Clinical Outcomes and Electrocardiographic Score in Patients with Clinical Probability of Pulmonary Thromboembolism

Jeffrey M. Chua, MD; Ricky Choa, MD

Background --- Pulmonary Embolism (PE) produces electrocardiographic (ECG) abnormalities in proportion to the degree of pulmonary hypertension and pulmonary vascular obstruction. We hypothesized that an ECG score may be of use, in combination with clinical parameters and prediction rules, in identifying such patients at risk for in-hospital clinical adverse events.

Methods --- All adult patients admitted for at least 72 hours at the private and service wards of Philippine Heart Center (PHC) between January 2005 and November 2009 with confirmed PE were enrolled in the study. A clinical decision scoring system based on the Revised Geneva Score comprising of eight variables were used to stratify patients into high clinical probability or non-high clinical probability (low and intermediate) of PE. Electrocardiograms were obtained within 72 hours after suffering symptoms related to PE or onset of clinical deterioration after initial stabilization during admission. The ECG score was then calculated. Eligible patients were further subdivided into groups comprising of those with ECG score of ≥ 3 and those with score of ≤ 3. The information on the clinical outcomes were analyzed and compared among the four groups.

Results --- One hundred (100) patients were included in the study. Twenty-one patients (21%) died during the index confinement. The incidence of hemodynamic deterioration and major complications were also found to occur in 37% and 20% of patients, respectively. The incidence of hemodynamic deterioration exhibited significant differences between groups with low and high ECG scores (19% vs. 47%, p=0.005). The incidence of in-hospital hemodynamic collapse and the necessity for treatment upgrade and catecholamine infusion were all significantly more frequent in patients with high ECG scores (11% vs. 30%, p=0.027; 17% vs. 38%, p=0.023; and 11% vs. 28%, p=0.039, respectively). The composite outcome of major complications did not reach statistical significance but recurrent thromboembolic events were noted to be significantly higher in patients with high ECG score (3% vs. 17%, p=0.029). Mortality rate was also increased among patients with high ECG score (11% vs. 27%, p=0.050). In the subgroup analysis, patients with high clinical probability and high ECG scores in combination have a significantly higher incidence of hemodynamic deterioration compared to other groups (p=0.018). There was also a similar trend for this group to have an increased rate of mortality and major complications, although the difference did not reach statistical significance in this study.

Conclusions --- The ECG-scoring system can be very useful in identifying patients at risk for developing clinical endpoints of mortality and hemodynamic deterioration among patients with low and high clinical probability of PE. Although the prognostic accuracy of the ECG score does not allow identification of all those who will develop adverse outcomes, it can provide an incremental role to the clinical stratification provided by the Revised Geneva Scoring. ***Phil Heart Center J 2013;17(1):17-27.***

Key Words: Pulmonary thromboembolism ■ electrocardiogram (ECG)

Pulmonary embolism (PE) and deep venous thrombosis, which encompass the term venous thromboembolism, afflict millions of individuals worldwide with a case fatality rate, approximately 10-15%, exceeding the mortality rate for acute myocardial infarction.[1]

PE is a common difficult problem to diagnose and the application of therapy depends on appropriate identification of clinical risk for adverse events. Patients with high-risk of life-threatening PE may benefit from thrombolysis while those with low-risk PE can be treated

Finalist, Oral Paper Presentation 19th PHC Annual Research Paper Competition held on February 21, 2011 at Philippine Heart Center,
Correspondence to ***Dr. Jeffrey Chua MD,*** Department of Adult Cardiology. Philippine Heart Center, East Avenue, Quezon City, Philippines 1100
Available at **http://www.phc.gov.ph/journal/publication** ISSN 0018-9034

as outpatients with anticoagulation only. In other words, in order to employ effective management, the clinician relies on clinical judgement or high index of suspicion prior to confirmatory imaging of PE so that those most at risk will be recognized and treated early and aggressively, and those with non-life threatening PE could be investigated at a later time period.

