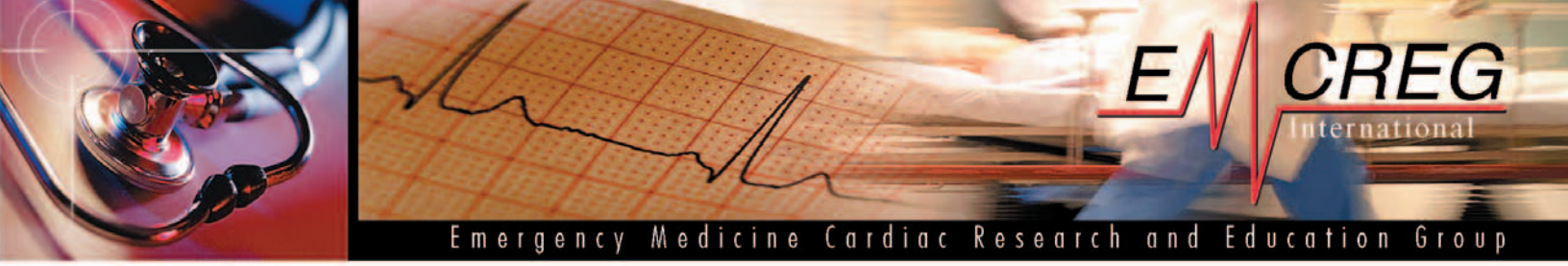


Third and Fourth Heart Sounds – Lost Art to Modern Advance

A SUMMARY FOR EMERGENCY PHYSICIANS

Dear Colleagues:

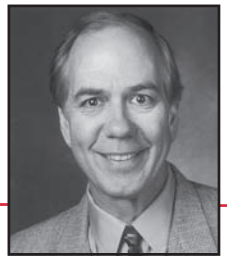
Patients presenting to the Emergency Department (ED) with potential cardiovascular disease present significant challenges and demands on resources. Over eight million patients present to EDs with chest pain while congestive heart failure has reached nearly epidemic proportions. Therefore, it is essential that emergency care providers utilize all tools, resources, and knowledge to efficiently and effectively diagnose and treat these patients at great risk for cardiovascular complications and death.

With time constraints in the emergency setting and advancing technology, many care givers have drifted further away from the subtleties of physical diagnosis. Such is the case with the art of cardiac auscultation. Even the most proficient of emergency care providers have difficulty discerning the low frequency rumblings of an S3 or S4 from the background noise of monitors in a hectic emergency setting. Nearly half a century has passed since phonocardiography originally was developed to assist in cardiac auscultation. Modern technology is now making it possible to once again use S3 and S4 heart sounds to facilitate the diagnosis of heart failure and acute coronary syndrome (ACS).

The Emergency Medicine Cardiac Research and Education Group International (EMCREG) is pleased to present this newsletter summarizing and reviewing the significance of third and fourth heart sounds in the diagnosis of ACS and heart failure. EMCREG International seeks to keep emergency medicine community informed of cutting-edge diagnostic and therapeutic technologies. We hope therefore to introduce emergency healthcare providers to the advancements in heart sound technology and its potential for the timely diagnosis and risk stratification of seriously ill patients with myocardial ischemia and heart failure in the emergency department.

Sincerely,

Andra. L. Blomkalns, MD
Director of CME and Enduring Materials
EMCREG International



W. Brian Gibler, MD
President
EMCREG International

Third and Fourth Heart Sounds

The third and fourth heart sounds are first introduced to all physicians in the medical school introduction to clinical medicine. Often referred to as "gallops," these third (S3) and fourth (S4) heart sounds may be physiologic, but are often the harbingers of serious cardiac conditions. While an S3 can be found in young, asthenic adults and in patients with hyperkinetic cardiac states, the most common cause of a pathologic S3 is ventricular dysfunction. An audible S4 is almost never physiologic and generally signifies a pathologic condition.

