neurons, cardiomyocytes and the vascular cells. Recently, World Heart Journal has published an editorial on recent advances on cardiovascular imaging [1-3]. Further studies indicate that, neuroimaging may be used to examine live brain dysfunction which can predispose athero-thrombosis resulting in to acute myocardial infarction. Although advances in cardiac magnetic resonance imaging and nuclear imaging techniques are becoming quite important in the diagnosis of atherosclerosis processes and vulnerable plaques, 3-dimensional echocardiography (3D-Echo) and multi-detector-row computed tomography have improved our capability to know more about valve heart disease as well as acute coronary syndrome (ACS). It is interesting that new recommendations for cardiac chamber quantification using echocardiography in adults provided updated normative values for all four cardiac chambers but our knowledge is limited in patients with ACS possibly due to delay in the diagnosis [1,2].

The proposed guidelines include reference values for chamber quantification with 3D-Echo and myocardial deformation with strain imaging, which is quite valuable but still needs further specification and grading [3,4]. Fortunately, these normative data allow us to differentiate between normal and abnormal findings as well as further quantification of dysfunction from a clinical perspective which appear to be of great clinical significance. However, there may be several problems in determining the cut-off values that define the degree of abnormality and provide experience-based partition values only for left ventricular (LV) size, function and mass, and for left atrial (LA) volume [1,3,4]. The VALIANT (Valsartan in Acute Myocardial Infarction Trial) trial included 248 patients with left ventricular systolic (LV) systolic dysfunction, heart failure, or both, which demonstrated that regional LV longitudinal strain was significantly impaired even in segments with normal wall motion score index compared with healthy controls (-10.4 ± 5.2% vs. -20.0 ± 7.6, $P < 0.001$) [3]. An increasing number of LV segments with abnormal regional strain was associated with an increased risk of all-cause mortality (HR 1.42; 95% CI 1.06 - 1.90, $P < 0.001$). Mojto., *et al.* have reviewed on effects of climate, weather, cosmos and environmental degradation which can predispose CVDs and other chronic diseases [5]. This indicate that these environmental factors can also influence, the function of neurons, cardiomyocytes and endothelial cells.

Ongoing research is in way to find out the prognostic value of regional LV longitudinal strain among patients with ACS, which is considered to be more relevant than LV global longitudinal strain (GLS) [6-8]. This could be possible by development of Chest Pain Unit (CPU) for early detection of the involvement of myocardium by 3-D echo. assessment [5,6]. In a clinical study, 214 patients with ACS with low to intermediate risk, presented to CPU due to acute chest pain with normal or non-specific changes in the electrocardiogram (ECG) [5]. The peaks of longitudinal systolic strain, strain rate and post systolic shortening from 3 of apical views were measured by 3D echo. The GLPSS [global longitudinal peak systolic strain] and the GLPSSR [global longitudinal peak systolic strain rate] were measured after tracing the endocardium in 3 apical projections, then acoustic markers automatically drawn and global strain and strain rate balls eye could be constructed in automated way. The average length of stay in the hospital of these patients was 12 hours with 55 percent of patients discharged within the first 24 hours. The peak SS and peak SSR of regions of interests of left ventricle were significantly lower in the low-intermediate risk group ($P < 0.05$ and $P = 0.004$, respectively). Receiver operating characteristics curve showed that the optimal values of GLS and GLSR for detecting the critical CAD were -15.0% and -0.8 s^{-1}. The sensitivity, specificity, negative predictive value and positive predictive value of non-invasive techniques for detection of acutely ischemic myocardium (Echocardiography-strain, strain rate imaging and PSS] as compared to invasive techniques coronary angiography [CAG] was; 98.5%, 91.5%, 99% and 97% respectively. It is possible that doppler and 3D echo-derived myocardial strain imaging represent exciting advances in the field of noninvasive cardiac imaging. Strain and SR are highly sensitive earliest manifestations which correlate and are consistent with other measures of cardiac function, and detect changes in myocardial contractility, both normal and abnormal, across a wide range of ACS. Our study confirms that establishment of a CPU improves the prognosis of patients with chest pain due to ACS and also saves financial resources, because early diagnosis by 3D Echo in a CPU caused significant decline in cardiac end points (Figure 1) [5]. It possible that further quantification and grading via myocardial strain imaging may be useful in the early assessment of treatment modality.

