ORIGINAL ARTICLE

Accurate Diagnosis of Pulmonary Embolism in ECG Taking Computed Tomography Pulmonary Angiography (CTPA) As Gold Standard

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ABSTRACT

Aim: To determine the diagnostic accuracy of Electrocardiography (ECG) in detecting pulmonary embolism, taking Computed tomography pulmonary angiography (CTPA) as gold standard.
Study design: Descriptive, Cross-sectional study
Setting: Department of Cardiology, Ch. Pervaiz Elahi Institute of Cardiology, Multan.
Duration of study:20-May-2015 to 19-Nov-2015
Methods: A total of 114 patients were included in the study. Patients of age 20-75 years and any gender with suspected pulmonary embolism were included. Collected data was analyzed through SPSS v20.0. A 2×2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of ECG. Effect modifiers like age, gender, duration of symptoms and size of embolus was controlled by stratification. P value ≤0.05 was considered significant.
Results: The mean age of the patients was 53.14±6.19 years, 89(78.1%) patients were males. Mean size of pulmonary embolus was 6.00±1.13 mm. Sensitivity of ECG in diagnosing pulmonary embolism was 98.05% taking CTPA as a gold standard, and the specificity was 72.72% which indicates that ECG is a good tool for diagnosing pulmonary embolism. The positive predictive value was 97.11% and negative predictive value was 80%. Kappa statistics was applied to see the effect of confounder variable in diagnosing PE using ECG. We do not find any significant effect of these variables on diagnosis of PE using ECG.
Conclusion: Electrocardiogram (ECG) is a good tool for the early diagnosis of Pulmonary Embolism.
Keywords: Electrocardiogram, Pulmonary Embolism, Computed Tomography Pulmonary Angiogram.

INTRODUCTION

Pulmonary emboli usually arise from thrombi that originate in the deep venous system of the lower extremities; however, they rarely also originate in the pelvic, renal, upper extremity veins, or the right heart chambers. After travelling to the lung, large thrombi can lodge at the bifurcation of the main pulmonary artery or the lobar branches and cause hemodynamic compromise[1]. Pulmonary embolism is a common and potentially lethal condition. Most patients who succumb to pulmonary embolism do so within the first few hours of the event. Despite diagnostic advances, delays in pulmonary embolism diagnosis are common and represent an important issue. As a cause of sudden death, massive pulmonary embolism is second only to sudden cardiac death[3] Cetinkaya PD et al[4] in his study has shown the prevalence of pulmonary embolism as 69.23%. Symptoms of pulmonary embolism include difficulty in breathing, chest pain on inspiration, and palpitations. Clinical signs include low blood oxygen saturation and cyanosis, rapid breathing, and a rapid heart rate. Severe cases of PE can lead to collapse, abnormally low blood pressure, and sudden death[5].

Evidence-based literature supports the practice of using clinical scoring systems to determine the clinical probability of pulmonary embolism before proceeding with testing. Validated clinical prediction rules should be used to estimate pretest probability of pulmonary embolism and to interpret test results[6]. Perform diagnostic testing on symptomatic patients with suspected pulmonary embolism to confirm or exclude the diagnosis or until an alternative diagnosis is found. Routine laboratory findings are nonspecific