The detection of an S3 heart sound after the age of 40 is considered abnormal[1-4]. An S3 is very predictive of elevated left ventricular filling pressure and indirectly, ventricular dysfunction. In one study, the detection of an S3 was found to be the most specific finding of elevated LVEDP (95%)[5]. Also, it has been noted that the detection of an S3 has a high specificity and positive predictive value for detection of patients with low ejection fraction and adverse outcomes, including progression of heart failure[6]. Maisel et al, found that 52% of patients with acute anterior myocardial infarction and 36% of patients with acute inferior myocardial infarction had audible S3's [7]. Perhaps most conclusively, patients with a detectable S3 have an increased risk of hospitalization and death compared to those patients without this heart sound [8-10].

The intensity and timing of the S3 are related to the patient's volume status and treatment. Therapy such as diuresis, may decrease the intensity of the sound or cause it to disappear. In short, the presence of an S3 is an ominous sign for both acute coronary syndrome (ACS) and heart failure patients and is associated with higher morbidity and mortality. Conversely, its disappearance is associated with improved prognosis [6, 11, 12].

An S3 is considered to be a high risk feature for ACS patients according to the updated consensus treatment guidelines for these individuals. In the ACC/AHA 2002 Update for the management of patients with unstable angina and non-ST-segment elevation myocardial infarction, the following are listed as high risk features (Class I, Level of Evidence A) for an early invasive strategy: recurrent angina/ischemia at rest or with low level activities despite intensive anti-ischemic therapy; elevated troponin (Tn) T or TnI; new or presumably new ST-segment depression; recurrent angina/ischemia with heart failure symptoms; an S3 gallop, pulmonary edema, worsening rales, or new or worsening MR; high-risk findings on noninvasive stress testing; depressed left ventricular (LV) systolic function (e.g., ejection fraction < 0.40 on noninvasive study); hemodynamic instability; sustained ventricular tachycardia; percutaneous coronary intervention within 6 months; or prior coronary artery bypass graft.

In pathologic conditions, forceful atrial contraction in the setting of decreased ventricular compliance generates the fourth heart sound (S4). While an S3 may be physiologic in some patients, an audible S4 is most often pathologic[13]. The S4 may be present in any condition that causes decreased ventricular compliance such as hypertrophic cardiomyopathy, diastolic dysfunction, aortic stenosis, or ischemic heart disease. An S4 may be present in the early phases of acute myocardial infarction and unstable angina[14, 15], but would not be present in patients with coronary artery disease without acute ischemia or left ventricular dysfunction[16]. The presence of an S4, even as long as one month post myocardial infarction, portends poor prognosis for those patients[17].

The S3 and S4 heart sounds may occur together in some patients and produce a "quadruple rhythm," or if fused, a "summation gallop." This may occur in patients with a left ventricular aneurysm, end-stage ischemic cardiomyopathy, or concomitant ischemia and left ventricular dysfunction. In the context of a patient with an acute cardiovascular related complaint, the combination of these sounds portend significant disease and potentially substantial morbidity and mortality.

- *Congestive heart failure (CHF) is a worldwide problem of epidemic proportions and represents a tremendous burden to overall healthcare costs [1].*
- *The detection of an S3 heart sound after the age of 40 is considered abnormal [1-4].*
- *The most common cause of a pathologic S3 is ventricular dysfunction [14].*
- *An S4 may be present in the early phases of acute myocardial infarction and unstable angina [14,15].*
- *Identification of an S3 or S4 heart sound by auscultation may be difficult, particularly in the ED and other noisy environments.*

