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INSIDE

Abdominal CT in Blunt Trauma: Hold the Contrast?

ABSTRACT & COMMENTARY

Source: Allen TL, et al. Computed tomographic scanning without oral contrast solution for blunt bowel and mesenteric injuries in abdominal trauma. *J Trauma* 2004;56:314-322.

Since the 1980s, computed tomography (CT) scanning has been used to search for traumatic injuries to the abdomen in stable patients. From CT's inception as an imaging modality, oral contrast agents were employed, as they were thought to aid in the identification of injuries to the bowel wall and mesentery. Blunt bowel and mesenteric injuries (BBMIs) are thought to occur in 1-5% of patients suffering blunt abdominal trauma. Further, morbidity and mortality from missed injuries to these organs is believed to be significantly increased when surgical treatment is delayed by as few as eight hours. There have been a number of smaller studies that have questioned this dogma of oral contrast administration. Only one, however, was prospective: Stafford's study published in 1999 cast doubt on whether oral contrast added any significant data to the evaluation of this patient population.[1]

This prospective, non-randomized, cohort study from Salt Lake City included 500 consecutive Trauma I (their highest designation) patients; oral contrast was omitted from the routine trauma abdominal CT scan. CT images were interpreted initially by the attending radiologist, trauma surgeon, and chief surgical resident, and a prospective data sheet was completed. Routine trauma care, including laparotomy if indicated, was provided based on the results of the trauma evaluation. All scans were re-read 24 hours later by a study radiologist who was blinded to the first reading and to the patient's clinical course. True BBMI was determined to be present if either laparotomy or autopsy identified bowel or mesentery injury, or both the study radiologist and the hospital discharge summary described bowel or mesenteric injury. All patients had three-month phone follow-up to determine if there were any late missed injuries.

Nineteen of 20 BBMIs were identified on the initial non-contrast study, for a sensitivity of 95% (95%; CI: 75-99%). There were two

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false-positive readings, yielding a specificity of 99.6% (95%; CI: 98-99%). The missed injury was a duodenal tear that became clinically apparent approximately 12 hours after admission. Notably, this injury was identified by the blinded study radiologist the following day. The two false-positive scans were a) a suspected gastric hematoma that was ruled out by adding oral contrast following the non-contrast study; and b) a suspected bowel injury that resulted in a laparotomy where the bowel was uninjured, but a splenic injury was found, resulting in splenectomy. The authors note that their sensitivity and specificity compares favorably with published numbers for contrasted studies.

■ COMMENTARY BY ANDREW D. PERRON, MD, FACEP, FACSM

In a perfect world, this would have been a prospective, randomized, double-blinded study in which the two groups go head-to-head to show equivalency between the two techniques. Unfortunately, as the authors of this paper point out, with an incidence of 1-5% for BBMI, an equivalency study would need to enroll more than 30,000 patients to have 80% power to reject the null hypothesis…no small feat, even for a multi-center trial. As with most "perfect-world" scenarios, we don't live in one, and have to make decisions based on what we have. What I do take away from this study is that at a large trauma center, eliminating oral contrast from the CT evaluation of blunt abdominal trauma patients resulted in sensitivities that are as good as, or better than, those cited in contrasted studies. While the attendant risk of oral contrast administration is low (e.g., aspiration, time delay), the risk of not giving it seems lower. ❖

References

1. Stafford RE, et al. Oral contrast solution and computed tomography for blunt abdominal trauma: A randomized study. *Arch Surg* 1999;134:622-627.

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Is Procalcitonin the Key to Discriminating Bacterial from Viral Lower Respiratory Infections?

A B S T R A C T & C O M M E N T A R Y

Source: Christ-Crain M et al. Effect of procalcitonin-guided treatment on antibiotic use and outcome in lower respiratory tract infections: cluster-randomized, single-blinded intervention trial. *Lancet* 2004; 363:600-607.

