THE ROLE OF HEART SOUNDS RECORDING AND ANALYSIS IN THE DYSPNEIC ED PATIENT

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OBJECTIVES:
1. Describe the etiology and importance of S3 and S4 heart sound recording and analysis in the ED
2. Describe the role S3 and S4 heart sound recording and analysis can play in the diagnosis of decompensated heart failure

INTRODUCTION

Extra diastolic heart sounds are produced as a result of increased stiffness and decreased compliance of the left ventricle. The third heart sound (S3) occurs 0.12 to 0.16 seconds after the second heart sound in early diastole (Figure 1). Of the many proposed theories, the most likely explanation is that excessive rapid filling of a stiff ventricle is suddenly halted, causing vibrations that are audible as the third heart sound. The fourth heart sound (S4) occurs after P wave onset and before the first heart sound in the cardiac cycle. It is produced in late diastole as a result of atrial contraction causing vibrations of the left ventricular muscle, mitral valve apparatus, and left ventricular blood mass. Atrial and ventricular “gallows” have been described in the literature dating back to the late 1800’s. The ventricular gallop is recognized as a third heart sound. The atrial gallop is synonymous with a fourth heart sound.

Auscultation of the S3 and S4
Both an S3 and S4 are auscultated in similar fashion. Harvey has suggested the “inching” technique as a way to distinguish the often times pathologic S3 and S4 from the physiologic S1 and S2. In both situations it is best to examine the patient in the left lateral position using the bell of the stethoscope. Starting at the aortic area (where the S2 is the loudest) the examiner “inches” down to the cardiac apex, using the S2 as a reference point. If one encounters an extra sound in diastole, just after the S2, this is an S3 or diastolic gallop. The S3 is generally absent at the base, so that as the examiner moves toward the apex the S3 is encountered. The opposite maneuver results in detection of an S4. In this instance the examiner inches from the apex upward.

Figure 1.
Location of Heart Sounds in the Cardiac Cycle.
to the base. The first heart sound (loudest at the apex) is used as a reference, because the S4 occurs in early systole, just before S1. If the stethoscope is moved away from the apex the S4 disappears. A further method to distinguish a split S1 from an S3 is to place pressure on the bell of the stethoscope - an S3 will disappear, while a fixed S1 will remain.

**Significance of an S3 and S4**

*Decompensated Heart Failure*

While detection of an S3 can be “normal” in adolescents and young adults, its detection after the age of 40 is considered abnormal.6-8 Table 1 Traditionally not very sensitive for left ventricular dysfunction, when detected, an S3 can be very predictive of elevated left ventricular pressure. In a study of outpatients referred for cardiac catheterization, the detection of an S3 was the most specific finding elevated left ventricular end diastolic pressure (LVEDP) (95%).9 A more recent study has also found that the detection of an S3 has a high specificity and positive predictive value in detection of patients with low ejection fractions.10 More importantly, it has been suggested that patients with a detectable S3 have an increased risk of hospitalization and death compared to those patients without a detectable S3.11-13

Furthermore, in patients with decreased ventricular compliance (i.e. heart failure) a greater proportion of filling occurs in late diastole. As a result, the atrial component of ventricular filling is increased resulting in a large amount of blood being forced into a stiff, noncompliant ventricle. The net result is an S4.14

**Acute Coronary Syndromes**

Patients with coronary artery disease without acute ischemia do not have an S4. However, an S4 may be present in the early phases of acute ischemia and acute myocardial infarction, with an incidence approaching 100%.15 The prevalence of the S4 in healthy individuals has been a subject of great debate. Previous heart sound studies have found a prevalence of S4’s from as low as 11%16 to as high as 75%17 as well as many values in between.18-23 The vast majority of these studies enrolled fewer than 300 patients, and suffered from enrollment bias because many of the subjects had been referred for cardiac workup, including left and right heart catheterization.

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**Table 1.**

Clinical relevance of heart sounds.

<table>
<thead>
<tr>
<th>Physical exam finding</th>
<th>Healthy subjects less than 40</th>
<th>With symptoms of ACS</th>
<th>With symptoms of heart failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S3</strong></td>
<td>May be present</td>
<td>High-risk feature, but not as sensitive as S4</td>
<td>Highly specific for LV dysfunction</td>
</tr>
<tr>
<td><strong>S4</strong></td>
<td>Usually not present</td>
<td>High likelihood of CAD</td>
<td>Indicative of high LV pressure</td>
</tr>
</tbody>
</table>
Coronary heart disease (CHD) without LV dysfunction does not produce an S3. However, if CHD results in LV dysfunction (either acute or chronic) leading to a poor ejection fraction, an S3 may develop. An S3 during acute myocardial infarction suggests a large infarction and does not necessarily mean LV dysfunction that requires treatment. The intensity of an S3 tends to decrease as the myocardium recovers from acute infarction. The ACC/AHA guidelines recommend that patients with unstable angina and a concurrent auscultated S3 be classified in the group at highest risk for adverse outcomes and considered candidates for an early invasive strategy.

**Detection of S3 and S4 on Physical Exam**

Recent studies indicate that physicians are becoming less proficient at performing the physical examination, and physicians in training programs have been shown to have poor cardiac auscultatory skills. Furthermore, interobserver agreement of S3 detection is poor, with board-certified cardiologists having no better agreement than house staff. Compounding the difficulty of S3 or S4 detection is the loud ED environment, confounding illnesses such as COPD and obesity that make detection difficult, and the inability of the patient to tolerate being placed in the ideal examining position (left lateral decubitus) because of their dyspnea.

**Heart Sound Recording and Analysis Advances**

The introduction of new heart sound recording and analysis technology has allowed this topic to be revisited. The Audicor® System is an example of a cardiac diagnostic tool that may aid physicians in the diagnosis of cardiac conditions such as acute myocardial infarction and decompensated heart failure at the point of care. The Audicor® System uses correlated audioelectric cardiography (COR) to combine an analysis of electrical signals from the ECG with heart sound detection in a correlated report format, without altering current ECG testing procedures. The Audicor® device uses a dual sensor in conjunction with standard ECG electrodes (Figure 2). The dual sensor

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**Figure 2.**

Placement of acoustic heart recording chest leads in the V3 and V4 position.
Perform CHF workup
Suspected Decompensated Heart Failure

Suspected Acute Coronary Syndrome

Simultaneous acoustic heart sound recording or cardiac auscultation for detection of S3 and/or S4

S3 detected: consider LV dysfunction or ACS
S4 detected: consider LV dysfunction or ACS
S3 not detected
S4 not detected
S3 not detected
S3 detected
S4 detected

Initiate simultaneous CHF workup and treatment
Perform CHF workup
If decompensated, heart failure likely
Initiate simultaneous ACS workup and treatment
Perform ACS workup
Suggests CHF and high risk*
Consider early invasive strategy

Patient disposition to appropriate level of care

Figure 3.
Example of an electrocardiograph printout with accompanying acoustical information.

Figure 4.
Early Diagnostic and Treatment Pathway for CHF and ACS
SUMMARY

An S3 and S4 are often produced as a result of pathologic processes that produce elevated ventricular pressures. The presence of an S3 or S4 in a symptomatic ED patient should alert the treating physician to the presence of underlying cardiovascular abnormalities ([Figure 4]). The difficulty in identifying an S3 or S4, even for the trained practitioner, is well documented. Fortunately, with recent technological advancements, the treating physician is now able to electronically detect these abnormal heart sounds readily with no inconvenience to the patient.

REFERENCES