The guidelines on the diagnosis and clinical management of PE recommended the use of prediction rules, whether the Weil's score or the Revised Geneva score, to identify suspected PE patients into groups of clinical probabilities. When either rule is used, the percentage of PE patients is around 10% in the low probability group, 30% in the moderate probability group and 65% in the high probability group.[1]

The utility of an electrocardiographic (ECG)-based predictive rule in the diagnosis of PE is limited, in part due to poor positive predictive value and sensitivity.[2] However, patients with extensive amount of embolization found on diagnostic imaging were found to have greater prevalence of ECG abnormalities and accordingly a normal ECG is seldom seen in those with extensive PE.[3] With the purpose of making it clinically relevant, the ECG have recently been expanded to scoring systems in order to correlate ECG findings with the extent of vascular occlusion.[4,5] However, the clinical value of ECG-based scoring systems still remains a speculation. Methods used to diagnose and define the severity of PE, such as CT scan, V/Q scan, and the finding of right ventricular (RV) dysfunction on echocardiography are either overused or not routinely and immediate ly done in the early management of those with clinical suspicion of PE in many centers. It remains unknown whether triage of patients with clinical suspicion of PE could become easier and faster if it includes the use of ECG score. Furthermore, the implications of a high ECG score in relation to clinical outcomes particularly the risk of in-hospital death have not yet been explored. Based on the available data, we feel that the ECG score may be of use in combination with clinical parameters and prediction rules, thus, warrants further evaluation on its relation with relevant adverse clinical outcomes. This study was done to determine the usefulness of ECG-scoring system in identifying patients at risk for developing clinical endpoints of mortality, hemodynamic deterioration and major complications among patients with clinical probability of PE.

METHODOLOGY

This is a retrospective cohort study involving adult subjects admitted for at least 72 hours at the private and service wards of PHC between January 2005 and November 2009 with clinical suspicion and/or evidence confirmed pulmonary embolism (PE).

For inclusion in the study, patients had to have clinical suspicion and confirmation of PE by imaging studies (CT angiography, ventilation, perfusion lung scan, and leg ultrasound) in accordance with the guidelines existing at the time of this study. Excluded were the following: patients with ST-elevation MI; patients with evidence of valvular heart disease and congenital heart disease with pulmonary hypertension; and patients with left bundle branch block, pre-excitation, pacemaker rhythms, and idioventricular rhythms on baseline ECG.

Patient data selection and admission to the study was done by the principal investigator. Data were abstracted from the medical records and registry data of the 3 imaging departments, and were then entered into a database. Pertinent information on: 1) the clinical presentation of the patients on admission; 2) the presence of predisposing factors for venous thromboembolism; 3) the findings of relevant laboratory and diagnostic procedures performed, including the original 12-lead ECG and echocardiogram (Table 1 and 2). All of the predisposing risk factors and clinical parameters were likewise in accordance with standard definition. A clinical decision scoring system (Appendix A) based on the Revised Geneva Score comprising of eight (8) variables stratified patients into high clinical probability or non-high clinical probability (low and intermediate) of PE.[7] Markers of disease severity such as presence of hemodynamic instability at the time of hospital admission, evidence of RV dysfunction and myocardial injury, were also obtained.

Electrocardiograms from patients with confirmed PE were searched from the medical records and were considered legible only if obtained within 72 hours after suffering symptoms related to PE or onset of clinical deterioration after initial stabilization during admission. Specific ECG abnormalities that were previously shown to be associated with PE are listed in Table 2. The index test and ECG score were calculated according to the method of the original authors (Appendix B).[3] Subsequently, eligible patients corresponding to groups with high and low clinical probabilities of PE were further subdivided into groups comprising of those with ECG score of ≥ 3 and those with score of <3. The information on the clinical outcomes of mortality, hemodynamic deterioration, and major complications was gathered from the index admission, and then were analyzed and compared among the four (4) groups (Figure 1). The ECG scores were then evaluated with regard to their impact on these clinical outcomes.

Mortality was defined as death due to fatal PE, bleeding, cancer, or other established diagnosis. Hemodynamic deterioration was taken into account to evaluate the short-term clinical course PE patients. It is a composite study end-point including: (1) new onset of hemodynamic collapse, (2) necessity for treatment upgrading, with thrombolysis or emergency surgical embolectomy or catheter thrombus fragmentation or inferior vena cava filter,in adjunct to standard therapy such as low-molecular-weight heparin, unfractionated heparin, or vitamin K antagonists. (3) need for endotracheal intubation or cardiopulmonary resuscitation, (4) necessity for catecholamine infusion. Hemodynamic deterioration could be due to both treatment failure and early recurrence of pulmonary emboli. Major complications include incidence of major bleeding and recurrence of PE. Major bleeding was defined as fatal bleeding, and/or symptomatic bleeding in a critical area or organ, and/or bleeding causing a fall in hemoglobin level of ≥ 20 g/L, or leading to transfusion of ≥ 2 units of whole blood or red cells. Recurrent PE was judged to be present if recurrent PE or DVT were documented or if there was a death in which PE could not be identified as a causative factor with assurance.