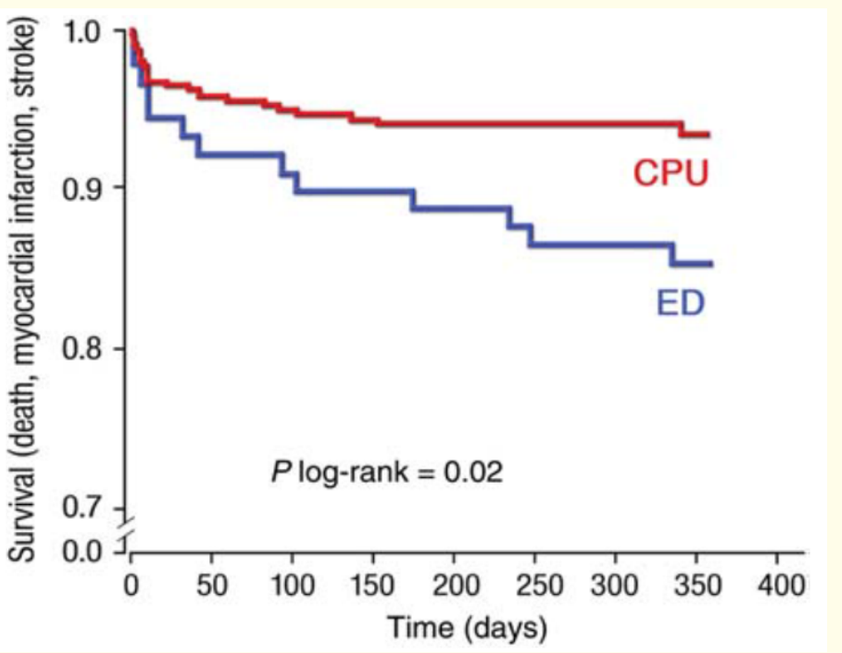

Figure 1: *Survival analysis: The Kaplan-Meier survival curves in patients with acute coronary syndrome for the composite endpoint of death, myocardial infarction, and stroke within 1 year. CPU, patients treated in the chest pain unit; ED, patients treated in the emergency department (modified from reference 6).*

Among 5721 patients, a meta-analysis including myocardial infarction(MI), the prognostic value of LV GLS exceeds that of LV ejection fraction (EF) [4]. In patients with MI, regional LV longitudinal strain was clinically more meaningful than GLS. Abnormal longitudinal strain segments were defined as having a strain value higher (less negative) than the 95% percentile of corresponding normal control segments [4]. It is known that in ACS as well as in acute heart failure, neuro-humoral dysfunction is the primary event causing damage to myocardium and brain resulting in to further myocardial damage leading to cardiac dilatation and hypertrophy of the heart, hence biochemical parameters in relation to echocardiographic findings can further quantitate the cardiac damage [7,8]. In a recent study involving 30 patients with NSTEMI were examined for the potential of strain Doppler echocardiography analysis for the assessment of LV infarct size when compared with standard two-dimensional echo and cardiac magnetic resonance (CMR) [9]. The assessment of left ventricular ejection fraction, wall motion score index (WMSI), and LV global longitudinal strain (GLS) was done in all the subjects. A complete set of global longitudinal stain (GLS) and standard echo, GLS and CMR were performed in all the subjects. The findings showed that the linear relationship demonstrated moderately strong and significant associations between GLS and ejection fraction (EF) as determined using standard echo (r = 0.452, P = 0.012), WMSI (r = 0.462, P = 0.010), and the gold standard CMR-determined EF (r = 0.57, P < 0.001). In a multivariate linear regression analysis (β = 1.51, P = 0.027), GLS was the best predictor of size of myocardial infarction. Patients with substantial infarction (≥ 12% of total myocardial volume measured using CMR) with accuracies of 76.7% and 80%, respectively had WMSI > 1.125 and a GLS cutoff value of -11.29%. GLS remained the only independent predictor in a multivariate logistic regression analysis in the diagnosis of an infarct size ≥ 12%. It is clear that GLS was an excellent predictor of infarct size in and it may serve as a tool in conjunction with risk stratification scores for the selection of high-risk NSTEMI patients [9]. However, there are many confounders which may be either risk markers or protective factors [10]. The importance of imaging has also been emphasized by the editors [11].

Conclusion

In brief, a rapid diagnosis of regional LV longitudinal strain compared to GLPSS and GLPSSR may be new imaging markers for quantification and grading of myocardial dysfunction which can change the guidelines for management of ACS. The opinions of the other experts in this field would be highly appreciated which may be highly relevant to the audience of this journal.

Conflict of Interests

Conflict of interests has not been declared by the authors.

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