Procalcitonin concentrations have been shown to be elevated in severe bacterial infections, but remain low in viral infections and non-specific inflammatory diseases. The objective of this study was to assess the capability of a new, rapid, and sensitive procalcitonin assay to identify bacterial lower respiratory tract infections needing antimicrobial treatment.

The study design was a prospective, cluster-randomized, controlled, single-blinded intervention trial. A total of 243 patients who were suspected of having lower respiratory infections were recruited from an academic, tertiary care hospital emergency department (ED). Appropriate exclusion criteria (e.g., immunocompromised patients) were employed. Patients were assigned randomly either standard care or procalcitonin-guided treatment. In the procalcitonin-guided group, the treating physician was advised either to use or withhold antibiotics depending upon the serum procalcitonin level (one of four categories), although the final decision was at the discretion of the treating physician. On the basis of the procalcitonin level, the use of antibiotics was *strongly discouraged* (0.1 mcg/L or less suggests absence of bacterial infection), *discouraged* (0.1-0.25 mcg/L suggests bacterial infection unlikely), *recommended* (0.25-0.5 mcg/L suggests bacterial infection likely), or *strongly recommended* (0.5 mcg/L or greater suggests presence of bacterial infection). The primary endpoint was the use of antibiotics, and analysis was by intention to treat.

In the procalcitonin-guided treatment group, the adjusted relative risk of antibiotic exposure was 0.49 (95%; CI: 0.44-0.55; $p < 0.0001$) compared with the standard group. Antibiotic use was reduced significantly in all diagnostic subgroups, including those with community-acquired pneumonia, bronchitis, chronic obstructive pulmonary disease (COPD) exacerbation, and asthma. Clinical and laboratory outcomes were similar in both groups, including frequency and length of hospitalization, need for intensive care, death, and rate of re-exacerbation and re-admission of patients with acute COPD after six months. This study showed that a procalcitonin level could reduce the use of antibiotics in patients with lower respiratory tract infections by 50%, which translated into 39 fewer antibiotic courses per 100 patients. Withholding antibiotics was safe and did not compromise clinical outcome.

COMMENTARY BY STEPHANIE B. ABBUHL, MD, FACEP

This study also confirms that most respiratory tract infections are due to viral etiologies, with serologic evidence of acute infections reported in 81% of tested patients and IgM-positive in most. Overall, bacterial cultures were grown from sputum or bronchoalveolar lavage fluid in 21% of patients, and from blood in 7%. It is interesting to note that the highest number of positive sputum cultures was found in patients with acute exacerbations of COPD (45%), and in the procalcitonin group this percentage was the same for patients with and without antibiotic treatment. Yet antibiotics were prescribed in only 38% of the patients in the procalcitonin group, compared with 83% in the standard group, with similar outcomes in both groups. This underscores the limitation of using sputum cultures in COPD patients to decide the need for antibiotics.

This study has limitations. The study protocol allowed for the physician in charge to overrule the procalcitonin algorithm, and antibiotics were given in a small group of patients with low procalcitonin levels. In another group of patients in the procalcitonin group, antibiotics that were withheld initially were given later due to rising procalcitonin levels or at the physician's discretion. It is unclear just how many patients may have received antibiotics at a later time. While the results from this study are encouraging, further studies will need to be done to more clearly define the sensitivity and specificity of the procalcitonin assay for predicting bacterial infections. However, in light of the current overuse of antibiotics in what are self-limited often, viral respiratory infections, the potential of a rapid test to aid in the clinical decision-making is worth more investigation. ❖

Diagnosing Pulmonary Embolism in the ED: What's Tops in the Toolbox?

A B S T R A C T & C O M M E N T A R Y

Source: Perrier A, et al. Diagnosing pulmonary embolism in outpatients with clinical assessment, D-dimer measurement, venous ultrasound, and helical computerized tomography: A multicenter management study. *Am J Med* 2004;116:291-299.