Sample size and Statistical analysis: The computed sample size was ≥ 97 at 95% confidence level with relative error of 20% and assumed hemodynamic instability rate of 46% among patients with PE.[6]

Descriptive statistics included percentages for categorical data. Chi-square test was used to compare incidence of mortality, hemodynamic deterioration, and major complications with ECG score of ≥ 3 and <3. To determine the agreement of cut-off scores for ECG with the study outcomes, sensitivity, specificity, positive predictive value, and negative predictive value were determined. The prognostic relevance of a high ECG score with respect to the study outcomes was analyzed univariately using Fischer's exact test.

RESULTS

Between 2005 to 2009, a total of 152 patients were diagnosed and confirmed to have PE at the Philippine Heart Center, of whom 52 patients (34%) were excluded because of predefined exclusion criteria: No available ECG during hospital admission (n = 17), diagnosis of Congenital heart disease (n = 14) and Valvular heart disease (n = 16), and presence of ECG abnormalities such as pacemaker rhythm (n =2), left bundle branch block (n = 2), and pre-excitation (n=1). This left 100 cases (66%) in which both the Revised Geneva Score and ECG Score were evaluated.

The baseline characteristics of eligible patients are described in Table 1. As part of the diagnostic workup on admission due to clinical suspicion of PE, an intermediate to high-probability lung scan was obtained in 52 patients (52%), and pulmonary CT angiography was performed in 53 patients (53%), confirming the presence of PE obstruction in all cases. In addition, the diagnosis of DVT was established in 42 of the patients (42%) studied by vein sonography. A complete echocardiographic examination was available in 80 patients (80%), and revealed the presence of moderate to severe pulmonary hypertension (53%), RV enlargement (51%) and systolic dysfunction (44%), and tricuspid regurgitation (49%).

