The Incidence of Clinically Significant ECG Abnormalities Detected by Routine Everyday ECG: The First Analysis from CCU/ICCU Patients in Siriraj Hospital

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Background: *Electrocardiography (ECG) has been routinely performed in all patients in CCU and ICCU in Siriraj Hospital everyday in the morning until discharge for screening the abnormalities, such as ischemic changes and arrhythmia. Nevertheless, the occurrence of ECG changes from everyday recording is not common and the real incidence has not been studied. There is uncertainty regarding the benefit derived, when weighted with the cost and the time wasted from the routine everyday ECG.*
Objective: *The purpose of the present study was to demonstrate the incidence of ECG abnormalities that can be detected and have the effects on treatment from the routine everyday ECG in the patients admitted in CCU and ICCU.*
Material and Method: *One hundred and ten patients, admitted in CCU/ICCU in Siriraj Hospital were consecutively enrolled in the present study. Routine everyday 12 leads ECG was performed in the morning in all patients. ECG was interpreted by 2 cardiologists for the incidence and detail of ECG changes as compared to prior ECG. Furthermore, the incidence of those changes that affected management was recorded. Disease spectra and onset of ECG changes were reported.*
Results: *ECG changes from routine everyday ECG was 52.7%, however 25.9% of these changes could be detected by telemetry recorded in every CCU/ICCU patients. ECG changes which affected treatment were 20%, whereas 36.4% of them could be detected by telemetry. Incidence was more pronounced in patients with acute coronary syndrome (ACS), heart failure (HF) and arrhythmias, and found mostly within the first 4 days of hospitalization.*
Conclusion: *While ECG changes from routine everyday ECG occurred in half of the CCU/ICCU patients, one-fourth could be detected by the telemetry recorded. ECG changes that affected treatment were much lower and found merely in one-fifth. This incidence could lead to the limitation of every routine ECG to only high-risk patients during the high-risk period.*

Keywords*: Routine ECG, CCU/ICCU, ECG changes*

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Everyday ECG has been performed in all patients in CCU and ICCU in the early morning until discharge as a routine care since the foundation of CCU/ICCU as long as 24 years ago. There are 8 CCU and 8 ICCU beds in Siriraj Hospital. The reasons for hospitalization were diverse, including acute coronary syndrome (ACS), heart failure (HF), valvular heart disease, arrhythmia, congenital heart disease, pericardial disease, and disease of aorta and pulmonary artery. The purpose of routine ECG was to screen the abnormalities, such as ischemic changes and arrhythmia that can occur in cardiac patients.

Nonetheless, the occurrence of ECG changes from everyday recording is not frequent and the real incidence has not been explored. Moreover, the incidence varies from disease to disease. For example, ECG abnormalities were more pronounced in ACS patients, as well as arrhythmic patients [1]. On the

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opposite hand, patients hospitalized for heart failure or aortic disease have less possibility of ECG changes. In addition, the chance of ECG changes depends on duration after the onset of acute illness. Timing with high likelihood of ECG changes was not been evaluated. There was no definite guideline for routine ECG in CCU/ICCU patients[2-4].

A significant number of patients with clinically important ECG changes, report symptoms, such as angina, dyspnea, palpitation, or syncope, thus providing physician able to performed ECG with vital information, even it was not be done routinely. In fact, all CCU/ICCU patients have bedside continuous ECG telemetric monitoring, thus provide the early detection of ECG abnormalities, although the accuracy is not as high as 12 lead ECG.

Incidence of ECG abnormalities during CCU/ICCU admission, as well as the impact of disease variety and timing, has not been explored. There is uncertainty regarding the benefit derived, when weighted with the cost and the time wasted from the routine everyday ECG.

Objective

The purpose of this study was to establish the incidence of ECG abnormalities that could be detected and affected on management from the routine everyday ECG in the CCU/ICCU patients.

Material and Method

Inclusion criteria

All patients admitted to CCU and ICCU who have everyday ECG in the morning until discharge as a routine care.

Exclusion criteria

Patients that may be harmed or get pain from ECG performing such as wound at chest wall around the area of electrode placement.

Methods

Twelve leads ECG was performed everyday in the morning in all patients admitted in CCU and ICCU. ECG was interpreted by 2 cardiologists for the incidence and detail of ECG changes as compared to prior ECG. Definition of significant ECG changes was noted in Table1. Further, the changes that affected on management such as the need of intervention or pacemaker (as defined in Table 2) were determined. For example, new significant ST depression along with angina leads to coronary angiography and adjustment of antithrombotic therapy. In another example, discovery of complete heart block in setting of anterior wall MI leads to temporary pacemaker insertion. Definition of ECG changes that effect treatment is shown in Table 2.