THE AUTHORS ANALYZED 965 CONSECUTIVE PATIENTS presenting to any of three European emergency departments (EDs) between October 2000 and June 2002 with complaints suggestive of pulmonary embolism (PE)—sudden or worsening dyspnea, chest pain without another etiology, or syncope. A clinical point score was calculated according to a published prediction rule,[1] including previous PE or deep vein thrombosis (DVT), recent surgery, age greater than 60, pulse greater than 100/min, pO_2 less than 60 mmHg, pCO_2 less than 36 mmHg, and abnormal chest x-ray. Low, intermediate, and high probability were defined. Average age was 61; females composed 58% of the cohort. Chest pain was present in 70%, dyspnea in 66%, and syncope in 7% of cases.

On initial assessment, plasma D-dimer (Dd) was measured by enzyme-linked immunosorbent assay (ELISA) technique. Patients with Dd levels less than 500 mcg/L were followed clinically. Those with Dd levels greater than 500 mcg/L underwent leg compression ultrasound (US). If DVT was detected, anticoagulation treatment was begun. If no DVT was apparent, patients underwent helical computed tomography (CT). If PE was visualized on CT, anticoagulation was initiated. Those with low or intermediate clinical probability and normal CT and US were not anticoagulated or tested further. High clinical probability patients underwent pulmonary angiography. Those with inconclusive CT scanning (mostly due to motion artifact) underwent ventilation-perfusion (V/Q) scanning.

The overall incidence of PE in this symptomatic cohort was 222/965 (23%). Of the 891 patients with low or intermediate clinical probability of PE, 275 (31%) had normal Dd levels, compared with only 5/74 (6.8%) of those with high probability point scores ($p < 0.0001$). US confirmed DVT in 92/685 (13.4%) cases with elevated Dd levels. Helical CT was negative for PE in 458/593 (76%) of patients with normal leg US studies, positive for PE 124/593 (21%), and indeterminate in only 11 cases, in which five had low-probability V/Q scans. Overall, PE was diagnosed in 34/522 low-probability patients (7%; 95%; CI:5-9%), 125/369 intermediate probability cases (34%; 95%; CI:29-39%), and 63/74 high-probability patients (85%; 95%; CI:75-92). Only eight cases had high-probability point scores with elevated Dd levels but negative US and CT results; at angiography, two had PE, while six were normal.

During the three-month follow-up interval, 7/685 (1.0%; 95%; CI:0.5-2.1%) without PE or anticoagulation had a subsequent DVT ($n = 2$) or PE ($n = 5$); all were low-to-intermediate probability cases with normal US and CT examinations. Nine (4.1%) of those with initial PE had recurrent PE during follow-up. Major bleeding occurred in 7/222 (3.2%) of anticoagulated patients, of whom two died. Overall three-month mortality was 7.7% in patients with PE vs. 2.7% of those without PE. Costs for diagnosis in a hypothetical cohort of 1000 patients were roughly $200,000 less for the study algorithm vs. other published analyses. The authors conclude that their sequential-testing diagnostic algorithm is precise, safe, and cost-effective for detection and exclusion of PE in outpatients in the ED.

■ **COMMENTARY BY MICHAEL FELZ, MD**

Several features of Perrier's data are distinctive to me: Dd performed quite well as first-step testing to suggest, or exclude, DVT and PE. I wonder how soon ELISA technology (as utilized in Europe) will replace rapid, less expensive latex methodologies in widespread use in this country. Furthermore, the role of V/Q scanning was limited in this analysis. Lack of thromboembolic events during a three-month follow-up was 99% among those with PE excluded, even without anticoagulation. In my view, the instruments studied by Perrier need to be "tops in the toolbox" for all ED physicians considering PE in symptomatic patients. ❖

