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A Comparison of Cornell and Sokolow-Lyon Electrocardiographic Criteria for Detecting Left Ventricular Hypertrophy In Type 2 Diabetes

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ABSTRACT

Background: Type 2 diabetes mellitus is commonly related to asymptomatic ventricular hypertrophy. While echocardiography is the gold standard, electrocardiography (ECG) is a proper diagnostic method that is both practical and cost-effective. ECG may accurately diagnose left ventricular hypertrophy (LVH) with a sensitivity and specificity similar to echocardiography. However, due to the high cost of managing diabetic patients, there is a need for a simple diagnostic tool to detect early cardiovascular complications. This study aimed to compare the diagnostic performance of Cornell and Sokolow Lyon's criteria for detecting LVH in type 2 DM.

Methods: This research is a cross-sectional analysis including 84 participants. The objective is to evaluate the diagnostic accuracy of Cornell voltage and Sokolow's criteria for detecting left ventricular hypertrophy (LVH). The sensitivities and specificities were calculated by constructing a ROC curve to diagnose LVH.

Results: The Cornell voltage criterion demonstrated superior performance compared to the Sokolow Lyon voltage criteria in the examination of the area under the ROC curve. The Cornell voltage criteria demonstrated an enhanced sensitivity of 66.67%, a specificity of 95.24%, and an AUC of 0.814.

Conclusion: The Cornell criteria had better performance sensitivity than the Sokolow-Lyon criteria for detecting LVH in type 2 DM.

Keywords: Cornell criteria, electrocardiography, left ventricular hypertrophy, Sokolow-Lyon criteria.
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INTRODUCTION

Diabetes mellitus is a multifaceted condition characterized by anatomical and physiological issues that arise from either a complete lack of insulin or a reduced ability of insulin to work properly.[1–4] Diabetes mellitus (DM) is a significant worldwide public health problem, projected to increase by 200 million cases by 2040. Chronic elevation of blood sugar levels, in combination with other metabolic abnormalities, leads to impairment of other organ systems.[5–7]

According to the International Diabetes Federation (IDF), around 463 million individuals between the ages of 20 and 79 were diagnosed with diabetes in 2019. This accounts for a prevalence rate of 9.3% among the entire population within this age range. Indonesia is positioned 7th globally, with 10.7 million individuals affected. It is believed to be a contributing factor to the high occurrence of diabetes cases in Southeast Asia. Multiple research has investigated the financial burden of Type 2 DM in Indonesia. Research done at Dr. Sardjito Hospital examined the expenses accrued by 29 hospitalized patients. The cost of treating T2DM patients with multiple organ impairment was IDR 105 million (US $7892), nearly 20 times more than the cost for those without difficulties and comorbidities (around US $338).[8,9]

Electrocardiography (ECG) and echocardiogram (Echo) are often used for the diagnosis of LVH. Despite Echo being the recommended method because of its heightened sensitivity, ECG is often used in extensive research studies and clinical practice to identify LVH due to its ease and cost-effectiveness, despite its relatively poor sensitivity.[10]

In addition, both ECG-LVH and Echo-LVH have the ability to predict mortality independently and provide distinct prognostic information. Two often used voltage criteria are the gender-neutral Sokolow-Lyon voltage and the gender-specific Cornell voltage criteria. The management of diabetes mellitus incurs significant expenses, highlighting the need for a straightforward diagnostic tool to identify early cardiovascular problems in individuals with type 2 diabetes mellitus.[11] This study compares ECG cornell criteria and Sokolow Lyon for detecting LVH in type 2 DM.

METHODS

Design of the Study and Study population

This cross-sectional study was conducted in June 2023 at Dr. Wahidin Sudirohusodo Hospital, Makassar, South Sulawesi, a tertiary referral hospital. The study focused on patients diagnosed with type 2 diabetes. We employed a non-probability sampling method, specifically consecutive sampling, to include patients who met our criteria until the required sample size of 84 subjects was reached.

Sampling Method

Data were taken from the population based on inclusion criteria and exclusion criteria. This study used secondary data on medical records and recorded the entire number of patients with type 2 DM at the Hospital P RSUP. Dr. Wahidin Sudirohusodo's sampling was done by nonprobability sampling with a consecutive sampling method. Patients who meet the criteria are included in the study until the required number of samples is reached, then determined LVH patients 42 samples and Non-LVH 42 samples are assessed to meet Cornell or Sokolow criteria, then final analyses.