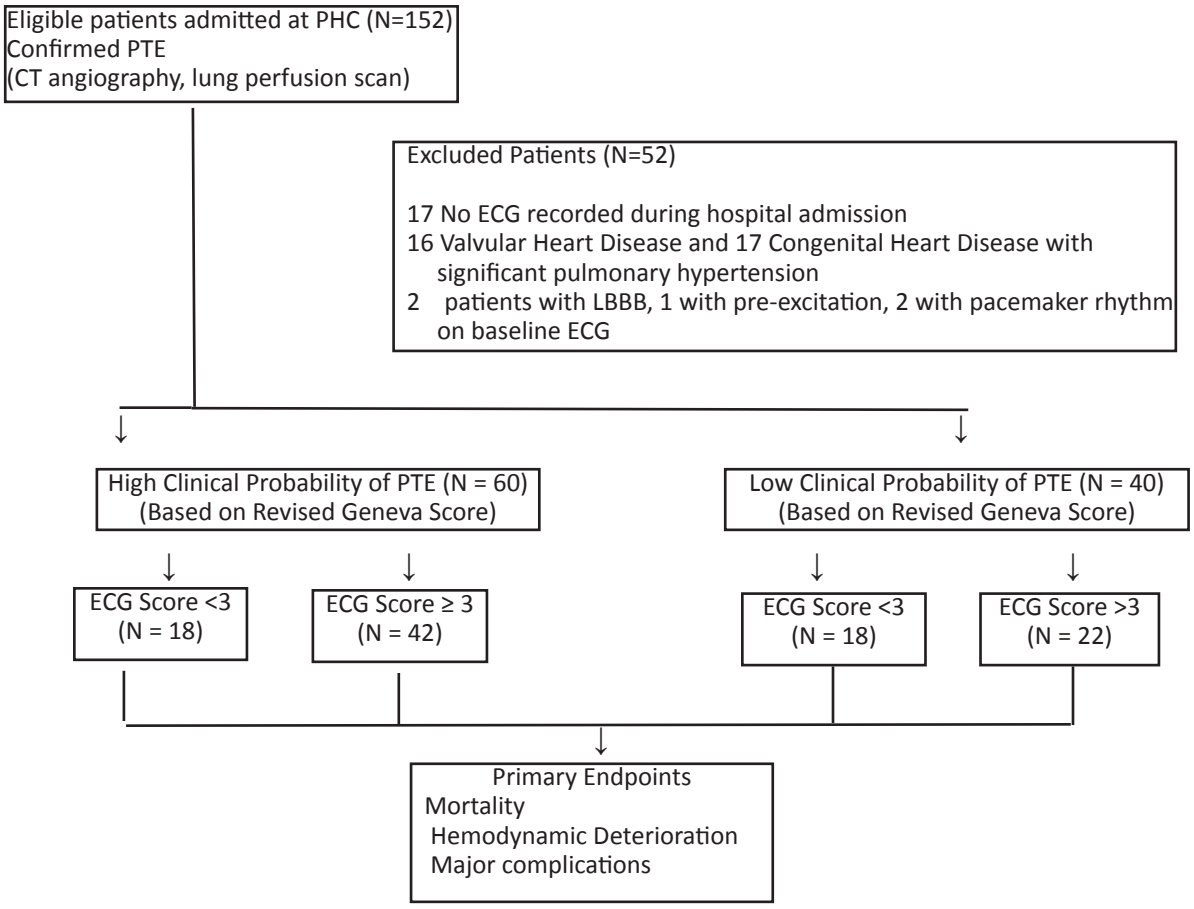

Figure 1. Flow Diagram of Study Protocol

Patients most frequently presented with dyspnea (91%) that was associated with tachycardia (67%) and unilateral limb edema (75%), and they showed lower values of O2 saturation in arterial blood gas (75%). Electrocardiographic abnormalities were identified in 77% of patients (Table 2); T-wave inversions in the right precordial leads was the most frequent abnormality (45%) followed by sinus tachycardia (38%).

Of the 100 patients diagnosed with PE, 21 patients (21%) died during the index confinement. None of the fatalities had an available autopsy reports to confirm the cause of death. The incidence of hemodynamic deterioration and major complications were also found to occur in 37% and 20% of patients, respectively (Table 3).

The Revised Geneva Score and ECG score correlation with patient outcome. The summary of clinical and electrocardiographic variables used in the Revised Geneva Score and the ECG score are summarized in Tables 4 and 5. The patient outcomes with low or high scores are compared in Table 6. The incidence of hemodynamic deterioration and major complications differed significantly between those with low and high clinical probabilities (Revised Geneva Score), (15% vs. 27%, p=0.033; and 10% vs. 27%, p=0.034), respectively. The differences were significantly seen in the necessity for treatment upgrading (15% vs. 40%, p=0.006) and mechanical ventilation and/or CPR (13% vs. 32%, p=0.023), and incidence of bleeding complications (8% vs. 23%, p=0.033). The incidence of hemodynamic deterioration also exhibited significant differences between groups with low and high ECG scores (19% vs. 47%, p=0.005). The incidence of in-hospital hemodynamic collapse and the necessity for treatment upgrade and catecholamine infusion were all significantly more frequent in patients with high ECG scores (11% vs. 30%, p=0.027;

Table 1. Baseline Characteristics of Subjects with Pulmonary Embolism Included in the Study (PHC, 2011)

Characteristics	N (%) N = 100
Male	4 (44)
Medical History	
Immobility	38 (38)
Hypercoagulability	8 (8)
Congestive heart failure	27 (27)
Diabetes Mellitus	27 (27)
Hypertension	59 (59)
CAD/Stable Angina/MI	27 (27)
Cerebrovascular disease	6 (6)
Chronic Kidney Disease	5 (5)
Peripheral Vascular Disease	11 (11)
Chronic Lung Disease	27 (27)
Symptoms/signs	
Unexplained dyspnea	91 (91)
Chest pain, either pleuritic or "atypical"	48 (48)
Altered mental status	22 (22)
Systolic BP <100	31 (31)
Respiratory failure	23 (23)
Echocardiographic findings (if available)	80 (80)
Pulmonary hypertension (moderate to severe)	42 (53)
RV enlargement	41 (51)
RV systolic dysfunction	35 (44)
RA enlargement	42 (53)
Tricuspid regurgitation (moderate to severe)	39 (49)
Laboratory findings	
PaO2 <80mmHg	75 (75)
Imaging Techniques	
CT angiography	53 (53)
V/Q scan (high probability)	37 (37)
Compression UTZ (evidence of DVT)	42 (42)

17% vs. 38%, p=0.023; and 11% vs. 28%, p=0.039, respectively). The composite outcome of major complications did not reach statistical significance but recurrent thromboembolic events were noted to be significantly higher in patients with high ECG score (3% vs. 17%, p=0.029). Mortality rate was also increased among patients with high ECG score (11% vs. 27%, p=0.050).