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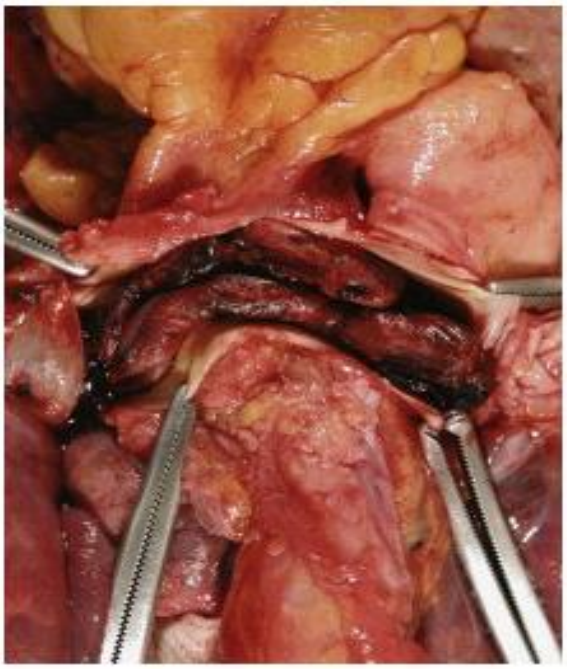
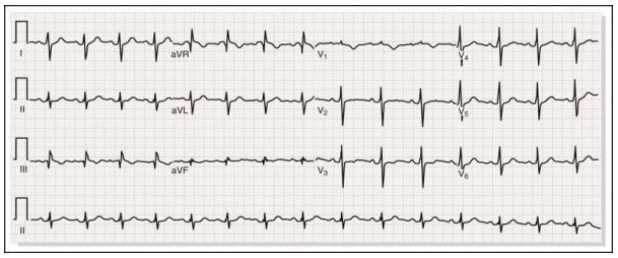
and are not helpful in pulmonary embolism, although they may suggest another diagnosis.[7] D-dimer is highly sensitive but not very specific (specificity around 50%).[8]Interest in diagnosis of acute pulmonary embolism (PE) utilizing the electrocardiogram (ECG) has decreased since the creation of imaging techniques such as V/Q scanning and Computed tomography pulmonary angiography (CTPA).[9]Although Computed tomography pulmonary angiography (CTPA)is the "gold" standard of reference for confirming or refuting a diagnosis of PE with sensitivity and specificity of 92% and 98% respectively but it cannot always be utilized.[9,10] A small but significant number of patients have co-morbid conditions that make this imaging technique either contraindicated or non-diagnostic and also it is an invasive, expensive procedure associated with morbidity and mortality, and not available in all centers.[9-11]In these circumstances, the ECG in addition to clinical acumen can be essential in directing the physician towards the diagnosis and has shown the sensitivity and specificity of 85% and 81% respectively in diagnosing pulmonary embolism[12].

The purported significance of this study was to establish the diagnostic accuracy of electrocardiography (ECG) in detecting pulmonary embolism. As no such study has been done previously in the region of south Punjab, Pakistan and this study may help in the early diagnosis and management of acute pulmonary embolism which is a life threatening condition.

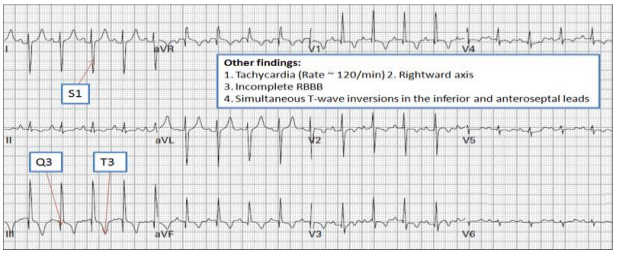
A 41-year-old woman with Pulmonary Embolism.



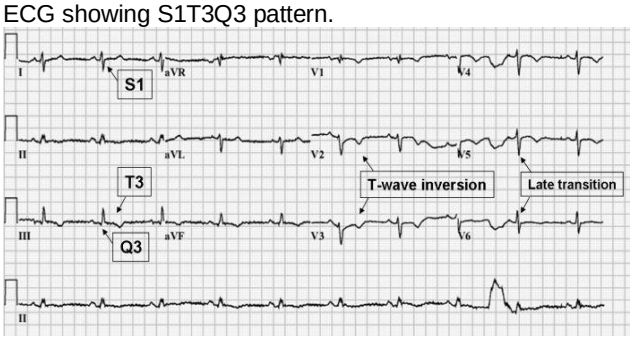
Electrocardiogram from a 33-year-old man who presented with a left main pulmonary artery embolism on chest CT scan.



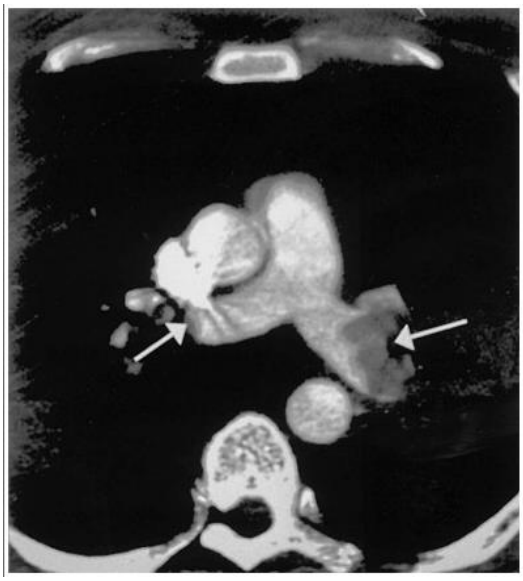
ECG showing Tachycardia, Incomplete RBBB and T-wave inversion.