Data Collection of the Study

This study focused on people who had type 2 diabetes. Echocardiography and ECG measurements with 12 leads were performed. All standard 12-lead body surface ECGs were obtained using a Philips Page Writer Trim III at a paper speed of 25 mm/sec and a voltage of 1 mV/cm. The Sokolow-Lyon stress criteria, defined as a combined amplitude (SV1 or V2 + RV5 or V6) of 35 mm, were used to diagnose LVH. RaVL+ SV3 28 mm for men and RaVL+ SV3 20 mm for women were used as Cornell voltage criteria for LVH. Trained researchers performed echocardiograms by standard protocols. End-diastolic interventricular septum (IVSd), posterior wall thickness (PWTd), and left ventricular internal diameter (LVIDd) were all measured. The cube method calculates the left ventricular mass (LVM).

Inclusion and exclusion criteria

Inclusion criteria were patients diagnosed with type 2 diabetes, echocardiography, and electrocardiography examinations. The exclusion criteria were incomplete data and the patient refused to contribute in this study.

Assessment of the 12-lead body surface electrocardiogram (ECG)

The diagnosis of LVH was made based on the Sokolow-Lyon voltage criteria, which defines LVH as composite amplitudes (SV1 or V2 + RV5 or V6) equal to or more than 35 mm. The Cornell voltage criteria for LVH were established as the sum of the R wave in aVL lead and the S wave in V3 lead being more than or equal to 28 mm for males and greater than or equal to 20 mm for women.[12]

Echocardiography

Trained researchers conducted echocardiography exams in accordance with established guidelines. The measurements consisted of IVSd, PWTd), and (LVIDd). The American Society of Echocardiography has established that the threshold values for Echo-LVH are 115 g/m² for men and 95 g/m² for females.[13,14]

Statistical analysis

The diagnostic test results were evaluated using SPSS 25. We computed the Positive Predictive Value (PPV) and Negative Predictive Value (NPV) to evaluate the test's accuracy in correctly diagnosing patients. In addition, we computed the sensitivity and specificity to assess the accuracy of the diagnostic test. The accuracy of the screening test was assessed to evaluate the probability of obtaining proper findings. An examination of the Receiver Operating Characteristic (ROC) curve was performed to evaluate the performance of a test. The test was deemed satisfactory if the area under the curve (AUC) was ≥ 0.7.[15]

RESULT

Study population

A total of 84 subjects participated in this study, meeting the inclusion criteria, with an equal split of 42 (50%) subjects showing evidence of Left Ventricular Hypertrophy (LVH) and 42 (50%) subjects without LVH. The gender distribution among the participants was 49 (58.3%) male subjects and 35 (41.7%) female subjects. Based on the criteria used, the subjects were divided into groups. Based on the age category, the most subjects involved in the 18-60 years category were 53 subjects (63.1%), and subjects > 60 years were 31 subjects (36.9%). Following the Sokolow criteria, four subjects (4.8%) were classified as positive for LVH, while 80 (95.2%) were negative. Using the Cornell criteria, 30 subjects (35.7%) were classified as positive, with 54 (64.3%) classified as negative (Table 1).

The study yielded diagnostic test results for both the Sokolow and Cornell criteria. The Sokolow criteria demonstrated a PPV of 100%, a NPV of 52.50%, an AUC of 0.558, a sensitivity of 9.52%, and a specificity of 100%. In comparison, the Cornell criteria showed a PPV of 93.33%, NPV of 74.07%, AUC of 0.814, sensitivity of 66.67%, and specificity of 95.24%. The sensitivity and specificity of the ECG criteria for diagnosing left ventricular hypertrophy were assessed using the AUC method (Table 2).

Comparison of Cornell and Sokolow criteria using ROC curve characteristics

The ROC curve analysis revealed distinct performance characteristics of the Cornell and Sokolow criteria in detecting left ventricular hypertrophy (LVH). The results demonstrated that the Cornell criteria outperformed the Sokolow criteria in identifying LVH, as evidenced by a AUC. Specifically, the Cornell criteria yielded an AUC of 0.814, while the Sokolow criteria obtained an AUC of 0.558.

In ROC analysis, the AUC represents the overall diagnostic accuracy of a test. The AUC value can range from 0 to 1, with a wider AUC indicating a superior test ability to detect the condition. An AUC value equal to or greater than 0.7 for medical diagnostic tests is generally considered indicative of a reliable and effective test (Figure 1).

This analysis underlines the superior diagnostic potential of the Cornell criteria over the Sokolow criteria for detecting LVH, providing valuable insights for clinical practitioners and researchers in their diagnostic endeavors.