In the subgroup analysis (Table 7), it showed that patients with high clinical probability and high ECG scores in combination have a significantly higher incidence of hemodynamic deterioration compared to other groups (p=0.018). There was also a similar trend for this group to have an increased rate of mortality and major complications, although the difference did not reach statistical significance in this study. The prognostic sensitivity and specificity, as well as the positive and negative predictive value of the high ECG score, which was univariately associated with most of the study outcomes ($p < 0.05$), are displayed in Table 8.

DISCUSSION

PE usually come about 3-7 days after the beginning of DVT, and possibly become fatal within 1 hour after the start of symptoms in 10% of cases without clinically being recognized. The presence of clinical shock or hypotension (5-10% of cases) or laboratory signs of right ventricular and/or injury (up to 50% of cases) indicates a poorer prognosis.[8]

PE commonly presents to the emergency department physicians unrecognized because the clinical presentation is not specific and very common. Both underdiagnosis and

Table 2. Distribution of subjects according to ECG findings associated with Pulmonary Embolism (PHC, 2011)

ECG Findings	N = 100 (%)
Arrhythmias	
Sinus Tachycardia	38 (38)
Atrial Fibrillation	17 (17)
Premature Contractions	2 (2)
T wave inversions in the right precordial leads	45 (45)
QR or qR pattern in the right ventricular leads	18 (18)
Right axis deviation	32 (32)
S1Q3 or S1Q3T3 patterns	11 (11)
Right bundle branch block	13 (13)

Table 3. Clinical outcomes of subjects with Pulmonary Embolism included in the study (PHC, 2011)

Clinical Endpoints	N = 100 (%)
Mortality	21 (21)
Hemodynamic deterioration	37 (37)
New onset of hemodyanamic collapse	23 (23)
Need of treatment upgrading	30 (30)
Need for endotracheal intubation or CPR	24 (24)
Need for cathecholamine infusion	22 (22)
Major complications	20 (20)
Bleeding	17 (17)
Recurrent thromboemobilic event	12 (12)

Table 4. Distribution of subjects according to clinical variables included in the Revised Geneva Score (PHC, 2011)

Clinical Variables	N = 100 (%)
Age >65 years	21 (21)
Previous DVT or PE	37 (37)
Malignancy	23 (23)
Recent surgery (within 1 month)	30 (30)
Unilateral lower-limb pain	24 (24)
Hemoptysis	22 (22)
Tachycardia	20 (20)
Bleeding	17 (17)
Recurrent thromboembolic event	12 (12)

overdiagnosis usually results in sizeable morbidity and mortality rates. Untreated cases can be deadly and unnecessary treatment may lead to unjustified risk of major bleeding for patients without PE. Equally important is the practice of VTE prophylaxis. In a study of Bernardo at PHC, the use of VTE prophylaxis in the institution is insufficient and not matched to the risk.[9] Diagnostic and therapeutic management not in accordance with the guidelines are common nowadays and have proven to be detrimental in patients with suspected PE.

The management of those with suspected PE requires that an initial assessment of adverse risks be made. Clinical prediction rules for PE, such as the Well's score and the Geneva Score have been developed to reduce the requirements of invasive tests. Based on the Revised Geneva Score,[7] the prevalence of pulmonary embolism is 74% among patients with high clinical probability category. In our study, high-probability patients accounted for 60% of the study population. The agreed method of defining the severity of PE ranges from clinical parameters (e.g., hypotension, shock) to the more objective determination of right ventricular dysfunction by echocardiography and evidence of myocardial injury which have been shown to be associated with an increase in mortality. However, the availability of echocardiography as a prognostic instrument in may local centers especially in the emergency department continues to be inadequate. The accessibility of ECG made itself an attractive tool for clinicians and researchers to be of use for evaluating severity of PE.