Reference

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Special Feature

Electrocardiographic Electrode Misconnection

By Richard A. Harrigan, MD

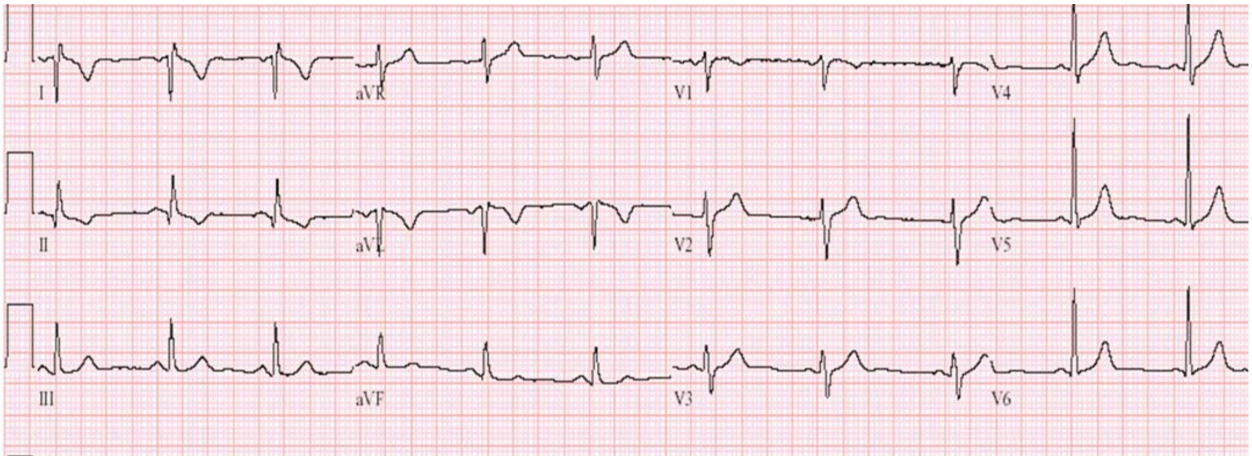
The old adage "the best chest x-ray is an old chest x-ray" can be extended to the world of electrocardiography. With the myriad and subtle changes that may occur on the 12-lead surface electrocardiogram (ECG), at times the emergency physician's (EP) best ally is an old tracing for comparison. Our residents, when asked to interpret an ECG, often will say, "It's unchanged from the last one," rather than give a detailed interpretation, especially if the ECG is not stone-cold normal. Moreover, ECG changes plus a history of chest pain or an anginal equivalent invariably spells admission. Keeping all this in mind, the EP should be wary and knowledgeable of the changes associated with ECG limb electrode misconnection—inadvertently switching the placement of electrodes on the extremities of the patient. Such changes are, in most cases, predictably abnormal and should be considered when the EP is confronted with ECG changes confined to the limb leads. The circumstances surrounding the case depicted in Figure 1 led one EP initially to recommend admission and cardiology consultation. In this case, the ECG "changes" were due to limb electrode reversal. *(See Figure 2.)*

Manifestations of Limb Electrode Reversal

There are many possible ways to inadvertently misconnect the four limb electrodes when performing a 12-lead ECG; usually such mistakes involve confusing the right and left sides or switching upper extremity and lower extremity electrodes on the same side. This discussion will be limited to the manifestations of the most common limb electrode reversal[1,2] —right arm (RA) and left arm (LA) (*See Figures 1 and 2.*)—as well as other commonly encountered misconnections: right leg (RL) / left leg (LL), RA/RL, and LA/LL. Other less common misconnections (e.g., RA/LL; LA/RL; misconnections involving three, or all four, electrodes), although rare, would result in bizarre tracings that should lead the EP to question the validity of the tracing and repeat the ECG. An understanding of the manifestations of limb electrode reversal begins with a review of the vector polarity of Einthoven's triangle (leads I, II, and III) and the augmented limb leads (aVR, aVL, and aVF). (*See Figure 3.*)

RA/LA Electrode Reversal. This limb electrode misconnection results in a change in appearance of all

Figure 1. Reversal of Arm Electrodes



At first pass, the ECG is notable for sinus rhythm with T wave inversion in leads I, aVL, and II. Closer scrutiny reveals an inverted P wave, QRS complex, and T wave in lead I, as well as a "normal" appearing complex in lead aVR. These findings, together with normal precordial lead complexes, signify RA/LA electrode reversal. Dextrocardia is excluded due to the normal R wave progression across the precordium.