Table 1. Characteristics of Research Subjects

Variable	Total (n=84)	%
Left Ventricular Hypertrophy		
LVH Positive	42	50
LVH Negative	42	50
Gender		
Male	49	58.3
Female	35	41.7
Age (years)		
18-60	53	63.1
>60	31	36.9
Sokolow Voltage		
Positive	4	4.8
Negative	80	95.2
Cornell Voltage		
Positive	30	35.7
Negative	54	64.3

Note: LVH (Left Ventricular Hypertrophy).

Table 2. Electrocardiographic comparison of Cornell and Sokolow criteria about PPV, NPV, and AUC

Variable	Sokolow	Cornell
Sensitivity, (%)	9.52	66.67
Specificity, (%)	100	95.24
PPV, (%)	100	93.33
NPV, (%)	52.50	74.07
AUC	0.558	0.814

Note: PPV, Positive predictive value; NPV, negative predictive value; AUC, Area Under the Curve.

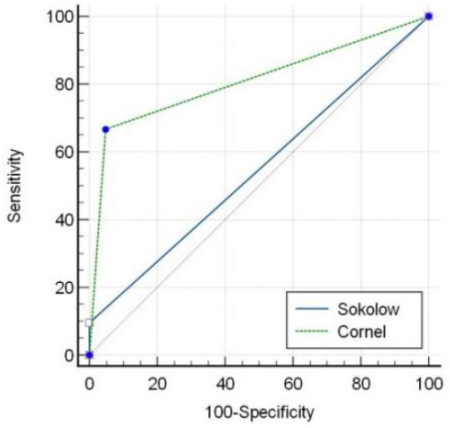

Figure 1. Receiving operating characteristic (ROC).

DISCUSSION

Cornell and Sokolow's criteria for electrocardiographically comparing left ventricular hypertrophy in type 2 diabetes have been shown to be similar. Several medical investigations have identified patients with type 2 diabetes as a significant risk factor for the macrovascular complications of cardiovascular disease. Furthermore, heart hypertrophy, a condition that is very prevalent and may remain asymptomatic for extended periods in individuals with diabetes, poses an additional risk for the development of type 2 diabetes. LVH is difficult to detect and is closely linked to a heightened risk of heart failure and sudden cardiac death.[16–19]

The study included 84 participants in total, split into two groups such us DM patients with LVH (50%) and those without LVH (50%). Furthermore, there were 49 male participants (58.3%) compared to 35 female participants (41.7%). According to age group, there were 53 participants (63.1%) in the 18–60 age group, which was higher than the subjects older than 60. In this study, it was found that the Cornell criteria were more positive for LVH in 28 samples (93.3%), which was statistically significant ($p < 0.05$) compared to the Sokolow criteria of 4 samples (100%) ($P = 0.116$). The ROC approach was then used in a diagnostic test to evaluate the sensitivity and specificity of the ECG criteria for left ventricular hypertrophy. While the Sokolow-Lyon criteria had sensitivity and specificity of 9.52% and 100%, the Cornell voltage criteria had 66.67% and 95.24%. In the research, we conducted according to The Sokolow Lyon and Cornell criteria for electrocardiographic left ventricular hypertrophy were assessed as a cardiovascular event predictor in individuals with diabetes mellitus by the findings of a study published in S. Haxha et al. 183,749 individuals were included in a multivariable analysis, and Cornell performed better than Sokolow Lyon ($p=0.068$) in identifying mortality in patients with and without diabetes mellitus ($p<0.001$).[20]

The research conducted by Jin Kyu *et al.* used electrocardiography and echocardiography to identify LVM in a sample of 332 individuals, consisting of 159 males and 173 females. The Cornell criteria demonstrate more efficacy than the Sokolow Lyon criteria in diagnosing left ventricular hypertrophy in Korean men and women, as determined by relative sensitivity and specificity when using the ROC curve. Cutoff and sensitivity values were determined at specificity levels of 90%, 95%, and 100%.[11]

Fang Yin Su and colleagues published a study examining the Cornell and Sokolow-Lyon criteria for echocardiographic left ventricular hypertrophy in 539 male military personnel aged 18 and 50. When it came to LVM index, the Cornell criteria and product criteria had a better association ($P<0.0001$) than the Sokolow-Lyon criteria. Similarly, in the region under the ROC curve study, Cornell's performance and its product LVH echocardiography criterion both $P<0.0001$ outperformed the Sokolow-Lyon criteria.[21]

From several other studies, it has been found that the Cornell criteria are better than the Sokolow criteria in detecting LVH. Where the Cornell criteria are more gender-specific (R wave in aVL + S wave in V3 is positive if ≥28 mm for men and R wave in aVL + S wave in V3 is positive if ≥20 mm for women) using precordial leads and extremities in ECG examination, while in Sokolow only in precordial leads (S wave in V1 or V2 + R wave in V5 or V6 is positive if ≥35 mm).