Table 5. Distribution of subjects with Pulmonary Embolism according to variables included in the ECG Score (PHC, 2011)

ECG Parameters	N = 100 (%)
Tachycardia (>100 bpm)	45 (45)
Incomplete RBBB	9 (9)
Complete RBBB	4 (4)
T-wave inversion in lead V1-V4	29 (29)
T-wave inversion in lead V1	
< 1 mm	52 (52)
1-2 mm	36 (36)
> 2 mm	12 (12)
T-wave inversion in lead V2	
< 1 mm	11 (11)
1-2 mm	25 (25)
>2 mm	15 (15)
T-wave inversion in lead V3	
< 1 mm	8 (8)
1-2 mm	20 (20)
> 2 mm	18 (18)
Q wave in lead 3	31 (31)
Inverted T wave in lead 3	39 (39)
If all of S1Q3T3	11 (11)

The ECG may provide important information on diagnosis, extent, and hemodynamic effect of PE. Horak, et.al stressed the importance of ECG for evaluation of the severity of PE, and concluded that the absence of ECG changes does not rule out serious PE and the finding of typical ECG changes is very frequently associated with pulmonary hypertension right ventricular dilatation and a serious hemodynamic finding.[10]

The utility of ECG were recently extended to the development of ECG-based scoring systems in order to correlate ECG findings with the extent of vascular occlusion and severity of pulmonary hypertension. In two retrospective studies, an ECG score of >9 correlated with the degree of pulmonary hypertension with a systolic pulmonary artery pressure > 50 mm Hg, and a score of > 3 predicted those with > 50% perfusion defect on Ventilation/perfusion (V/Q) scanning with a

Table 6. Relationship of clinical outcomes stratification based on the Revised Geneva Scores and ECG Scores (PHC, 2011)

Study Outcomes	Revised Geneva Score			ECG Score		
	Low n=40 (%)	High n=60 (%)	P-Value	Low n=36 (%)	High n=64 (%)	P-Value
Mortality	5 (13)	16 (27)	0.071	4 (11)	17 (27)	**0.050**
Hemodynamic deterioration	6 (15)	16 (27)	**0.033**	7 (19)	30 (47)	**0.005**
New onset of hemodyamic collapse	7 (18)	16 (27)	0.206	4 (11)	19 (30)	**0.027**
Need of treatment upgrading	6 (15)	24 (40)	**0.006**	6 (17)	24 (38)	**0.023**
Need for endotracheal intubation or CPR	5 (13)	19 (32)	**0.023**	5 (14)	19 (30)	0.060
Need for cathecolamine infusion	6 (15)	16 (27)	0.128	4 (11)	18 (28)	**0.039**
Major complications	4 (10)	16 (27)	**0.034**	5 (14)	15 (23)	0.189
Bleeding	3 (8)	14 (23)	**0.033**	4 (11)	13 (20)	0.186
Recurrent thromboembolic event	3 (8)	9 (15)	0.209	1 (3)	11 (17)	**0.029**

Table 7. Relationship of clinical outcomes and patient subgroups based on Geneva Score and ECG Scores (PHC, 2011)

Study Outcomes	Subgroup based on Geneva Score - ECG Scores				P-Value
	1* n=18 (%)	2+ n=42 (%)	3§ n=18 (%)	4‡ n=22 (%)	
Mortality	3 (17)	13 (31)	1 (6)	4 (18)	0.144
Hemodynamic deterioration	5 (28)	22 (52)	2 (11)	8 (36)	**0.018**
New onset of hemodyamic collapse	3 (17)	13 (31)	1 (6)	6 (27)	0.156
Need of treatment upgrading	4 (22)	20 (48)	2 (11)	4 (18)	**0.010**
Need for endotracheal intubation or CPR	4 (22)	15 (36)	1 (6)	4 (18)	0.073
Need for cathecolamine infusion	3 (17)	13 (31)	1 (6)	5 (23)	0.164
Major complications	4 (22)	12 (29)	1 (6)	3 (14)	0.180
Bleeding	3 (17)	11 (26)	1 (6)	2 (9)	0.160
Recurrent thromboembolic event	1 (6)	8 (19)	0 (0)	3 (14)	0.158

*1 = High Geneva Score, Low ECG Score +2 = High Geneva Score, High ECG Score, §3 = Low Geneva Score, Low ECG Score, ‡4 = Low Geneva Score, High ECG Score

Table 8. Prognostic Sensitivity, Specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) of the ECG Score with Clinical Outcomes

