

The Electrocardiogram Interpretation in Primary Care Derived from 10,001 Subjects in Makassar, South Sulawesi, Indonesia: A Survey by Makassar Telemedicine Study

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Abstract—Background: Indonesia is an archipelago, a country of thousand islands with unevenly distributed medical experts; therefore telemedicine is arguably the most suitable tool to solve health problem in the country. The electrocardiogram (ECG) interpretation in primary care analyzed through telemedicine service in Indonesia remains unknown. This study aimed to describe the ECG interpretation in primary care patients in Makassar, South Sulawesi, Indonesia, that analyzed by cardiologist of the telemedicine service. Methods: A total of 10,001 ECGs from 46 primary health care that transmitted to telemedicine service between August 2015 and February 2018 were studied. Results: The mean age of the patients was 53.6 ± 9.0 years and 51.9% were male. ECG was normal in 72.6% subjects. The majority abnormality was sinus bradycardia (8.9%) followed by OMI (5.5%) and ST-T wave changes suggestive myocardial ischemia (5.1%). Sinus tachycardia was found in 3.9% of patients. SVT was present in 0.1% of subjects, AF in 1.1% and atrial flutter in 0.1%. APC and VPC were present in 0.9% and 1.0% of subjects, respectively. SA block was present in 0.1% of patients, while AV was found in 0.5% of patients. RBBB and LBBB were found in 1.6% and 0.2% of patients, respectively. ECG feature of AMI was present in 1.0% of patients. Early repolarization was present in 0.7% of patients. There were 0.1% subjects with non-specific ST and/or T wave changes. Left and right atrial enlargement were present in a similar proportion of patients (0.5%). There were 4.2% and 0.2% patients with left and right ventricular hypertrophy, respectively. Prevalence of several ECG abnormalities was age-related. Conclusion: This is the first study about the use of telemedicine for ECG interpretation in primary health care in Indonesia. It needed further study in order to assess the telemedicine service implementation related to patients and primary care practitioners outcome.

Keywords—Electrocardiogram, primary care, telemedicine, Makassar, Indonesia.

I. INTRODUCTION

Indonesia is an archipelago of 17,504 islands and more than 240 million inhabitants.¹ With improved health financing, increased social mobilization, community empowerment, and prioritization of primary health care, the country has made visible achievements in several health outcomes. For example, life expectancies have steadily increased from 62 to 69 and 65 to 73 years for men and women, respectively, over the past decades, and rates of infant and maternal mortality have significantly decreased.² As a likely consequence of improvements in the country's economic development, Indonesia is experiencing a rapid

epidemiological transition in terms of both its current and projected disease burden. While the existing burden of communicable diseases is a key concern in Indonesia, the burden of disease related to non-communicable diseases has become a major public health issue.³ Contemporary estimates indicate that coronary artery disease (CAD) is the leading cause of death in the Indonesian population, accounting for 37% of all mortality. According to the National Survey 2013, the prevalence of CAD in Indonesia is 1,146,009 cases for male and 1,416,557 cases for female.^{1,4}

Makassar (formerly called Ujung Pandang 1971-1999), the capital of South Sulawesi province, is located in the Eastern part of Indonesia. It is the fourth largest city in Indonesia and the largest in eastern Indonesia. The city's area is 199.3 km² and it had a population of around 1.6 million in 2013.⁵ Administratively, Makassar consists of 14 sub districts, 143 urban villages, 885 RW (community associations) and 4,446 RT (neighbourhoods).⁶ The Makassar city community consists of several ethnic groups. Majority of the Makassar population is from the Makassar tribe. Others include Buginese, Torajanese, Mandarnese, Butonese, Javanese and Chinese. Of 34 provinces in Indonesia, 2.9% of CAD prevalence by diagnosis or symptoms was reported in South Sulawesi province which is the third highest prevalence nationally.⁴

Currently, the provision of healthcare personnel and services for CAD is inadequate, chronically undersupplied and unevenly distributed in Indonesia. Between 2015 and 2016,

there were an estimated 1.5 cardiologists per 1,000,000 inhabitants of Indonesia, with the majority of specialists services provided in the urban area.⁷ Scarcity of medical experts which are unevenly distributed and the nature of the country that consists of many islands is the main constraint in raising social health care of the people. Therefore, telemedicine is arguably the most suitable tool to solve health problem in the country. The telemedicine offers mechanisms for centralizing specialists, reducing costs for specialty care, and supporting primary care clinicians. It can reduce burdens for patients, such as travel to receive specialty care, and improve monitoring, timeliness, and communications within the healthcare system.