Both ECG changes and ECG changes that affected treatment were reviewed whether they could be detected by ECG telemetric monitoring as routine CCU/ICCU care. Telemetries could be assessed as 12 leads and data were saved for 48 hours. If ECG telemetric monitoring could detect these changes, the benefit of routine everyday ECG seemed to be further diminished. Disease spectra in which ECG changes occured and

Table 1. Definition of significant ECG changes

ST segment depression or elevation $\geq$ 1 mm from previous study
New inverted T wave in $\geq$ 2 contiguous leads
New significant Q wave in $\geq$ contiguous leads
Rhythm changes such as change from sinus rhythm to atrial fibrillation, supraventricular tachycardia, ventricular tachycardia
New heart block *e.g.* Sinoatrial block, atrioventricular block
Ectopic beat *e.g.* PVC, PAC
New conduction disturbances such as LBBB (left bundle branch block), RBBB (right bundle branch block), IVCD (intraventricular conduction delay), LAHB (left anterior hemiblock), LPHB (left posterior hemiblock)

Table 2. Definition of ECG changes that effect treatment

Initiate new drugs such as enoxaparine, heparin, aspirin, clopidrogrel, glycoprotein IIb/IIIa, antiarrhythmic drugs
Terminate current drugs such as Betablocker or Antiarrhythmic drugs when Bradycardia detected
Perform interventions such as coronary angiogram, pacemaker insertion
Order investigations such as follow-up ECG, cardiac enzymes, Echocardiogram

onset of ECG changes were reported.

Statistical analysis

Number of the patients included in this trial was 110 patients that was calculated from the following formula.

$$n = \frac{Z_{\alpha/2}^2(\pi(1-\pi))}{d^2}$$

When $Z_{0.05/2} = 1.96$ for 95% confidence interval

π = Ratio of patients with ECG changes that had effect on treatment from pilot study = 0.20

d = Allowance error = 0.04

Continuous data were expressed as mean $\pm$ SD, whereas categorical data were demonstrated as percent and 95% confidence interval. Primary outcome, the incidence of ECG changes that affected treatment, was analyzed as percent and 95% confidence interval. Secondary endpoints were the incidence of routine ECG changes, and routine ECG changes that could not be detected by ECG telemetric monitoring, routine ECG changes that had effect on treatment and could not be detected by ECG telemetric monitoring which were shown as percent and 95% confidence interval. Time consumed during performing ECG and cost for routine ECG performing were presented as mean $\pm$ SD. Furthermore, primary and secondary outcomes were analyzed according to 6 different diagnoses, including ACS, arrhythmia, HF, post-intervention and surgery care, other cardiac diseases and non-cardiac diseases.

Results

All 110 patients (mean age 64.6 $\pm$ 15.1 years, 57.3% male) admitted to CCU and ICCU were consecutively enrolled. All were performed routine everyday ECG in the early morning. Demographic data were shown in Table 3. ACS contributed to 50.9% of all diagnosis. Length of stay varied from 1 to 22 days with mean of 4.58 $\pm$ 3.53 days.

A total of 502 routine ECG was analyzed. Significant ECG changes occurred in 58 patients (52.7%), however 15 of 58 changes (25.9%) could be already detected by continuous telemetry, such as premature ventricular contraction (PVC) and premature atrial contraction (PAC). The primary outcome, which was ECG change that affected management or investigation occurred in 22 patients (20%). The majority of ECG changes that affected treatment occurred within the first 4 days of CCU/ICCU admission.

Regarding the detail of different diseases, ECG changes occurred in various frequencies as shown in Table 4. The incidence was highest in patients with ACS (66.1%) and HF (61.5%), nevertheless, the changes in HF indicated only 1 patient whose treatment was affected (7.7%). ECG changes were also high in patients with arrhythmia. Incidence was higher in bradycardia rather than tachycardia group. In contrast, ECG changes were lower for the other diagnoses, including post-intervention and surgery care, valvular heart disease and other cardiac diseases.

