Third and Fourth Heart Sounds Are Highly Specific Markers for Elevated Left Ventricular Filling Pressure and Reduced Ejection Fraction

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Background

The determination of abnormal left ventricular (LV) hemodynamics by non-invasive measures may improve the early diagnosis and management of patients with suspected heart failure. The aim of this study was to compare the sensitivity and specificity of third (S3) and fourth (S4) heart sounds detected by a computerized algorithm for detecting elevated LV end diastolic pressure (LVEDP), reduced LV ejection fraction (EF), elevated echo-derived E/E`, and elevated BNP.

Methods

Adult patients referred for cardiac catheterization were enrolled. Patients with atrial arrhythmia were excluded. Within a 4-hour period, each subject had left heart catheterization for LVEDP, measurement of serum BNP, and echocardiography for LVEF and E/E'. E/E` was derived from the early diastolic transmitral inflow velocity (E) and early diastolic mitral annular velocity (E`) from the lateral mitral annulus. The presence of an S3 and/or S4 was determined by correlated audioelectric cardiography (COR, AUDICOR®, Inovise Medical, Portland, OR), a computerized detection of heart sounds on an acoustic signal collected in the V3 or V4 position.

Table 1. Predictors of Elevated LV End Diastolic Pressure and Reduced LV Ejection Fraction

	LVEDP >15 mmHg (n=45)			LVEF <50% (n=30)		
	Sensitivity (%)	Specificity (%)	AUC	Sensitivity (%)	Specificity (%)	AUC
S4	48	80	0.68**	44	80	0.65*
S3	40	91	0.72**	48	93	0.77**
E/E` ratio >12	32	100	0.81**	32	94	0.67*
BNP >100 pg/mL	80	59	0.79**	83	60	0.74**

* p<0.05, ** p<0.01, AUC=area under ROC curve

Results

100 patients were enrolled. The mean age was 62 ± 14 (range 24-91) years, 65 were male, 29 were diabetic, 81 had hypertension, 37 had a history of heart failure, and 68 had coronary artery disease. Assessment of an S3 and/or S4 was available in 90 subjects, and echo data was available in 88 patients. Forty-one subjects had abnormal heart sounds [S3 only (n=12), S4 only (n=20), or both (n=9)]. The mean EF was 49 ± 19% and the mean LVEDP was 15.6 ± 8.0 mmHg.

Compared to subjects with a normal LVEDP, those with an elevated LVEDP (>15 mmHg) had higher BNP (mean 874 ± 1232 pg/ml vs 150 ± 228 pg/ml, p<0.001), higher E/E` (10.3 ± 5.6 vs 5.4 ± 2.0, p<0.001), and were more likely to have an S4 (48% vs 20%, p=0.007) and an S3 (40% vs 9%, p=0.001). Compared to subjects with a normal LVEF, those with a reduced LVEF (<50%) had higher BNP (mean 888 ± 1286 pg/ml vs 275 ± 678 pg/ml, p=0.01), higher E/E` (9.2 ± 5.5 vs 6.0 ± 3.0, p=0.006), and were more likely to have an S4 (44% vs 40%, p=0.04) and an S3 (48% vs 8%, p=0.001). The sensitivity, specificity, and area under the curve for an elevated LVEDP and reduced LVEF are shown in the table.

Conclusions

The presence of an S3 and S4 detected by correlated audioelectric cardiography using a computerized algorithm is highly specific for elevated LVEDP and reduced LVEF. This non-invasive test may be a useful point of care test in patients with suspected heart failure. Since COR has a greater specificity compared to BNP, this test may complement BNP testing for patients with suspected heart failure and an elevated BNP.

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