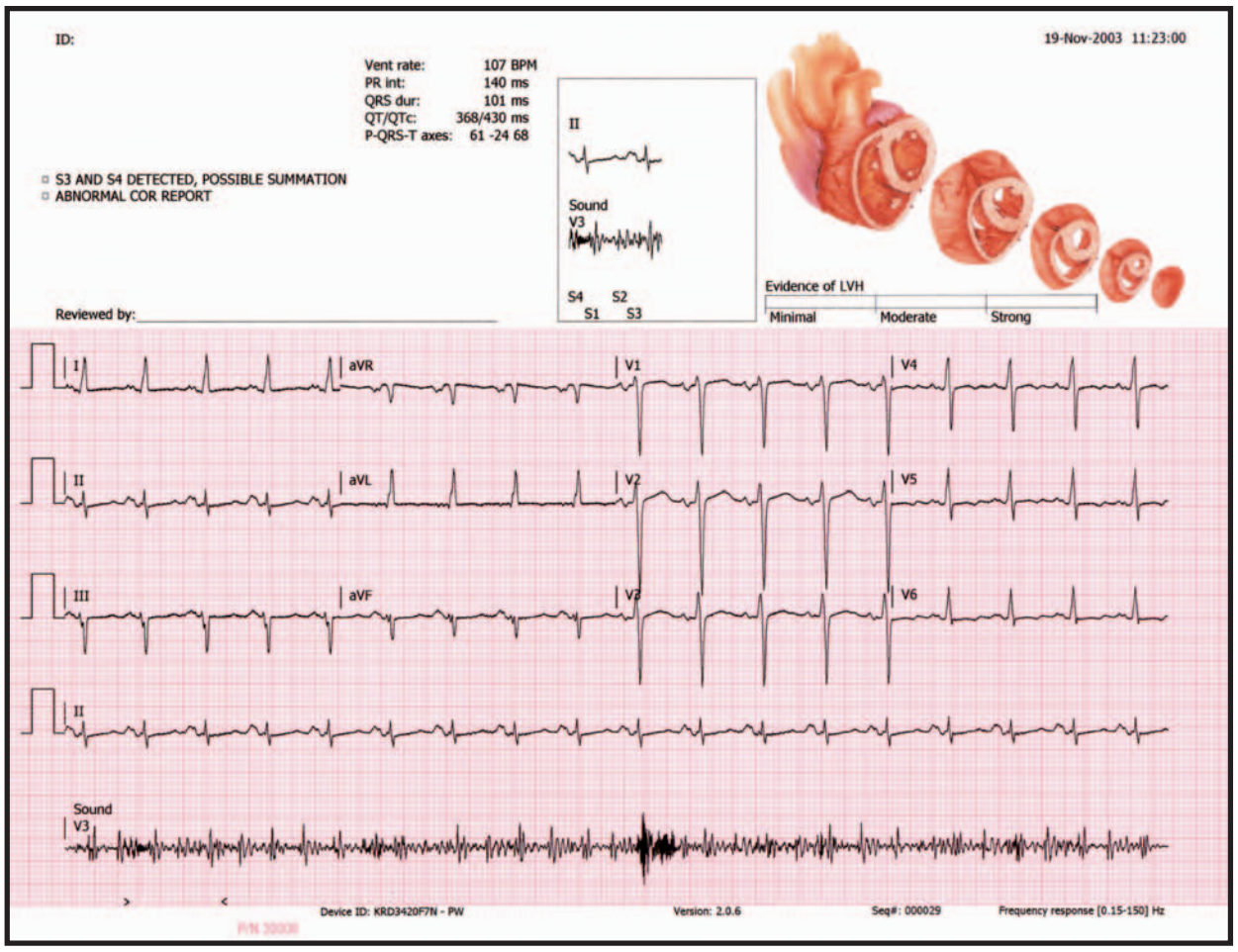
The Challenge for the Clinician

Identification of an S3 or S4 heart sound can be difficult, in the ED and other noisy clinical environments. The true incidence of S3's in heart failure is likely underestimated, as the abnormal heart sounds may be present but physicians are unable to detect them. Recent studies also indicate that physicians are becoming less proficient at performing the physical examination. Particularly, physicians in residency programs have been shown to have poor cardiac auscultatory skills[18-21]. Furthermore, interobserver agreement of S3 detection is suboptimal, with board-certified cardiologists having no better agreement than house staff[22, 23]. Compounding the difficulty of S3 or S4 detection is the loud ED environment, confounding illnesses such as COPD and obesity that make detection difficult, as well as the inability of the patient to tolerate being placed in the ideal examining position (recumbent and lateral). Heart sounds are therefore quite important, yet we as caregivers may not have the skills or the appropriate environment in which to assess them.