To date, the ECG findings analyzed by telemedicine service in Indonesia remains unknown. The aim of the present study was to assess the interpretation of ECG in primary care that analyzed by cardiologist of the telemedicine service in Makassar, South Sulawesi, Indonesia.

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II. METHODS

A. Study Population

This retrospective observational study assessed all the 12-lead ECG of primary care patients whose exams were sent to telemedicine service in Makassar between August 2015 and February 2018. Telemedicine in Makassar is a telehealth service that was created in 2015. After successive expansion, this service now assists 46 primary health care in Makassar.

B. Data Acquisition

Each primary care center received one digital ECG to record the 12-lead ECG. The ECGs were sent through the internet to the analysis center of the telemedicine service and were saved in a database that was used for data collection in the present study. All ECG were reviewed by two cardiologists. Figure 1 shows the ECG example of patient in primary health care that sent to cardiologist by telemedicine.

C. Statistical Analysis

Descriptive statistics were computed for the whole database. Continuous variables were expressed as mean value \pm standard deviation (SD) and compared with t-Student test for unpaired variables and categorical variables expressed as counts and percentage. A p value < 0.05 was considered as statistically significant. Data management and statistical computation were performed with IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp. Released 2013. Armonk, NY: IBM Corp.).

III. RESULTS

A total of 10,001 ECGs from 46 primary health care were studied. The patients characteristics are shown in Table 1. The mean age of the patients was 53.6 ± 9.0 years; range 27-86 years, and 5189 (51.9%) were male. ECG was reported as normal sinus rhythm in 72.6% individuals. A myriad of abnormalities were noted in the remaining 27.4% individuals (Table 2, Figure 2.).

Table 1. Characteristics of the patients

| Patients characteristics | |
|----------------------------|-----------------|
| Age (years), mean \pm SD | 53.6 \pm 9.0 |
| Gender M/F | 5189/4812 |
| Weight (kg), mean \pm SD | 61.3 \pm 3.2 |
| Height (cm), mean \pm SD | 158.7 \pm 2.4 |

Of these, the majority was sinus bradycardia (8.9%) followed by old myocardial infarction (5.5%) and ST-T wave changes suggestive myocardial ischemia (5.1%). Sinus tachycardia was found in 3.9% of patients. A supraventricular tachycardia was present in 0.1% of subjects, an atrial fibrillation in 1.1% and an atrial flutter in 0.1%. There was 0.9% and 1.0% ECG with atrial and ventricular premature complexes, respectively. Sinoatrial block was present in 0.1% of patients, while atrioventricular block was found in 0.5% of patients. There was 1.6% right bundle branch block and 0.2% left bundle branch block. ECG feature of acute myocardial infarction was present in 1.0% of patients, while ST elevation suggestive of early repolarization was found in 0.7% of subjects.

Non-specific ST and/or T wave changes were present in 1.0% of patients. Left and right atrial enlargement were reported in a similar proportion of patients (45 and 48

patients, respectively; 0.5%). Left and right ventricular hypertrophy were found in 4.2% and 0.2% of patients, respectively.

Prevalence of ECG abnormalities was often related to age; mean age comparison between subjects presenting with abnormalities and controls was shown in Table 3.

Table 2. Interpretation of ECG by Telemedicine Service in Makassar

| ECG Diagnosis* | Total <i>n</i> = 10,001 | % |
|---|----------------------------|------|
| Normal sinus rhythm | 7265 | 72.6 |
| Sinus bradycardia | 892 | 8.9 |
| Sinus tachycardia | 393 | 3.9 |
| Supraventricular tachycardia | 11 | 0.1 |
| Atrial fibrillation | 110 | 1.1 |
| Atrial flutter | 9 | 0.1 |
| Atrial premature complexes | 94 | 0.9 |
| Ventricular premature complexes | 105 | 1.0 |
| Sinoatrial block | 6 | 0.1 |
| Atrioventricular block | 49 | 0.5 |
| Right bundle branch block | 160 | 1.6 |
| Left bundle branch block | 21 | 0.2 |
| Myocardial infarction (new) | 98 | 1.0 |
| Myocardial infarction (old) | 548 | 5.5 |
| ST and/or T wave changes suggestive for myocardial ischemia | 509 | 5.1 |
| Non-specific ST and/or T wave changes | 99 | 1.0 |
| Early repolarization | 72 | 0.7 |
| Left atrial enlargement | 45 | 0.5 |
| Right atrial enlargement | 48 | 0.5 |
| Left ventricular hypertrophy | 418 | 4.2 |
| Right ventricular hypertrophy | 23 | 0.2 |

*more than one ECG diagnosis per patient possible.