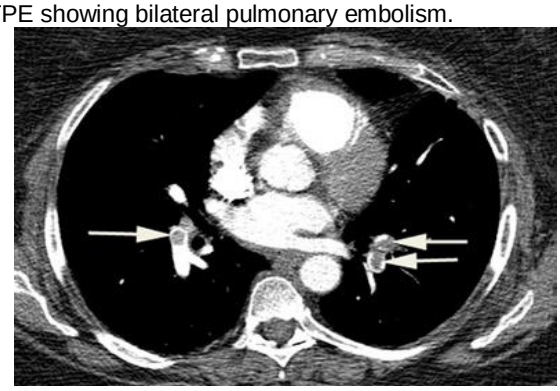
ECG showing S1T3Q3 pattern.



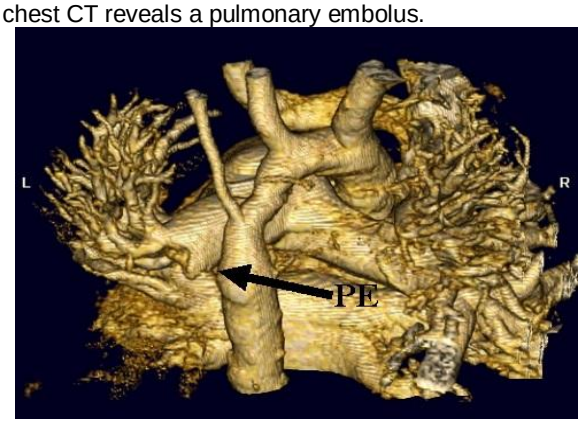
A 62-year-old physician suffered a massive pulmonary embolism



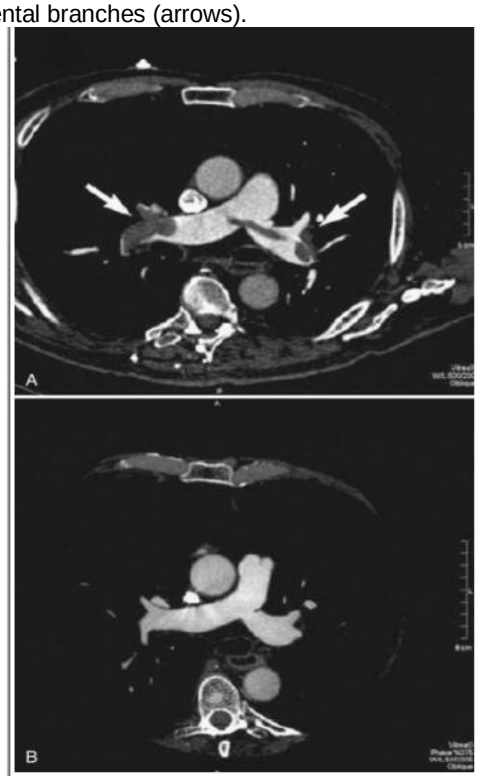
CTPE showing bilateral pulmonary embolism.



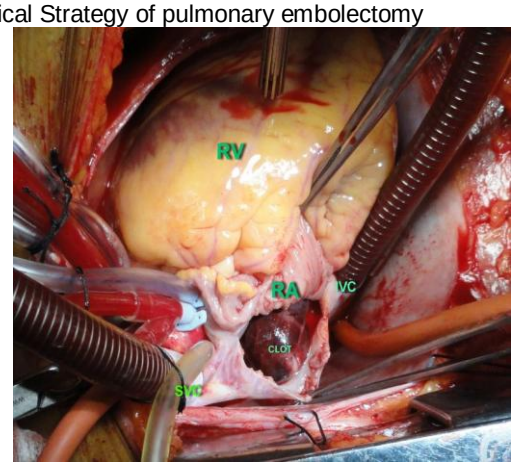
A chest CT reveals a pulmonary embolus.