Table 3. Demographic data

Age (year) Mean $\pm$ SD	64.64 $\pm$15.14
Sex	
Male	63 (57.3%)
Female	47 (42.7%)
Diagnosis	
ACS	56 (50.9%)
STEMI	18 (16.4%)
NSEMI	18 (16.4%)
Unstable angina	20 (18.2%)
Arrhythmia	18 (16.4%)
Tachyarrhythmia	7 (6.4%)
Bradyarrhythmia	11 (10%)
CHF	13 (11.8%)
Intervention & surgery	15 (13.6%)
Intervention	12 (10.9%)
Surgery	3 (2.7%)
Other Cardiac disease	6 (5.5%)
Valvulardisease	2 (1.8%)
Other Cardiac	4 (3.6%)
Non Cardiac	2 (1.8%)
Length of stay (Day) Mean $\pm$ SD	4.58 $\pm$ 3.53
Outcome	
Discharge	46 (41.8%)
Transfer to ward	60 (54.6%)
Dead	4 (3.6%)

The cost of ECG was 300 baht per patient in Siriraj Hospital, thus the total cost of ECG was 150,600 bahts in 110 patients with a total of 502 admission days. In respect to time consumed, average time recorded was between 2 to 5 min (Mean 3 min) by CCU/ICCU nurses. The time for performing routine ECG was around 4.30 to 6.00 AM, in order to complete the information before doctor and nurse rounds.

Discussion

The present study was the pioneer in thoroughly reviewing ECG changes from the routine everyday ECG. The authors explored the incidence of changes that affected treatment, as well as the impact of diagnosis on changes and the timing of changes.

Table 4. Daily routine ECG change and ECG change that affected treatment and those could not be detected by ECG monitoring

Diagnosis	n (n = 110)	Routine ECG change		Routine ECG changeand affected on treatment	
		Total ECG change	Total	Could not be detected by monitoring	Could not be detected by ECG monitoring
ACS	56	37 (66.1%)	15 (26.8%)	10 (17.8%)	27 (48.2%)
STEMI	18	13 (72.2%)	4 (22.2%)	3 (16.7%)	9 (50%)
NSEMI	18	15 (83.3%)	6 (33.3%)	3 (16.7%)	10 (55.5%)
Unstable angina	20	9 (45%)	5 (25%)	4 (20%)	8 (40%)
Arrhythmia	18	6 (33.3%)	4 (22.2%)	2 (11.1%)	4 (22.2%)
Bradyarrhythmia	11	5 (45.5%)	3 (27.3%)	2 (18.2%)	3 (27.3%)
Tachyarrhythmia	7	1 (14.3%)	1 (14.3%)	0 (0%)	1 (14.3%)
Intervention & surgery	15	4 (26.7%)	2 (13.3%)	1 (6.7%)	4 (26.7%)
Intervention	12	4 (33.3%)	2 (16.7%)	1 (8.3%)	4 (33.3%)
Surgery	3	0 (0%)	0 (0%)	0 (0%)	0 (0%)
CHF	13	8 (61.5%)	1 (7.7%)	1 (7.7%)	6 (46.2%)
Other Cardiac disease	6	3 (50%)	(0%)	0 (0%)	2 (33.3%)
Valvular disease	2	0 (0%)			0 (0%)
Other Cardiac	4	3 (75%)			2 (50%)
Non Cardiac	2	0 (0%)			0 (0%)

Although half of routine ECG revealed changes, one-forth could be detected by telemetric monitoring. Only one-fifth reported changes that affected treatment; moreover around one-third could be detected by continuous monitoring.

The authors CCU/ICCU are one of the few intensive care units that have performed routine everyday ECG. This strategy has both benefits and drawbacks. The major benefit is the accurate and early detection of ECG changes in these critical cardiac patients, which may lead to early diagnosis, investigation and management. Nevertheless, the drawback is the workload of medical personnel, the higher cost and the disturbance of patients in the early morning. Since our CCU/ ICCU is one of the few place in Thailand that have performed this routine ECG, it has given us an excellent chance to access the incidence of ECG changes and ECG changes which affect treatment from routine everyday ECG.

Because there were various diseases in CCU/ ICCU patients, the changes occurred with different incidence in patients with different diagnoses. The incidence was greatest in patients with acute coronary syndrome, that was 17.8%. Patients with acute coronary syndrome had higher incidence of ECG changes including ST segment elevation or depression, inverted T wave and Q wave formation. Moreover, there was also higher chance of arrhythmia, both tachyarrhythmia and bradyarrhythmia, such as ventricular tachycardia and AV block. The present study also found that ECG changes were more common in patients with acute myocardial infarction than patients with unstable angina. This could be explained by the difference in severity of the disease spectra. Myocardial infarction had more extensive area of involvement and had an area with infarction which is prone to be a substrate of arrhythmia. There was no difference between the incidence in ST elevation myocardial infarction (STEMI) and non-ST elevation myocardial infarction (NSTEMI).