Prevalence of grouped sinus bradycardia, supraventricular tachycardia, atrial fibrillation, atrial flutter, atrial premature complexes, ventricular premature complexes, sinoatrial block, atrioventricular block, right bundle branch block, left bundle branch block, old myocardial infarction, ST and/or T wave changes suggestive for myocardial ischemia, left atrial enlargement and left ventricular hypertrophy was age related. No statistically significant different in mean age between the presence of sinus tachycardia, acute myocardial infarction, right atrial enlargement and right ventricular hypertrophy.

IV. DISCUSSION

Indonesia is the largest archipelago in the world with an estimated total of 17,504 islands and more than 240 million inhabitants.¹ The provision of healthcare provider and services for the patients is still inadequate and unevenly distributed in Indonesia, with an estimated 1.1 hospital beds per 1,000 population; 38.1 general practitioners per 100,000 population; 3.4 public health centers per village/urban neighborhood; and 1.8 general practitioners per public health centers in 2013.³ Between 2015 and 2016, there were an estimated 1.5 cardiologists per 1,000,000 inhabitants of Indonesia, with the majority of specialists services provided in the urban area.⁷

Table 3. Mean age comparison between subjects with ECG abnormalities and control.

| ECG Abnormalities | (+) | (-) | <i>p</i> |
|--|------------------|------------------|----------|
| | Mean age ± SD | Mean age ± SD | |
| Sinus bradycardia | 56.2 ± 9.2 | 53.4 ± 8.9 | <0.001 |
| Sinus tachycardia | 53.5 ± 8.9 | 53.6 ± 9.0 | 0.793 |
| Supraventricular tachycardia | 36.4 ± 6.8 | 53.6 ± 8.9 | <0.001 |
| Atrial fibrillation | 60.7 ± 9.3 | 53.5 ± 8.9 | <0.001 |
| Atrial flutter | 61.9 ± 11.5 | 53.6 ± 8.9 | 0.006 |
| Atrial premature complexes | 58.6 ± 8.5 | 53.6 ± 8.9 | <0.001 |
| Ventricular premature complexes | 55.8 ± 8.8 | 53.6 ± 9.0 | 0.010 |
| Sinoatrial block | 64.2 ± 8.9 | 53.6 ± 8.9 | 0.004 |
| Atrioventricular block | 61.8 ± 8.9 | 53.6 ± 8.9 | <0.001 |
| Right bundle branch block | 58.8 ± 9.9 | 53.5 ± 8.9 | <0.001 |
| Left bundle branch block | 57.9 ± 8.4 | 53.6 ± 9.0 | 0.031 |
| Myocardial infarction (new) | 54.3 ± 8.1 | 53.6 ± 9.0 | 0.474 |
| Myocardial infarction (old) | 58.0 ± 9.5 | 53.4 ± 8.72 | <0.001 |
| ST and/or T wave changes suggestive for myocardial ischemia | 56.3 ± 9.2 | 53.5 ± 8.9 | <0.001 |
| Left atrial enlargement | 59.0 ± 10.4 | 53.75 ± 8.81 | <0.001 |
| Right atrial enlargement | 55.9 ± 8.8 | 53.6 ± 9.0 | 0.079 |
| Left ventricular hypertrophy | 56.7 ± 9.8 | 53.5 ± 8.9 | <0.001 |
| Right ventricular hypertrophy | 53.6 ± 8.9 | 55.8 ± 11.9 | 0.248 |

The dispersed nature of the islands in Indonesia makes the country an ideal place to implement telemedicine. Telemedicine is the use of telecommunications and electronic information processing technologies to provide health service at distant sites.⁸ It has been practiced as early as in 1910 when Einthoven's used ordinary telephones to transmit ECGs and electro-encephalogram (EEGs) to help diagnose medical conditions.⁹ Over the past thirty years, the use of telemedicine has widened because of improved digital imaging technology, reduction in transmission cost and increased accessibility of technology.¹⁰

Telemedicine offers several benefits, mechanisms for centralizing specialists, reducing costs for specialty care, and supporting primary care practitioners (PCP). It improved accessibility of health care to the rural area from the developed urban centers providing specialized care.