Figure 2. Correction of RA/LA Electrode Reversal

Limb leads from same patient as in Figure 1, yet electrodes now are properly connected.

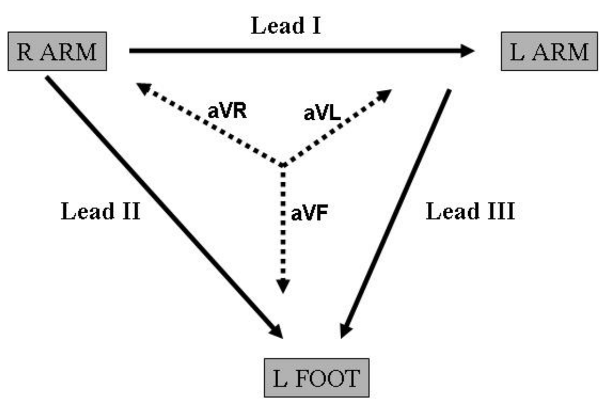
limb leads except aVF, and thus should be fairly easily suspected. The key change is an inverted P-QRS-T in lead I, due to the fact that the vector in that lead is reversed. (*See Figures 1, 2, and 3.*) Since the RA and LA electrodes are flipped, the ECG displays lead II as III (and vice versa), and displays lead aVR as aVL (and vice versa). (*See Figures 1, 2, and 3.*) Thus, a second key to detecting RA/LA electrode reversal is a normal appearing P-QRS-T in lead aVR. Since by convention the positive pole of lead aVR lies in the upper rightward quadrant of extreme axis deviation (virtually 180° opposite to the major vector of cardiac depolarization, which is in most cases into the lower leftward, or normal, axis quadrant), the P-QRS-T in lead aVR normally is upside down. Thus, a normal-appearing complex in that lead is a clue to possible limb electrode misconnection.

It should be remembered that a pattern similar to RA/LA reversal also is seen in patients with dextrocardia. Whereas dextrocardia will yield a negative P-QRS-T in lead I, it also will feature progressively smaller QRS complexes when moving from precordial leads V_1 to V_6, as the left-sided chest electrodes move further away from the right-sided heart. Normal R-wave progression across the precordial leads, coupled with an inverted P QRS-T in lead I, suggests limb electrode reversal.

RL/LL Electrode Reversal. RL/LL electrode rever-al results in no change in the ECG, since there is little difference in the electrical potential between the two legs. On the 12-lead ECG, the RL electrode serves as a ground. Due to the relatively greater distance of the leg (vs the arm) electrodes from the heart, the potential difference is negligible. Remembering that the computer within the ECG recognizes the RL electrode as a ground with no potential difference from the LL electrode, one also can predict the changes seen when the RL electrode is switched with that of the RA.

RA / RL Electrode Reversal. This electrode misconnection is relatively easy to detect, because all limb leads are affected except lead III (because it represents the LA/LL vector). (*See Figure 3.*) Now getting input from the RL electrode—in the RA position—the ECG records this negligible potential difference between leg electrodes in lead II—the lead that normally demonstrates the vector of RA to LL electrical activity, but now must record the RL electrode situated on the RA. Thus, the key to detecting RA/RL electrode reversal is a near flat line in lead II.[1,3] Similarly, if the RL electrode was switched with that of the LA, lead III now would be nearly flat, as the computer reports no potential difference between the electrodes it "sees" on the left arm

Figure 3. Standard and Augmented Limb Leads



Solid arrows depict leads I, II, and III, with arrowheads located at the positive poles; similarly, augmented leads aVR, aVL, and aVF (dotted arrows) are shown with arrowheads again reflecting positive polarity.