The second most common ECG changes were patients admitted with CHF that was found in 8 patients (61.5%), but only 1 patient (7.7%) of these ECG changes affected on treatment. The third most common ECG change was arrhythmia, that was found in 2 patients (11.1%). Bradyarrhythmia had higher incidence of ECG changes than tachyarrhymia. Findings of arrhythmic changes usually leaded to investigation for the causes (such as electrolyte abnormalities and drugs) and treatment (such as pacemaker implantation).

In contrast, patients with valvular heart diseases, post percutaneous coronary intervention and

cardiac surgery and other cardiac diagnosis such as pericardial effusion, aortic dissection and pulmonary embolism had much lower incidence of ECG changes. Patients who admitted with non-cardiac diseases, such as sepsis, had no incidence of ECG changes. These results emphasized the influence of disease spectra on the likelihood of ECG changes.

Further, most ECG occurred within 4 days of CCU/ICCU admission. 66.7% occurred in the first 2 days, 13.3% occurred in the first 3 days and 13.3% occurred in the first 4 days. Only 15 patients (13.6%) happened after the first 4 days of admission.

Moreover, most patients who have ECG abnormalities report symptoms, such a angina, dyspnea, palpitation, or syncope. Even if the authors have not performed everyday ECG in the morning, the authors could perform ECG at the time the patient reports symptom. In fact, all patients in cardiac units have bedside continuous telemetric ECG monitoring; this helps to detect ECG abnormalities all the time.

Time consumed for ECG performing ranged between 2 to 5 minutes with mean of 3 minutes. This must be multiplied by the number of the patients admitted, which was 8 patients in CCU and 8 patients in ICCU. Thus, the overall time was 48 minutes per day, 1,440 minutes per month and 17,280 minutes per year in the early morning. This time will increase for general nurses and technicians working in the other wards, who have less experience in performing ECGs. Moreover routine ECG was performed in the early morning that was around 04.30-06.00 AM, in order to complete information before the doctors round. This may disturb the nurses and patients in early morning in unnecessary cases. If we can select the proper cases, we can save time and this time saved will be a benefit in patient care. The charge for performing ECG was one of the concerned aspects. One ECG charge 300 baht and routine everyday ECG in all 16 CCU/ICCU patients charge 144,000 baht per month and 1,728,000 baths per year. Patient selection can reduce this charge.

Clinical implication

This new thoroughly data about the relatively low incidence of ECG changes which affected the treatment with the relationship to disease spectra and timing of changes allowed us to establish a new guideline for routine ECGs in CCU/ICCU patients. There was no definite recommendation concerning routine ECG in CCU/ICCU patients according to standard guidelines[2-4]. The authors proposed the guideline to perform ECGs in the first 4 days in patients with ACS, HF and arrhythmia. The first ECG on the day of admission was done in patients with other diagnoses. However, ECG could be performed whenever clinical indicated and telemetric monitoring is thoroughly reviewed.

Limitations and future direction

The present study was derived from only one institute in CCU/ICCU, however, as mentioned, only few institutes performed this routine strategy. The authors have the expert doctors (fellows in training and sometimes cardiology staffs) and also the special cardiology nurses on duty all the time. The comprehensive analysis of the impact, including drawbacks after the new guideline is implemented, warrants further monitoring.

Conclusion

A relatively low incidence of ECG changes, particularly ones that affected treatment from routine everyday ECGs was established in our study. The incidences were varied among disease spectra and were more pronounced in ACS, HF, and arrhythmia. Almost all occurred within the first 4 days. The new guideline for routine ECG in our CCU/ICCU was implemented and warrants close monitoring.

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Potential conflicts of interest

None.

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อุบัติการณ์การเกิดการเปลี่ยนแปลงของคลื่นไฟฟ้าหัวใจที่มีความสำคัญทางคลินิกจากการตรวจคลื่นไฟฟ้าหัวใจประจำวันในหอผู้ป่วย ซี.ซี.ยู และ ไอ.ซี.ซี.ยู ในโรงพยาบาลศิริราช

ธนัญญา บุณยศิรินันท์, จิตหทัย สุขสมัย, พรรณี ผณินทรารักษ์, สุพาณี ช่วยประสาทวัฒนา, วันดี ฟูแสง, เรวัตร พันธุ์กิ่งทองคำ