Distance and problems with travelling to seek medical assistance from hospitals offering more specialist services has always been a barrier impacting on the health status of people living in the rural areas as compared to urban areas.¹¹ Telemedicine is also can reduce the number of unnecessary referrals. According to Broomwell Healthwatch (the Telemedical Monitoring Service in United Kingdom), telemedical ECG testing in general practioner surgeries could cut hundreds of thousands of unnecessary emergency hospital admissions, accident and emergency department attendances and referrals to outpatient clinics, saving the National Health Service over £120 million each year.¹² This fact could benefit in our findings that there was 72 patients (0.7%) with early repolarization. Although not a majority finding, there is a possibility to be referred to hospital due to misdiagnosed as STEMI.

Cardiovascular disease (CVD) are the leading cause of mortality and morbidity worldwide¹³, including Indonesia. According to the latest National Survey 2013, of 34 provinces in Indonesia, 2.9% of CAD prevalence by diagnosis or symptoms was reported in South Sulawesi province which is the third highest prevalence nationally.³ Makassar is the capital city of South Sulawesi province and the largest city in eastern Indonesia. Telemedicine has important role in early diagnosis of CVD. Several studies showed the feasibility of remote support by a cardiologist for PCP.^{14,15}

The most common method of diagnosing heart conditions is the ECG, but the skill required for accurate ECG analyses can be difficult to maintain outside of cardiology or emergency medicine specialties. The majority of PCP, by their nature deliver more general care over a much wider medical spectrum and may not all have able to maintain skills in the interpretation of ECG. If there is no facility for reliable the interpretation of ECG at the point of testing ECGs can be sent away, however this more time consuming as hospital ECGs take longer to process. Finding a way to bring expert ECG interpretation directly into the primary care could mean patients getting a quicker diagnosis of cardiac conditions, making a huge difference to their overall well-being and even potentially saving lives. The telemedicine service is not intended to replace traditional ECGs in hospitals, but to compliment services already in place by giving patients easy and quick access to effective expert cardiac diagnosis within the local PCP, in turn helping to remove some of the burden in hospitals.¹⁶