Study Outcomes	ECG Score				
	Sn	Sp	PPV	NPV	P-Value
Mortality	81.0%	40.5%	26.6%	88.9%	0.071
Hemodynamic deterioration	**81.1%**	**46.0%**	46.9%	**80.6%**	**0.006**
New onset of hemodyamic collapse	**82.6%**	41.6%	29.7%	**88.9%**	**0.034**
Need of treatment upgrading	**80.0%**	**42.9%**	37.5%	**83.3%**	**0.029**
Need for endotracheal intubation or CPR	79.2%	40.8%	29.7%	86.1%	0.076
Need for cathecolamine infusion	**81.8%**	**41.0%**	28.1%	**88.9%**	**0.048**
Major complications	75.0%	38.8%	23.4%	86.1%	0.252
Bleeding	76.5%	38.6%	20.3%	88.9%	0.239
Recurrent thromboembolic event	**91.7%**	**39.8%**	**17.2%**	97.2%	**0.033**

Sn - Sensitivity; **Sp** - Specificity; **PPV** - Positive Predictive Value; **NPV** - Negative Predictive Value

sensitivity of 70% and a specificity of 59%.[3,4] It was these latter 2 studies that suggested to us the possible usefulness of an ECG-based scoring system in combination with clinical stratification using The Revised Geneva Score for early prediction of adverse clinical outcomes related to PE.

There have been no studies to date that describe the association of the ECG Score in clinical outcomes, although, a few studies have demonstrated the impact of several ECG abnormalities. Atrial arrhythmias, complete right bundle branch block, low peripheral voltages, pseudoinfarction pattern (Q waves) in leads III and aVF, and ST segment deviation over the right precordial leads are all significantly more prevalent in patients who have a fatal outcome,

and overall, in-hospital death occurred in 29% of the patients presenting at least one ECG abnormality related to pulmonary embolism on admission as compared to 11% without an abnormality.[11] In our study, these abnormalities occurred with almost the same frequency, although, associated with a slightly lower mortality rate of 21%. The prognostic value of inverted T-waves was assessed in a prospective study of 40 patients with acute pulmonary embolism.[12] The prevalence of right ventricular dysfunction on echocardiography, along with the incidence of in-hospital adverse events (including death or need for catecholamine support, cardiopulmonary resuscitation or mechanical cardiovascular support for hemodynamic instability) increases proportionally from 8% to 46% with the number of leads presenting the T-wave inversion. Punukollu and colleagues also demonstrated that "T-wave inversion in leads V1 to V3 had the greatest sensitivity and diagnostic accuracy for identifying RV dysfunction in patients with acute PE."[13] In our study, T-wave inversion in the right precordial leads was the most frequently found ECG abnormality (45%), and was used as one of the parameters for the ECG scoring. Consequently, these may account for the significant association between the high ECG score and the clinical outcomes found in our study.

Other data to support the association of ECG score and clinical parameters of adverse out come were the presence of right ventricular enlargement and pulmonary hypertension which in themselves were previously shown to be associated with adverse clinical events in patients with PE.[14,15] Our data demonstrated these hemodynamic burden as 50% of the patients had echocardiographic evidence of moderate to severe pulmonary hypertension, RV enlargement and systolic dysfunction. It can then be inferred that this hemodynamic outcome and ECG score have a positive direct relationship, since 64% of our study patients had high ECG scores. This translated to a significant increase in mortality and in-hospital deterioration in patients with high ECG score. In terms of combining it with a high clinical probability score, a high ECG score resulted in an improved correlation with the incidence of hemodynamic deterioration with a non-significant trend towards increased mortality and major complications. This translated to a significant increase in mortality and in-hospital deterioration in patients with high ECG score. In terms of combining it with a high clinical probability score, a high ECG score resulted in an improved correlation with the incidence of hemodynamic deterioration with a non-significant trend towards increased mortality and major complications. A lesser significant percentage increase was also seen when a high ECG score is combined with a low clinical probability score. The low ECG score in some patients may likely be a sign of compensatory cardiac mechanisms that prevent right ventricular dysfunction in those with low clot burden, with no resultant ECG abnormality. In contrast to the group with high ECG score, ECG abnormality may have occurred because of cardiac decompensation secondary to occlusion of the majority of the pulmonary vascular bed.[4]