ภูมิหลัง: *การตรวจคลื่นไฟฟ้าหัวใจประจำวันทุกวันในหอผู้ป่วย เป็นการตรวจที่ปฏิบัติเป็นงาน ประจำวันในหอผู้ป่วย CCU และ ICCU ผู้ป่วยทุกรายจะได้รับการตรวจคลื่นไฟฟ้าหัวใจประจำวันทุกเช้า เพื่อดูความผิดปกติของคลื่นไฟฟ้าหัวใจ แม้ว่าจะมีการตรวจคลื่นไฟฟ้าหัวใจประจำวันในช่วงเช้าแล้วก็ตาม ยังมีการตรวจคลื่นไฟฟ้าหัวใจทำเพิ่มเติมในระหว่างวันเมื่อมีอาการผิดปกติ หรือเมื่อพบ ECG monitoring ผิดปกติที่เปลี่ยนไปจากเดิม อุบัติการณ์ความผิดปกติของคลื่นไฟฟ้าหัวใจประจำวันที่ตรวจพบในแต่ละวันยังไม่มีการเก็บรวบรวมข้อมูล จึงมีข้อสงสัยที่ว่าการตรวจคลื่นไฟฟ้าหัวใจในช่วงเช้าทุกวันมีความจำเป็นหรือไม่*

วัตถุประสงค์: *เพื่อให้ได้ข้อมูลเพื่อประกอบการกำหนดแนวทางในการตรวจ และลดค่าใช้จ่ายจากการตรวจที่ไม่จำเป็น*

วัสดุและวิธีการ: *การศึกษาครั้งนี้เป็น prospective descriptive study design ในผู้ป่วยทุกรายที่เข้ารับการรักษาในหอผู้ป่วย CCU และ ICCU โรงพยาบาลศิริราช โดยทำการตรวจคลื่นไฟฟ้าหัวใจประจำวันผู้ป่วยทุกราย ในช่วงเช้าและตรวจคลื่นไฟฟ้าหัวใจเมื่อมีอาการผิดปกติ จากนั้นวิเคราะห์หาอุบัติการณ์และชนิดของความผิดปกติของคลื่นไฟฟ้าทั้งหมด และความผิดปกติของคลื่นไฟฟ้าหัวใจที่เปลี่ยนแปลงการรักษา*

ผลการศึกษา: *ที่ได้พบว่าอุบัติการณ์การตรวจพบคลื่นไฟฟ้าหัวใจที่เปลี่ยนแปลงในแต่ละวัน การตรวจเป็นประจำในช่วงเช้ามีจำนวนทั้งสิ้น 52.7% อย่างไรก็ตามในจำนวนนี้มีอยู่ 25.9% ที่สามารถตรวจพบจาก ECG monitoring ส่วนคลื่นไฟฟ้าที่เปลี่ยนแปลงและมีผลต่อการรักษามีจำนวน 20% โดย 36.4% สามารถตรวจพบจาก ECG monitoring คลื่นไฟฟ้าหัวใจประจำวันที่พบว่าเปลี่ยนแปลงไปจากเดิมพบมากในผู้ป่วยโรค acute coronary syndrome, CHF และ arrhythmias ตามลำดับ*

สรุป: *จากการศึกษาพบว่า ผู้ป่วยที่พบการเปลี่ยนแปลงของคลื่นไฟฟ้าหัวใจประจำวันผิดปกติมากที่สุดคือ กลุ่ม acute coronary syndrome และพบมากในช่วง 4 วันแรกของการรักษา จึงเป็นแนวทางในการเลือกที่จะตรวจคลื่นไฟฟ้าหัวใจประจำวันในหอผู้ป่วย ซี.ซี.ยู และไอ.ซี.ซี.ยู. เฉพาะในผู้ป่วยกลุ่มนี้ หรือโดยเฉพาะอย่างยิ่งในผู้ป่วยโรคกล้ามเนื้อหัวใจตาย ซึ่งจะทำให้สามารถลดค่าใช้จ่ายจากการตรวจคลื่นไฟฟ้าหัวใจประจำวันจาก 1,728,000 บาทต่อปีเป็น 586,800 บาทต่อปี และลดระยะเวลาที่ต้องใช้ในการตรวจจาก 17,280 นาทีต่อปี เป็น 5,868 นาทีต่อปี อย่างไรก็ตามอาจต้องทำการศึกษาวิจัยเพิ่มเติมในผู้ป่วยแต่ละโรคในกลุ่มตัวอย่างที่จำนวนมากขึ้น*