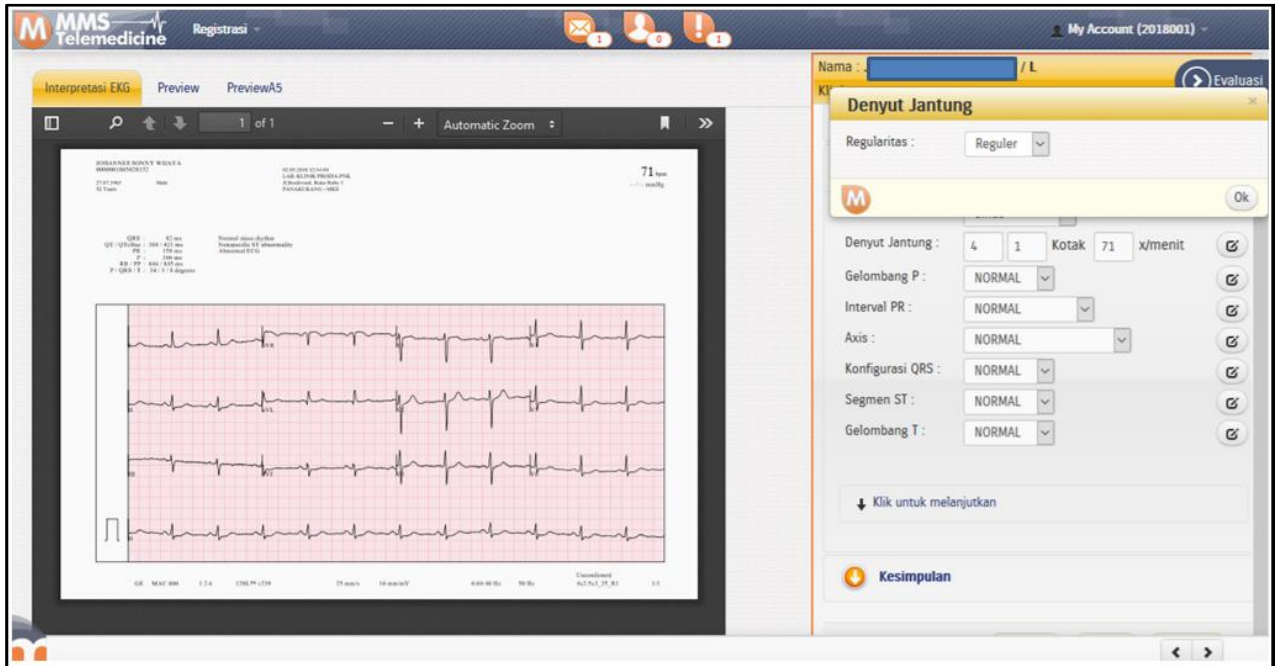


Figure 1. An example of ECG transmission in Makassar Telemedicine Service.

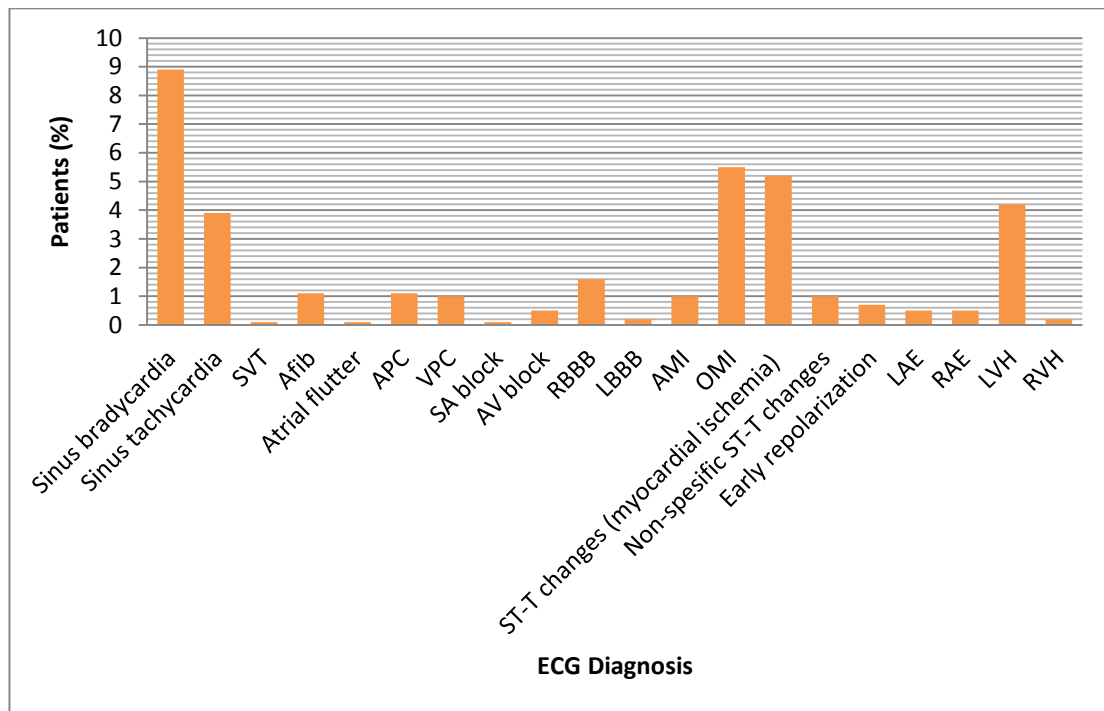


Figure 2. Distribution of ECG abnormalities.

SVT, supraventricular tachycardia; Afib, atrial fibrillation; APC, atrial premature complexes; VPC, ventricular premature complexes; SA block, sinoatrial block; AV block, atrioventricular block; RBBB, right bundle branch block; LBBB, left bundle branch block; AMI, acute myocardial infarction; OMI, old myocardial infarction; LAE, left atrial enlargement; RAE, right atrial enlargement; LVH, left ventricular hypertrophy; RVH, right ventricular hypertrophy.

V.CONCLUSION

To the best of our knowledge, this is the first study to describe the ECG interpretation in primary health care in Indonesia through telemedicine service. Further studies are necessary in order to evaluate the implementation of telemedicine service related not only to the patients (satisfaction, diagnosis, treatment and associated concern) but also to the PCP outcomes (ECG interpretation skill, immediate diagnosis and prompt management).

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