(placed incorrectly) and the left leg (placed correctly).

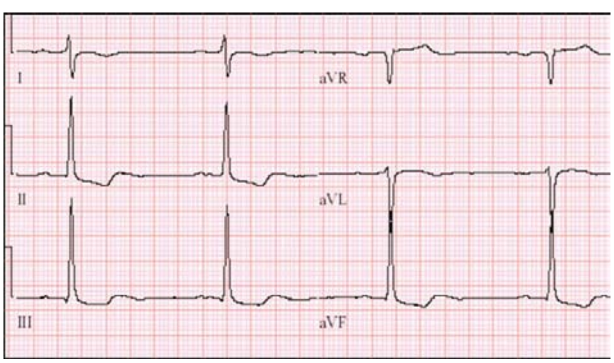
LA/LL Electrode Reversal. This is the most difficult limb electrode misconnection to detect without an old ECG; [3,4] furthermore, if an old ECG is used for comparison, any changes seen should not be ascribed reflexively to reversible cardiac ischemia. Although difficult to recognize as artifactual on any given single tracing, the changes associated with LA/LL electrode reversal should be suspected when unexpected limb lead changes are seen between one ECG and the next. These changes can be anticipated by viewing Figure 3 and mentally flipping the lead III vector from LA to LL. With LA/LL electrode reversal, leads I and II are interchanged; leads aVL and aVF are transposed; and lead III is inverted. What makes this difficult to detect when considering a lone tracing is the fact that the inferior limb leads (leads II and aVF) are becoming lateral (now leads I and aVL, respectively), and the lateral limb leads (leads I and aVL) are becoming inferior (now leads II and aVF, respectively). Moreover, inverting the P-QRS-T in lead III does not render the tracing blatantly abnormal, as the principal vector of the complexes in lead III normally may be either positive or negative. Further hindering ready detection of LA / LL electrode reversal is that lead aVR is unchanged (remember, only the left-side electrodes are misconnected).

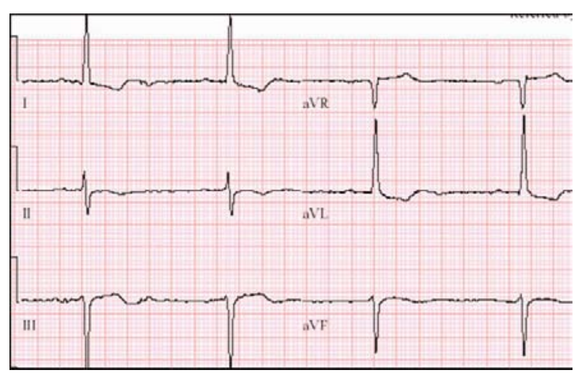
Scrutinizing the P waves in leads I, II, and III may help in detection of LA/LL electrode reversal. The P wave in lead II usually is larger than that seen in lead I, as the normal P wave vector is between +45° and +60°, and thus closely approximates the vector of lead II.[3,4] Furthermore, if a biphasic P wave appears in lead III, the terminal portion usually has a negative deflection. Using these two features, reversal of LA and LL electrodes could be detected in 90% of cases (n = 70). [4] (*See Figure 4.)*

Conclusions

Inadvertent limb electrode misconnection results in artifactual alteration of the ECG. Although the true incidence is unknown, limb electrode reversal, anecdotally, is not uncommon. Understanding the vector forces behind the standard and augmented limb leads results in an improved ability to detect limb electrode reversal. Several telltale changes occur with the commonly