Acoustic Heart Sound Recording & Computer Analysis

While detection of an S3 or S4 may be useful as a diagnostic and prognostic tool in emergency patients with chest pain, dyspnea and possible congestive heart failure or myocardial ischemia, the traditional method of auscultation is less than ideal. Fortunately, technology is available to aid the clinician with bedside diagnosis of an S3/S4. Acoustic heart sound recording and analysis devices are available for use in the clinical setting. More recently, acoustic heart sound detection can be achieved through the use of a dual sensor in conjunction with standard electrocardiogram (ECG) electrodes. These sensors simultaneously acquire electrical and acoustical data from the V3 and V4 position on the standard 12-lead ECG. This allows simultaneous recording of both the 12-lead ECG and acoustical information. The acoustic heart sound detection system can attach to the standard ECG machine. The system's diagnostic algorithms use correlated audioelectric cardiography to combine an analysis of the electrical signals from the ECG with heart sound detection. The system generates a report detailing the presence of an S3, S4, acute MI, prior MI, ischemia and left ventricular hypertrophy. All this is done without altering current ECG testing procedures. Examples of these output reports are presented in the following case series.

50 YEAR OLD MALE WITH SHORTNESS OF BREATH

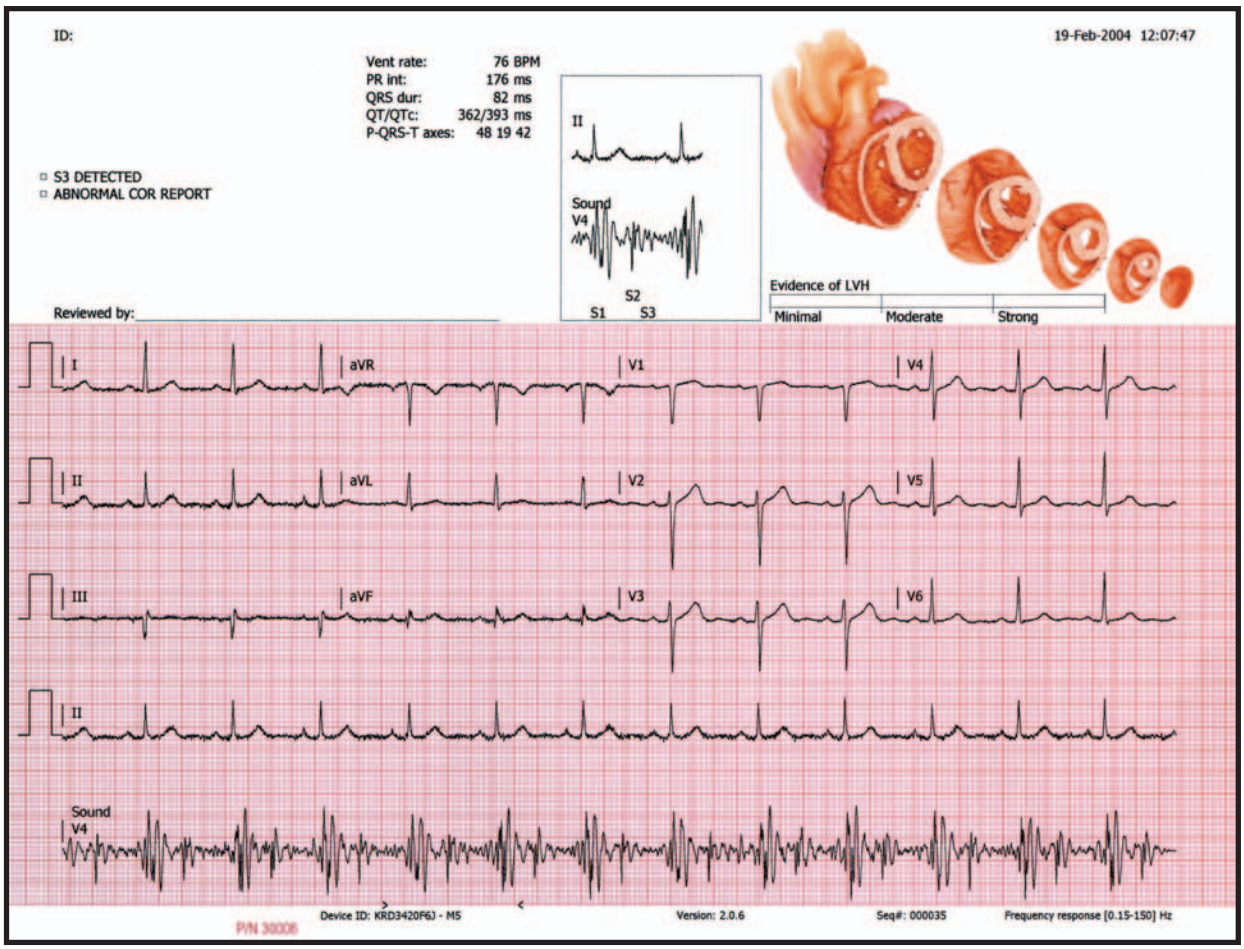


Clinical Profile

- 50 year old male presenting with shortness of breath
- PMH: Hypertension
- Physical exam: Mild peripheral edema, S3 detected, otherwise normal cardiopulmonary exam
- ECG: Normal sinus rhythm, right axis deviation, lateral T-wave inversions
- Acoustic heart sound recording – S3, S4 detected
- Troponin T <0.01 ng/mL, CKMB 2.3 ng/mL, BNP 239 pg/mL
- CXR: Interstitial edema
- Diagnosis: New onset heart failure

Key Point: The presence of an S3 and S4 in this case may have led the clinician to start treatment as early as the initial ECG and before CXR and laboratory results were available