Chest CT demonstrates thrombus in the right and left main stem pulmonary arteries, with clot extending into lobar and segmental branches (arrows).



Surgical Strategy of pulmonary embolectomy



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Surgical Pulmonary Embolectomy

MATERIAL AND METHODS

This descriptive, Cross-sectional study was conducted in the Department of Cardiology, Ch. Pervaiz Elahi Institute of Cardiology, Multan from 20-May-2015 to 19-Nov-2015. Sample size of 114 cases has been calculated with 95% confidence level, 13% desired precision and taking expected prevalence of pulmonary embolism i.e. 69.23%[4] with sensitivity of 85.0%[12] and specificity 81.0%[12] of ECG in diagnosing pulmonary embolism. Non-probability, consecutive sampling technique was used.

Inclusion criteria:

1. All patients with suspected pulmonary embolism within seven days clinically according to Simplified Well's Criteria (>1 score point = high probability) i.e., DVT signs or symptoms (calf pain with swelling and tenderness), A alternative diagnosis is less likely than pulmonary embolism, Heart rate > 100/min, Immobilization or surgery within 04 weeks, Prior DVT or pulmonary embolism, Hemoptysis, Cancer treated within six months or metastatic(cancer involving any body organ with metastasis anywhere in the body).
2. Adult patients of age > 20 years and < 75 years.

3. Both genders.

Exclusion criteria:

1. Patients with acute coronary syndrome (Established on history, examination, ECG, Cardiac Biomarker and Echocardiography for wall motion abnormality).
2. Patients with known case of COPD.
3. Patients with chronic heart failure (Established on history, examination and Echocardiography).
4. Patients not willing to be included in the study.

After permission from local ethical review committee, total number of 114 patients who will be presented to Department of Cardiology, Ch. Pervaiz Elahi institute of Cardiology, Multan fulfilling the inclusion/exclusion criteria will be selected. After taking informed consent and relevant history, 12 lead ECG will be performed in every patient and findings will be interpreted by the consultant cardiologist (with at least 5 years post-fellowship experience) for presence or absence of pulmonary embolism (as per-operational definition). After this all patients will undergo computed tomography pulmonary angiography (CTPA) and findings will be noted for presence or absence of pulmonary embolism (as per-operational definition) by the same consultant cardiologist. ECG findings will be correlated with the CTPA findings. Collected data was analyzed through computer software SPSS 20.0. Mean and standard deviation was calculated for quantitative variables i.e. age, duration of symptoms and size of embolus. Frequency and percentage were calculated for qualitative variables i.e. gender, pulmonary embolism on ECG and CTPA (present/absent). 2×2 contingency table was used to calculate sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of ECG in diagnosing pulmonary embolism taking computed tomography pulmonary angiography (CTPA) as gold standard. Effect modifiers like age, gender, duration of symptoms and size of embolus was controlled by stratification. Post-stratification kappa test was applied to see their effect on diagnostic accuracy and p-value ≤0.05 was considered as significant.

RESULTS

There was a total number of 114 patients in this study. The mean age of the patients in this study was 53.14±6.19 years (Table 1). The mean duration of symptoms was 3.71±1.62 days before arrival to hospital (Table 2). There were more males in this study, there were 89(78.1%) males and 25(21.9%) females in this study (Table 3). The mean size of pulmonary embolus in this study was 6.00±1.13mm (Table 4). There were 104 (91.2%) patients who were diagnosed for pulmonary embolism using electrocardiogram (ECG) and 10(8.8%) patients were patients who were diagnosed as not having pulmonary embolism (Table 5). There were 103(89.5%) patients who were confirmed on CTPA for pulmonary embolism whereas 11(10.5%) cases were not of having pulmonary embolism (Table 6). The calculated sensitivity of ECG in diagnosing pulmonary embolism was 98.05% taking CTPA as a gold standard, and the specificity was 72.72% which indicates that ECG is a good tool for diagnosing pulmonary embolism (Table 7 and 8). The positive predictive value was 97.11% and negative predictive value was 80% (Table 9, 10).

