Acoustic Cardiography

EMAT

The electromechanical activation time (EMAT) is the time from the onset of the Q wave on the ECG to the closure of the mitral valve within the S1 heart sound. The value of EMAT in ms reflects the time required for the left ventricle to generate sufficient force to close the mitral valve, and is therefore related to the acceleration of the pressure in the left ventricle. Prolonged EMAT has been associated with reduced LV EF, abnormally low LV dP/dt (often used as a measure of LV contractility), and poor prognosis. Percent EMAT (EMATc, %) is computed as EMAT divided by the dominant RR interval, and it relates to the efficiency of the pump function.

3rd Heart Sound

The strength of the third heart sound (S3 strength) is based on the intensity and persistence of that sound. AUDICOR® provides a value of S3 strength in the range of 0 to 10. If this value equals or exceeds 5.0, the algorithm declares that an S3 is present. In patients <=40 years the S3 is considered physiological. In patients with age > 40 years, the S3 has been associated with an abnormal diastolic filling pattern, and shown to indicate elevated LV filling pressures and systolic dysfunction. In patients with conditions such as severe mitral regurgitation or pregnancy, an S3 is not necessarily linked to LV dysfunction.

4th Heart Sound

The strength of the fourth heart sound (S4 Strength) is based on the intensity and persistence of that sound. AUDICOR® provides a value of S4 strength in the range of 0 to 10. The fourth heart sound (S4) appears after P-wave onset and before the first heart sound in the cardiac cycle. The S4 occurs as blood enters a relatively non-compliant ventricle late in diastole because of atrial contraction and causes vibrations of the left ventricular muscle, mitral valve apparatus, and left ventricular blood mass. Often associated with left ventricular hypertrophy due to the decreased compliance and frequently present in acute myocardial infarction, the presence of an S4 is always abnormal and associated with an increased left ventricular stiffness.

SDI

Systolic Dysfunction Index (SDI), a multiplicative combination of ECG and sound parameters has been shown to predict LV systolic dysfunction with high specificity. The multiplicative score SDI (systolic dysfunction index) is derived from QRS duration, QR interval, %EMAT and S3 strength. SDI is reported as a value of 0-10 where the index >=5 indicates systolic dysfunction (EF<50%) and >7.5 indicates EF<35% with elevated filling pressure.

Clinical Findings

- EMATc>15% predicts re-hospitalization for heart failure at and post discharge (HR 1.7 – 5.0) [3]
- Shortened EMAT correlates with increased contractility and short electromechanical delays [2]
- Shortened EMAT correlates with improved LV function [2]
- Prolonged EMATc correlates with reduced EF, lower end-systolic elastance and peak isovolumic LV pressure at end-diastolic volume, higher end-systolic volume index and end-diastolic volume index and dyssynchrony. Abnormal %EMAT is strongly associated with impaired LV contractility. [2]
- Presence of an S3 has a positive likelihood ratio of 4.8 for the prediction of LV dysfunction[4]
- Presence of an S3 correlates with increased LV end-diastolic pressure [4, 5]
- AUDICOR helped correct 34% of the patients initially missed for diagnosis of acute HF[6]
- Use of BNP plus S3 improves diagnostic accuracy for decompensated HF and LV dysfunction [7]
- Subjects with S3 had significantly lower EF and significantly increased E deceleration, E/E' and filling pressures. [8]
- An S4 is associated with increased LV stiffness and elevated LVEDP[10]
- The S4 was associated with increased LV stiffness even after controlling for age, gender and ejection fraction. This supports the conclusion that an S4 is a pathologic finding in older patients. [9]
- The combination of the S3 and systolic time intervals was highly specific and yielded superior performance for detection of LV dysfunction than the individual elements. [4]

1. Shah SJ et al. Hemodynamic Correlates of the Third Heart Sound and Systolic Time Intervals. CHF. 2006 Jul-Aug; 12(4 suppl 1):8-13.
2. Efstratiadis S et al. Computerized Acoustic Cardiographic Electromechanical Activation Time Correlates with Invasive and Echocardiogrpahic Parameters of LV Contractility. J of Card. Failure. 2008, 14(7):577-582.
3. Chao T et al. EMAT in the Prediction of Discharge Outcomes in Patients Hospitalized with AHFS. Internal Med. 2010, 49: 2031-2037.
4. Shapiro M, et al. Diagnostic Characteristics of Combining Phonocardiographic Third Heart Sound and Systolic Time Intervals for the Prediction of Left Ventricular Dysfunction. J of Cardiac Failure. 2007 13(1): 18-24.

5. Marcus G et al. Association Between Phonocardiographic Third and Fourth Heart Sounds and Objective Measures of Left Ventricular Function. J*ournal of the American Medical Association. 2005 May 11; 293(18):2238-2244.*
6. Peacock F et al, Clinical and Economic Benefits of Using Audicor S3 Detection for Diagnosis and Treatment of Acute Decompensated Heart Failure. CHF, 2006, Jul-Aug, 12(4 supp) 1) 32-36.
7. Collins et al, The Combined Utility of an S3 Heart Sound and B-type Naturetic Peptide.*Am J of Cardiol*, 2007
8. Shah et al. Physiology of the Third Heart Sound: Novel Insights from Tissue Doppler Imaging and Invasive LV Hemodynamics. J Am Soc Echo. 2008 21(4): 394-400.
9. Shah SJ et al. Hemodynamic Correlates of the Third Heart Sound and Systolic Time Intervals. CHF. 2006 Jul-Aug; 12(4 suppl 1):8-13.
10. Shah SJ et al. Association of the 4th HS with Increased Left Ventricular End-Diastolic Stiffness. JCF 2008; Vol. 14 No. 5:431-436.

www.inovise.com
+1 503 431 3800
info@inovise.com

INOVISE MEDICAL

8770 SW Nimbus Ave, Ste. D
Beaverton, Oregon 97008