65 YEAR OLD MALE WITH CHEST PAIN

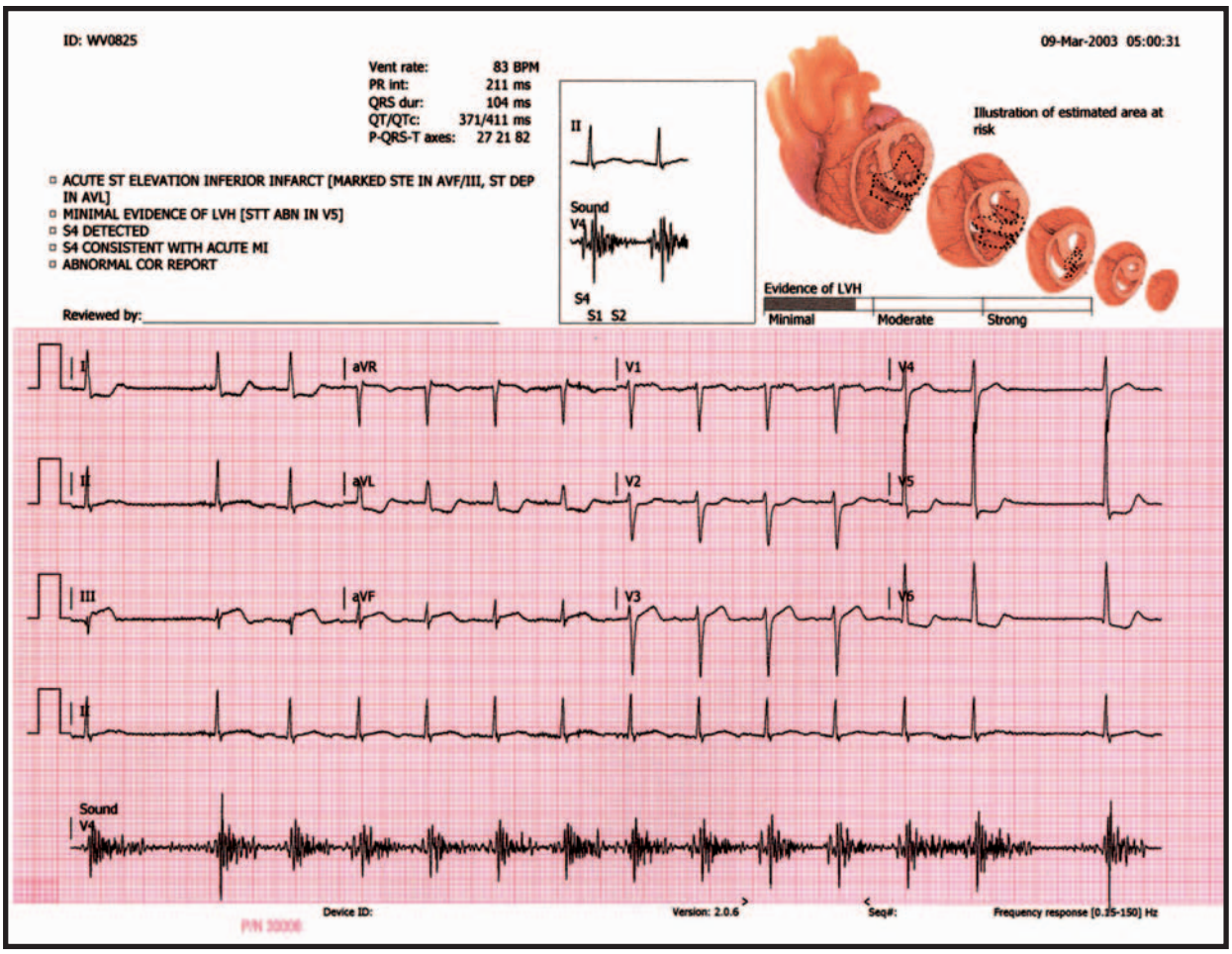


Clinical Profile

- 65 year old male presenting with chest pain
- PMH: No known medical conditions. No history of coronary artery disease. Previous evaluation for chest pain yielded negative stress test
- Physical exam: Normal cardiopulmonary examination
- ECG: Non-specific changes
- Acoustic heart sound recording – S3 detected
- Troponin T< 0.01ng/mL, CKMB 1.7 ng/mL, BNP 21 pg/mL
- CXR: Normal
- Angiogram revealed left anterior descending coronary artery occlusion of 85% with plaque rupture
- Diagnosis: Single vessel coronary artery disease with unstable angina

Key Point: The presence of an S3 in this case places the patient at "high risk," suggesting the need for aggressive therapy.