The main limitation of the study is that this was not done prospectively to establish the accuracy of the ECG score when used in the clinical setting. This prospective approach will better determine the best cut-off point for the ECG score, and elucidate if a particular criterion should be given a greater or lesser emphasis in the scoring system. A prospective study will be more ideal to better risk stratify patients clinically, evaluate clinical endpoints and determine confounding factors that may bring about significant effect on the study. Secondly, there is lack of uniformity and precision with regards to the grading severity of PE cases because of incomplete evidence of RV dysfunction and myocardial injury. Thirdly, the interpretation of the ECG readings and calculation of the ECG scoring which were done only by the principal investigator; however, a previous study have shown that interobserver agreement was adequate to suggest that the ECG scoring system will be reproducible among different observers.[3] Lastly, this study presumed that all established cases of PE included in this study were acute in presentation without the benefit of a documentation of a previous imaging test to confirm or exclude a chronic process. This may have compromised the prognostic value of ECG for PE since right-sided cardiac conduction and repolarization are affected to a greater degree when RV pressures are acutely elevated than when it is chronic.

In conclusion, the ECG-scoring system can be very useful in identifying patients at risk for developing clinical endpoints of mortality and hemodynamic deterioration among patients with low and high clinical probability of PE. Athough the prognostic accuracy of the ECG score does not allow identification of all those who will develop adverse outcomes, it can provide an incremental role to the clinical stratification provided by the Revised Geneva Scoring.

REFERENCES

1. ESC Guidelines on the diagnosis and Management of acute pulmonary embolism. Eur Heart J. 2008; 29: 2276-2315.
2. Rodger M, Makropoulos D, Turek M, Quevillon J, Raymond F, Rasulli P, et al. Diagnostic value of the electrocardiogram in suspected pulmonary embolism. Am J Cardiol. 2000 Oct 1; 86(7):807–809,A810.
3. Daniel KR, Courtney DM, Kline JA. Assessment of cardiac stress from massive pulmonary embolism with 12-lead ECG. Chest. 2001 Aug;120(2):474-81.
4. Iles S, Le Heron CJ, Davies G, Turner JG, Beckert LE. ECG score predicts those with the greatest percentage of perfusion defects due to acute pulmonary thromboembolic disease. Chest. 2004 May;125(5):1651-6.
5. Geibel I, Zehender M, Kasper W, Olchewski M, Klima W, Konstanides SV. ECG scoring system for prediction of RV dysfunction in patients with acute PE well. Eur Respir J. 2006;25(5):843-8.
6. Geibel I, Zehender M, Kasper W, Olchewski M, Klima W, Konstanides SV. Prognostic value of the ECG on admission in patients with acute major pulmonary embolism. Eur Respir J. 2005 May;25(5):843-8.
7. Le Gal G, Righini M, Roy PM, Sanchez O, Aujesky D, Bounameaux H, et al. Prediction of Pulmonary Embolism in the Emergency Department: The Revised Geneva Score. Ann Intern Med. 2006 Feb 7;144:165-171.
8. Wood KE. Major pulmonary embolism: review of a pathophysiologic approach to the golden hour of hemodynamically significant pulmonary embolism. Chest. 2002 Mar;121(3):877–905.
9. Bernardo, Jasmin. Practices and attitudes of physicians on venous thromboembolism prophylaxis among aritically ill patients admitted at the Medical and Neurological Intensive Care Unit. Philippine Heart Center. (Unpublished).
10. Horak I, Dvorak K. Importance of the ECG for evaluation of severity of pulmonary embolisms. Vnitr Lek. 2002 Dec; 48 Suppl 1: 76-80.
11. Ullman E, Brady WJ, Perron AD, Chan T, Mattu A. Electrocardiographic manifestations of pulmonary embolism. Am J Emerg Med. 2001 Oct;19(6):514-9.
12. Kosuge M, Kimura K, Ishikawa T, Ebina T, Hibi K, Tsukahara K, et al. Prognostic significance of inverted T waves in patients with acute pulmonary embolism. Circ J. 2006 Jun;70(6):750–5.
13. Punukollu G, Gowda M, Vasavada BC, Khan IA. Role of electrocardiography in identifying right ventricular dysfunction in acute pulmonary embolism. Am J Cardiol. 2005 Aug 1;96(3):450-2.
14. Gibson N, Sohne M, Buller H. Prognostic value of echocardiography and spiral computed tomography inpatients with pulmonary embolism. Curr Opin Pulm Med. 2005 Sep;11(5):380–4.
15. Konstantinides S. Pulmonary embolism: impact of right ventricular dysfunction. Curr Opin Cardiol. 2005 Nov;20(6):496–501.