Figure 4. Reversal of LA and LL Electrodes





The left-hand tracing appears to show ST segment/T wave changes inferiorly (leads II, III, and aVF); it does not appear obviously artifactual. The second tracing, recorded when the patient became free of chest pain, shows the initial ST segment/T wave changes are gone, and now similar changes are seen in leads I and aVL. Closer scrutiny reveals that lead III has become inverted, and that leads I and II are actually transposed—as well as leads aVL and aVF. These changes suggest reversal of the left-sided limb leads. Examining P wave height in leads I and II, as well as P wave morphology in lead III, does not help determine which tracing is incorrectly recorded in this case (*see text*). An old ECG showed that the right-hand tracing was indeed the "real" ECG.

encountered limb electrode misconnections; familiarity with these features may lead to better recognition of this phenomenon. ❖

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Physician CME Questions

32. Which of the following is the most difficult limb electrode reversal to detect on the ECG?
   a. Left arm / right arm
   b. Left leg / right leg
   c. Left arm / left leg
   d. Right arm / right leg

33. Which of the following is most useful in differentiating reversal of the arm electrodes from dextrocardia on the ECG?
   a. QRS complex vector in lead aVR
   b. P wave vector in lead aVR
   c. Discordance of P wave and QRS complex vectors in lead I
   d. Precordial R wave progression

34. Which of the following has been found to be useful in recognizing reversal of the left-sided limb electrodes?
   a. Precordial R wave progression
   b. Comparing P wave height in leads I and II
   c. Discordance between QRS complex vectors in leads I and III
   d. Flattening of the voltage in lead II

35. If done without oral contrast, abdominal CT scanning for bowel or mesenteric injury resulting from blunt trauma, ______________ for these injuries.
   a. suffers from low specificity
   b. suffers from low sensitivity
   c. suffers from low sensitivity and specificity
   d. has high sensitivity and specificity

36. Accurate ED diagnosis of pulmonary embolism seems to be most efficiently achieved by a combination of:
   a. clinical point score, D-dimer, leg ultrasound, and helical CT scanning.
   b. arterial blood gas measurement, D-dimer, ventilation-perfusion scanning, and echocardiography.
   c. electrocardiogram, D-dimer, helical CT scanning, and pulmonary angiography.
   d. chest x-ray, D-dimer, leg ultrasound, and ventilation-perfusion scanning.

37. In the study about the effect of procalcitonin-guided treatment on antibiotic use in lower respiratory tract infections, all of the following were found to be true *except*:
   a. A procalcitonin level could reduce the use of antibiotics in patients with lower respiratory tract infections by 50%.
   b. Antibiotic use was significantly reduced in all diagnostic subgroups except those patients with COPD exacerbations.
   c. Withholding antibiotics was safe and did not compromise clinical outcome.
   d. Most respiratory tract infections appeared to be due to viral etiologies with serologic evidence of acute infections reported in 81% of tested patients and IgM positive in most.

Answer Key

32. c

33. d

34. b

35. d

36. a

37. b

CME Objectives

To help physicians:
- Summarize the most recent significant emergency medicine-related studies;
- Discuss up-to-date information on all aspects of emergency medicine, including new drugs, techniques, equipment, trials, studies, books, teaching aids, and other information pertinent to emergency department care; and
- Evaluate the credibility of published data and recommendations.

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Physicians participate in this continuing medical education program by reading the article, using the provided references for further research, and studying the questions at the end of the article. Participants should select what they believe to be the correct answers, then refer to the list of correct answers to test their knowledge.

To clarify confusion surrounding any questions answered incorrectly, please consult the source material. After completing this activity, *you must complete the evaluation form that will be provided at the end of the semester and return it in the reply envelope provided to receive a certificate of completion.* When your evaluation is received, a certificate will be mailed to you.