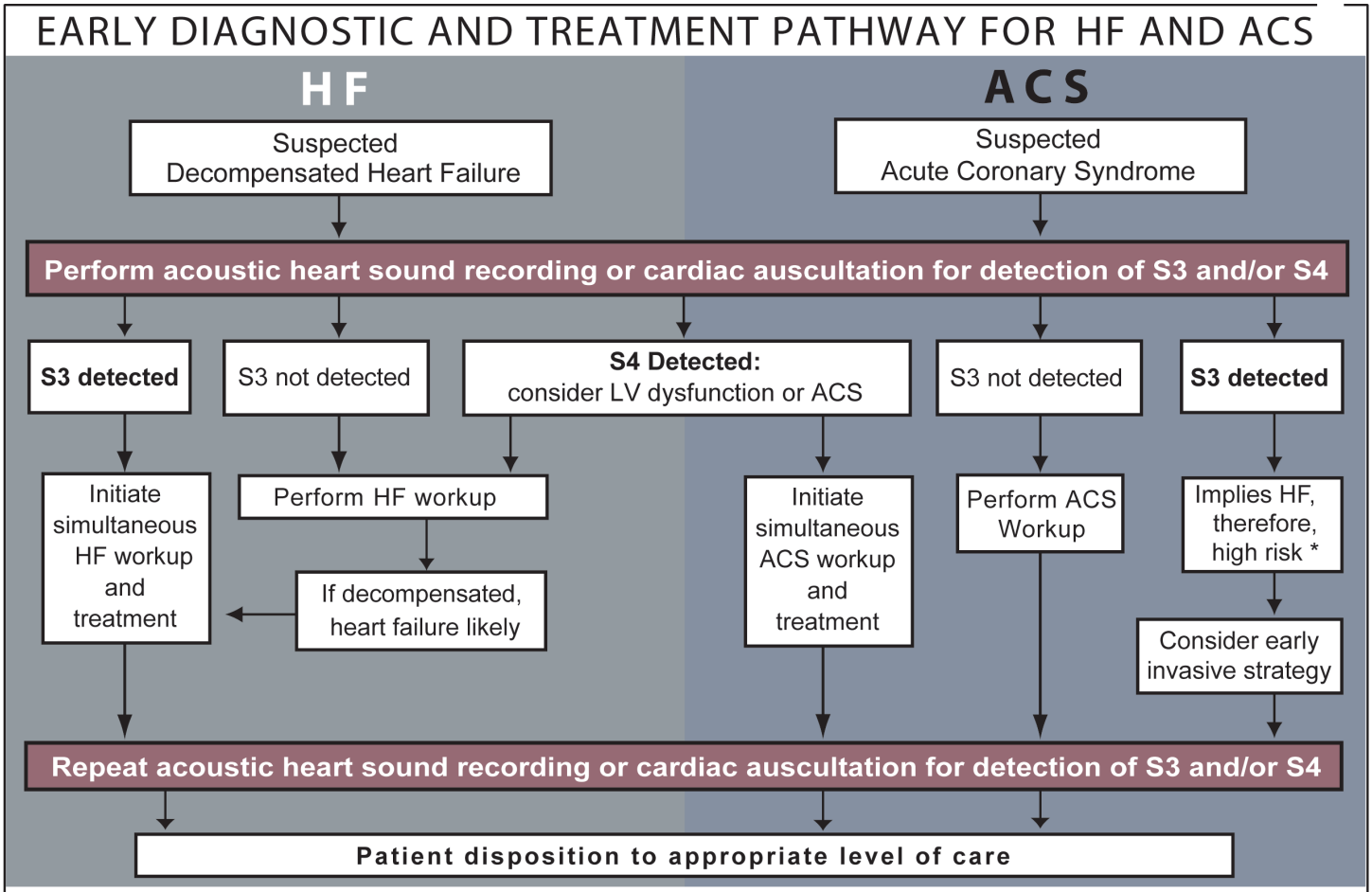
74 YEAR OLD FEMALE WITH CHEST DISCOMFORT



Clinical Profile

- 74 year old female presenting with chest discomfort
- PMH: hypertension, diabetes mellitus
- Physical exam: Faint S1 and S2. Clear lung fields.
- ECG: ST-segment elevation inferiorly with reciprocal depression in I, aVL, V5, V6
- Acoustic heart sound recording – S4 detected
- Troponin T 2.2 ng/mL, CKMB 8.0 ng/mL
- CXR: Mild cardiomegaly, otherwise unremarkable
- Emergent angiogram revealed diffuse, severe coronary artery disease
- Diagnosis: ST-segment elevation MI

Key Point: Some ACS patients, such as women and the elderly, might present with vague symptoms. Detecting abnormal heart sounds can assist the clinician in early risk stratification.



* An early invasive strategy is recommended in patients with UA/NSTEMI and any of the following high-risk indicators (Class I, Level of Evidence A): recurrent angina/ischemia at rest or with low level activities despite intensive anti-ischemic therapy; elevated TnT or TnI; new or presumably new ST-segment depression; recurrent angina/ischemia with CHF symptoms; an S3 gallop, pulmonary edema, worsening rales, or new or worsening MR; high-risk findings on noninvasive stress testing; depressed LV systolic function (e.g., EF < 0.40 on noninvasive study); hemodynamic instability; sustained ventricular tachycardia; PCI within 6 months; or prior CABG. Braunwald E, Antman EM, Beasley JW, Califf RM, Cheitlin MD, Hochman JS, Jones RH, Kereiakes D, Kupersmith J, Levin TN, Pepine CJ, Schaeffer JW, Smith EE III, Steward DE, Théroux P. ACC/AHA 2002 guideline update for the management of patients with unstable angina and non–ST-segment elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on the Management of Patients With Unstable Angina. 2002.

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CME POST - TEST ANSWER FORM

CME Questions

After you have read the monograph, carefully record your answers by circling the appropriate letter for each question.

1) An audible fourth heart sound (S4) is:
   a. Pathologic is most patients
   b. A normal sound associated with normal atrial contraction
   c. Diagnostic for pulmonary embolus
   d. Normal in adults with atrial myxomas
   e. None of the above

2) A third heart sound (S3) heart sound may be associated with:
   a. Ventricular dysfunction
   b. Acute ischemia
   c. Increased diastolic filling pressure
   d. Congestive heart failure
   e. All of the above

3) T or F. Traditional cardiac auscultation with a stethoscope is a reliable and reproducible means of detecting abnormal heart sounds.