To see the diagnostic accuracy Likelihood ratio was calculated. The Positive value of Likelihood ratio was 3.59 which means that there will be a strong probability of pulmonary embolism if it is detected of ECG. The –Ve value of likelihood ratio was 0.03, which shows that if will be a strong probability of not having pulmonary embolism if the results are negative on ECG.

Kappa statistics was applied by stratifying gender to see the effect of gender in diagnosing PE using ECG. We do not find any significant effect of gender on it . Similarly we stratified age to see the effect of age on diagnosis on PE using ECG and we do not found significant effect of age on it . Kappa statistics was also applied by stratifying the patients on the basis of duration of symptoms to see the effect of it in diagnosing PE. But we do not see any effect of duration of symptoms on diagnosis of PE . stratification was also done on the basis of size of embolus and kappa statistics was applied, we see that ECG diagnosis were accurate in all groups and there was no effect of embolus size on diagnosing PE using electrocardiogram.

Table 1: Descriptive Statistics of Age

Variable	Mean	Standard Deviation
Age (Years)	53.14	6.19

Table 2: Descriptive Statistics of Duration of Symptoms

Variable	Mean	Standard Deviation
Duration of Symptoms (Days)	3.71	1.62

Table 3: Descriptive Statistics of Size of Embolus.

Variable	Mean	Standard Deviation
Size of Embolus (mm)	6.00	1.13

Table 4: Frequency of Gender

Variable	Frequency	%age
Male Gender	89	78.1
Female Gender	25	21.9

Table 5: Frequency of Pulmonary Embolism on ECG

Variable	Frequency	%age
Embolism present	104	91.2
Embolism Absent	10	8.8

Table 6: Frequency of Pulmonary Embolism on computed tomography pulmonary angiography (CTPA)

Variable	Frequency	%age
Embolism present	103	89.5
Embolism Absent	11	10.5

Table 7: Calculation of Sensitivity

	Pulmonary Embolism	
	Present	Absent
Positive	101	03
Negative	02	08

$$\text{Sensitivity} = \frac{TP}{\text{All positive cases on CTPA}} \times 100$$

$$= \frac{101}{103} \times 100$$

Sensitivity = 98.05%

Table 8: Calculation of Specificity

	Pulmonary Embolism	
	Present	Absent
Positive	101	03
Negative	02	08

$$\text{Specificity} = \frac{TN}{\text{All negative cases on CTPA}} \times 100$$

$$\text{Specificity} = \frac{08}{11} \times 100$$

Specificity = 72.72%

Table 9: Calculation of Positive Predictive Value

	Pulmonary Embolism	
	Present	Absent
Positive	101	03
Negative	02	08

$$\text{Positive Predictive Value} = \frac{TP}{\text{All positive cases on ECG}} \times 100$$

$$\text{Positive Predictive Value} = \frac{101}{104} \times 100$$

Positive Predictive Value = 97.11%

Table 10: Calculation of Negative Predictive Value.

	Pulmonary Embolism	
	Present	Absent
Positive	101	03
Negative	02	08

$$\text{Negative Predictive Value} = \frac{TN}{\text{All negative cases on ECG}} \times 100$$

$$\text{Negative Predictive Value} = \frac{08}{10} \times 100$$

Negative Predictive Value = 80%

DISCUSSION

Pulmonary embolism due to thrombotic occlusion of the main pulmonary artery or branching pulmonary arteries is a common complication. Patients who come to cardiac emergency department due to cardio-pulmonary symptoms are often evaluated for pulmonary embolism. The diagnosis of pulmonary embolism remains difficult due to non-specific signs, symptoms and risk factors with which it is associated. Because no individual risk factor, patient symptom or clinical sign can diagnose or reject pulmonary embolism, different tools have been developed to help clinicians during evaluation of the patients with suspected acute pulmonary embolism. The purpose of these tools is to help the clinician to stratify patients into different groups for which different diagnostic strategies are appropriate; those for whom pulmonary embolism is so unlikely that they do not need further evaluation, those patients for whom plasma D-dimer study can provide additional risk scoring, those who are at enough risk that imaging study is indicated.