ECG Review

Best Obtainable Tracing

By Ken Grauer, MD

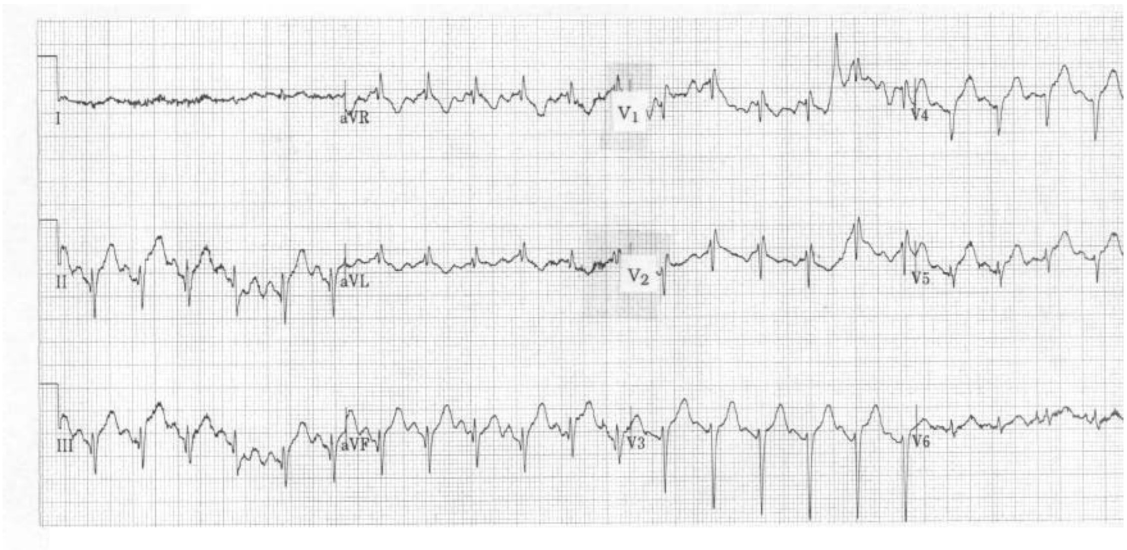

Figure. Best quality tracing obtainable from this 59-year-old woman with acute dyspnea and chest pain.

Clinical Scenario: The tracing in the Figure was obtained from a 59-year-old woman with a long history of smoking. She presented with acute dyspnea and atypical chest pain. Because of moderate respiratory difficulty, this was the best quality tracing obtainable. In full acknowledgment of its suboptimal technical quality, how would you interpret this ECG? What findings may be of potential concern?

Interpretation/Answer: As stated, the technical shortcomings of this tracing make accurate interpretation problematic. The clinical reality, however, is that optimal quality tracings may not always be obtainable in acutely ill patients, especially when there is respiratory distress.

What can be said about this tracing is that the QRS complex is narrow and that the rhythm is regular at a rate of approximately 150 beats/minute. Upright (sinus) P waves appear to precede each QRS complex in lead II, suggesting that the rhythm probably is sinus tachycardia. There is marked left axis deviation. An rSR′ pattern is seen in several of the complexes in lead V_1. Precision beyond this point is difficult to attain.

The overall pattern of this ECG is most suggestive of pulmonary disease. If new, these findings could be consistent with acute pulmonary embolism, although they more often reflect the long-standing existence of chronic obstructive pulmonary disease. The finding of a "null vector" (flat complex) in lead I is an interesting manifestation that when seen supports the ECG diagnosis of a pulmonary pattern. Additional findings that further support this impression are the incomplete right bundle branch block (rSR′) pattern in lead V_1, the relatively tall and somewhat peaked P waves in the inferior leads, and the dropoff in QRS amplitude with minimal R waves and persistent S waves in the lateral precordial leads. Findings of potential concern (especially in view of the history of chest pain on presentation) are apparent small q waves that occur in association with a difficult-to-assess ST segment appearance in each of the inferior leads. The possibility of acute ST segment elevation also exists in leads $V_3 - V_5$. Clearly, the patient needs to be monitored, acute serum markers (troponin, CK-MB) should be obtained, and a follow-up ECG should be done as soon as the patient's clinical condition allows, to confirm sinus tachycardia and rule out the possibility of acute infarction. ❖

In Future Issues: **Rhabdomyolysis**

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