Original
Contribution

NEW ELECTROCARDIOGRAPHIC CHANGES IN PATIENTS DIAGNOSED WITH PULMONARY EMBOLISM

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□ **Abstract—Background:** The electronic medical record is a relatively new technology that allows quick review of patients' previous medical records, including previous electrocardiograms (ECGs). Previous studies have evaluated ECG patterns predictive of pulmonary embolism (PE) at the time of PE diagnosis, though none have examined ECG changes in these patients when compared with their previous ECGs. **Objective:** Our aim was to identify the most common ECG changes in patients with known PE when their ECGs were compared with their previous ECGs. **Methods:** A retrospective chart review of patients diagnosed with PE in the emergency department was performed. Each patient's presenting ECG was compared with their most recent ECG obtained before diagnosis of PE. **Results:** A total of 352 cases were reviewed. New T wave inversions, commonly in the inferior leads, were the most common change found, occurring in 34.4% of cases. New T wave flattening, also most commonly in the inferior leads, was the second most common change, occurring in 29.5%. A new sinus tachycardia occurred in 27.3% of cases. In 24.1% of patients, no new ECG changes were noted, with this finding more likely to occur in patients younger than 60 years. **Conclusions:** The most common ECG changes when compared with previous ECG in the setting of PE are T wave inversion and flattening, most commonly in the inferior leads, and occurring in approximately one-third of cases. Approximately one-quarter of patients will have a new sinus tachycardia, and approximately one-quarter will have no change in their ECG. © 2016 Published by Elsevier Inc.

INTRODUCTION

Pulmonary embolism (PE) is the third most common cause of death from cardiovascular disease after heart attack and stroke [1]. The annual incidence of PE in the United States has been estimated at 600,000 cases, with an acute fatality rate ranging from 7% to 11% [2]. Despite new diagnostic methods and technology, the diagnosis of PE is frequently missed, with 10% to 30% of cases not diagnosed until autopsy [3].

McGinn and White were the first to describe electrocardiographic (ECG) changes with PE in 1935 [4]. Since then, >20 different ECG changes with PE have been described [5]. ECG is typically one of the first diagnostic procedures performed in the emergency department (ED) patient presenting with chest pain or dyspnea. However, the ECG has poor sensitivity and specificity for diagnosing PE, and its main value in this setting is its ability to identify other potentially life-threatening diagnoses, such as myocardial ischemia or infarction and pericarditis [3].

The advent of the electronic health record in the 21st century has allowed for rapid retrieval of previously

unavailable medical data, including previous ECGs. This new resource has proven to be valuable when interpreting ECGs in those patients with chest pain of possible cardiac origin, because many of them will have pre-existing nonspecific ECG changes. In light of this fact, the purpose of this study was to report the dynamic ECG changes found in those patients with known PE when their ECGs were compared with their previous ones.

METHODS

This was a retrospective study conducted at two university-affiliated teaching hospitals with a combined annual census of approximately 120,000. Approval from each hospital's Institutional Review Board was granted before the implementation of the study. During the study period, from January 1, 2008 through December 31, 2013 at one hospital, and from January 1, 2012 through May 31, 2015 at the other, the records of all patients with an ED diagnosis of PE were reviewed.

Only those patients with PE confirmed by computed tomography angiography (CTA), a ventilation-perfusion (VQ) scan with a high probability result, and patients in whom PE was suspected with right ventricular dysfunction noted on echocardiography (ECHO) were included in the study. Furthermore, only patients with an ECG performed in the ED at the time of PE diagnosis and an available previous ECG were included. ECGs obtained at the time of PE diagnosis were compared with the patients' most recent previous ECGs by a single board-certified emergency physician. Ten percent of the ECG comparisons were also assessed by a second board-certified emergency physician and inter-rater agreement was measured. Changes in rate, rhythm, axis, and interval/morphology, as well as new ischemic changes were recorded on a structured data form.

RESULTS

Data from 352 patient records was included in the study. Mean patient age was 68 years, with a range from 23 to 96 years. Seventy percent of patients were aged 60 years or older. The majority (62.5%) of patients were female. Two hundred and eighty-five (80.9%) of the PEs were diagnosed by CTA, 64 (18.2%) were diagnosed by high-probability VQ scan, and 3 (0.9%) were diagnosed by clinical suspicion with right ventricular dysfunction found on ECHO. Of those PEs diagnosed by CTA, 173 (60.7%) were in a segmental pulmonary artery, 85 (29.8%) were in a main pulmonary artery, and 28 (8.0%) were saddle emboli straddling the bifurcation of the main pulmonary arterial trunk.

Table 1 summarizes patient clinical characteristics and ECG abnormalities found on their most recent ECGs obtained before the diagnosis of PE. Dyspnea was the most common presenting symptom, present in more than half of the cases. An active malignancy was the most common predisposing condition for thromboembolic disease, present in 13.9% of cases. T wave flattening was the most common abnormality found on previous ECGs, noted in 12.5% of cases.

Mean duration of time between previous ECG and ECG at the time of PE diagnosis was 14.2 months, with a median of 10 months and range of 1 to 96 months. Table 2 summarizes the new ECG abnormalities found. There was 94.3% inter-rater agreement between the two emergency physicians in those ECG comparisons reviewed by both. The majority of patients had some notable change in their ECG, with only 24.1% having no change at all. Analysis of this subgroup of patients with no ECG change noted at the time of PE diagnosis revealed that this finding was more likely to occur in patients younger than 60 years than in older patients ($p = 0.05$). A new right axis deviation (RAD) occurred in 11.1% of cases, and a new right bundle branch block (RBBB) appeared in 5.7%. Only 3.7% of ECGs had a new S1Q3T3 pattern. Subanalysis comparing ECGs of patients with saddle emboli with those of patients with non−saddle emboli found that the ECGs of saddle emboli patients were more likely to show new T wave inversions ($p = 0.001$), T wave flattening ($p = 0.04$), sinus tachycardia ($p = 0.006$), ST segment depression ($p = 0.05$), RBBB ($p = 0.002$), and S1Q3T3 pattern ($p = 0.0001$).

Table 1. Patient Clinical Characteristics and Previous Electrocardiogram Abnormalities

Presenting Symptoms	n (%)	Associated Conditions	n (%)	Previous ECG Abnormalities	n (%)
Dyspnea	196 (55.7)	Malignancy (current)	49 (13.9)	T wave flattening	44 (12.5)
Chest pain	102 (29.0)	Previous DVT or PE	36 (10.2)	Sinus tachycardia	26 (7.4)
Unilateral leg swelling	21 (6.0)	Limb immobilization	34 (9.7)	T wave inversions	24 (6.8)
Upper abdominal pain	16 (4.5)	Obesity (BMI > 35)	33 (9.4)	Right bundle branch block	12 (3.4)
Altered mental status	10 (2.8)	Pregnancy	1 (0.3)	Left bundle branch block	9 (2.6)
Back pain	9 (2.6)				
Hemoptysis	8 (2.3)				
Syncope	5 (1.4)				
Cardiac arrest	2 (0.6)				

BMI = body mass index; DVT = deep venous thrombosis; ECG = electrocardiogram; PE = pulmonary embolism.