Computed tomography (CT) has become a gold standard for evaluation of patients suspected of pulmonary embolism. The use of CT has been increasing in inpatient, outpatient and emergency departments for the evaluation of PE. Although the incidence of PE has become increased due to CT, but there has been minimum or no reduction in mortality. But the risks of CT makes its use more concerning. Radiations from CT are thought to be a risk factor for cancer. In a cohort study, the children with exposure of CT have a higher incidence of leukemia and brain tumors later in life. The contrast die used in CT carries the risk of nephropathy. It has also been seen that one third of emergency department patients who underwent CT for the diagnosis of PE, also have to undergo CT for the same diagnosis within the five years. So the potential risks of CT should be kept in mind and the patient should not undergo though this diagnostic test until there is no other way.

Electrocardiogram (ECG) is another tool used for the diagnosis of PE. There is a wide range of ECG features associated with PE. The most well-known finding is the S1Q3T3 pattern. The most common presentation is that of sinus tachycardia. This occurs in response to the physiological demand for cardiac output with decreased left-sided stroke volume. There have also been case reports of electrical alternans and ST segment elevation in lead aVR with ST segment depression in leads I and V4–V6.

In this study, we found that ECG test has a good sensitivity and specificity in diagnosing the pulmonary

embolism. And we do not found any significant effect of age, gender, duration of symptoms and size of embolus on diagnostic accuracy of ECG.

CONCLUSION

ECG is a good tool for the early diagnosis of Pulmonary Embolism.

REFRENCES

1. Agnelli G, Buller HR, Cohen A, Curto M, Gallus AS, Johnson M, et al. Oral apixaban for the treatment of acute venous thromboembolism. N Engl J Med. 2013;369(9):799-808.
2. Ozsu S, Oztuna F, Bulbul Y. The role of risk factors in delayed diagnosis of pulmonary embolism. Am J Emerg Med. 2011;29(1):26-32.
3. Vanni S, Viviani G, Baioni M, Pepe G, Nazerian P, Socci F, et al. Prognostic value of plasma lactate levels among patients with acute pulmonary embolism: the thrombo-embolism lactate outcome study. Ann Emerg Med. 2013;61(3):330-8.
4. Cetinkaya PD, Erer OF, Ozkan SA, Ari G, Ozkan M. A Comparison of ECG and three clinical scoring methods for the diagnosis of pulmonary thromboembolism. Turk Toraks Dergisi. 2011;12(1):9-13.
5. Douma RA, Mos IC, Erkens PM, Nizet TA, Durian MF, Hovens MM, et al. Performance of 4 clinical decision rules in the diagnostic management of acute pulmonary embolism: a prospective cohort study. Ann Intern Med. 2011;154(11):709-18.
6. Singh B, Parsaik AK, Agarwal D, Surana A, Mascarenhas SS, Chandra S. Diagnostic accuracy of pulmonary embolism rule-out criteria: a systematic review and meta-analysis. Ann Emerg Med. 2012;59:517-20.
7. Henzler T, Roeger S, Meyer M, Schoepf UJ, Nance JW Jr, Haghi D, et al. Pulmonary embolism: CT signs and cardiac biomarkers for predicting right ventricular dysfunction. Eur Respir J. 2012;39(4):919-26.
8. Kline JA, Hogg MM, Courtney DM, Miller CD, Jones AE, Smithline HA, et al. D-dimer and exhaled CO2/O2 to detect segmental pulmonary embolism in moderate-risk patients. Am J Respir Crit Care Med. 2010;182(5):669-75.
9. Cohen R, Loarte P, Navarro V, Mirrer B. Echocardiographic findings in pulmonary embolism: An important guide for the management of the patient. World J Cardiovas Dis. 2012;2:161-4.
10. Becattini C, Agnelli G, Vedovati MC. Multidetector computed tomography for acute pulmonary embolism: diagnosis and risk stratification in a single test. Eur Heart J. 2011;32(13):1657-63.
11. Wiener RS, Schwartz LM, Woloshin S. When a test is too good: how CT pulmonary angiograms find pulmonary emboli that do not need to be found. Br Med J. 2013;347:f3368.
12. Ferrari E, Imbert A, Chevalier T, Mihoubi A, Morand P, Baudouy M. The ECG in pulmonary embolism. Predictive value of negative T waves in precordial leads--80 case reports. Chest. 1997;111:537-43.