4) T or F. Pathologic third and fourth heart sounds have been shown to lessen or disappear with successful treatment.

5) T or F. Third and fourth heart sounds have been shown to be prognostic in the diagnosis and treatment of congestive heart failure and acute myocardial ischemia.

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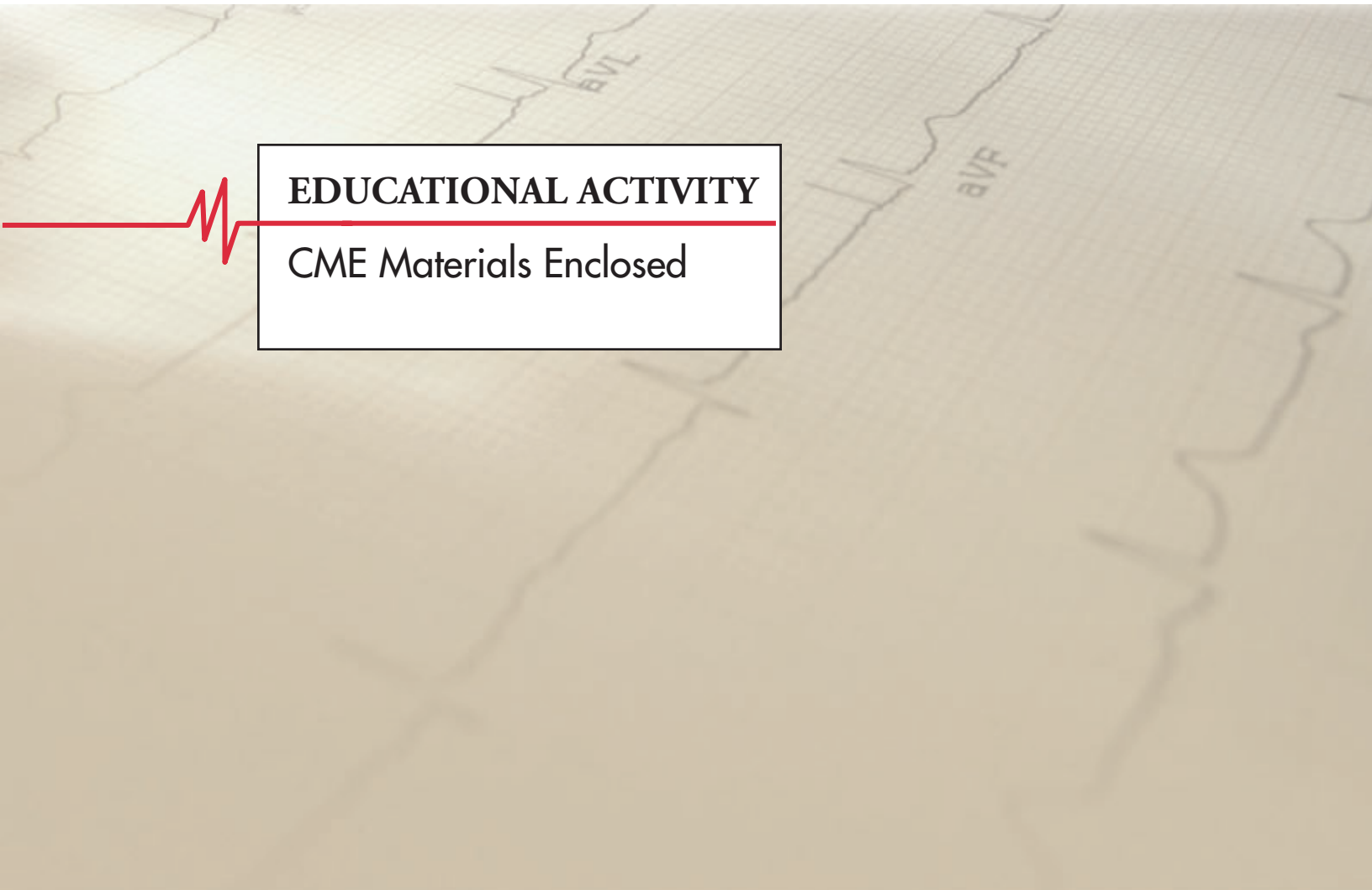

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