The pathophysiology of type 2 diabetes's ventricular hypertrophy represents

Cardiomyocyte failure, which causes hypertrophy in response and inflammatory pathways that lead to fibrosis, two primary structural abnormalities that include cardiac hypertrophy. Apart from the independent effects of insulin resistance on left ventricular thickness, other factors contributing to aberrant contractile function and heart failure include microvascular endothelial dysfunction and the production of nitrogen and reactive oxygen.[22–26]

The strengths of this study can be used, especially in primary healthcare facilities, to detect early LVH in patients with type 2 DM whose health facilities do not have echocardiography. The limitations of this study are that there are not too many samples and no exclusion criteria. There are several limitations in our study. We compared Sokolow-Lyon with Cornell-based criteria for echocardiographic LVH, and the accuracy of the other ECG criteria requires further investigation, and a small number of hypertrophic cardiomyopathy patients with hypertension need to be excluded from differentiating LVH due to hypertension or DM; patients were not followed for history, and only one hospital center was studied. In conclusion, the Cornell criteria stress and product criteria for echocardiographic LVH perform better than the Sokolow-Lyon ECG criteria in type 2 DM.

CONCLUSIONS

The study's findings support that the Cornell criteria are superior to the Sokolow criteria in identifying left ventricular hypertrophy in type 2 diabetes. Healthcare facilities without echocardiography may find this study helpful in enabling them to detect left ventricular hypertrophy (LVH) using alternative electrocardiography.

AUTHOR'S CONTRIBUTION

The major investigators are SL, PT, and AMA. SB and IM participated in developing and formulating the research idea and design. AA had a significant role in developing the research hypothesis, designing the study, and conducting statistical data analysis. Each author contributed to the drafting, revising, and evaluating the paper's content. All authors have thoroughly reviewed and consented to the paper's content, affirming the precision and integrity of every aspect of this study.

CONFLICT OF INTEREST

Nothing to disclose

ETHICAL CLEARANCE

This research was approved by the Ethics Committee of Biomedical Research on Humans, Faculty of Medicine, Hasanuddin University, Makassar, South Sulawesi, Indonesia. Based on recommendation Number: 577 /UN.4.6.4.5.31/PP.36/2023.

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REFERENCE

1. Setiati S, Alwi I, Sudoyo AW, Simadibrata M, Setiyohadi B, Syam AF. Buku Ajar Ilmu Penyakit Dalam Jilid II Edisi VI. Interna Publishing. 2014. 1–1474 p.
2. Lv J, Liu Y, Yan Y, Sun D, Fan L. Hypertrophy and Diabetes Is Likely. 2023;1–10.
3. A Giha H. Correlates and Severity of Left Ventricular Hypertrophy in Type 2 Diabetes Patients in an Afro-Arab-cross Ethnic Community. Cardiology Research and Reports. 2022;4(4):01–9.
4. Oley MH, Oley MC, Tjandra DE, Sedu SW, Sumarauw ERN, Aling DMR, et al. Hyperbaric oxygen therapy in the healing process of foot ulcers in diabetic type 2 patients marked by interleukin 6, vascular endothelial growth factor, and PEDIS score: A randomized controlled trial study. International Journal of Surgery Open. 2020;27:154–61.
5. Setiati S, Alwi I, Sudoyo AW, Simadibrata M, Setiyohadi B, Syam AF. Buku Ajar Ilmu Penyakit Dalam Jilid II Edisi VI. Interna Publishing. 2014. 1–1474 p.
6. Lv J, Liu Y, Yan Y, Sun D, Fan L. Hypertrophy and Diabetes Is Likely. 2023;1–10.
7. A Giha H. Correlates and Severity of Left Ventricular Hypertrophy in Type 2 Diabetes Patients in an Afro-Arab-cross Ethnic Community. Cardiology Research and Reports. 2022;4(4):01–9.
8. Kementerian Kesehatan RI. Infodatin tetap produktif, cegah, dan atasi Diabetes Melitus 2020. Pusat Data dan Informasi Kementerian Kesehatan RI. 2020. p. 1–10.
9. Hidayat B, Ramadani RV, Rudijanto A, Soewondo P, Suastika K, Siu Ng JY. Direct Medical Cost of Type 2 Diabetes Mellitus and Its Associated Complications in Indonesia. Value in Health Regional Issues. 2022;28:82–9.
10. Park JK, Shin JH, Kim SH, Lim Y-H, Kim K-S, Kim SG, et al. A Comparison of Cornell and Sokolow-Lyon Electrocardiographic Criteria for Left Ventricular Hypertrophy in Korean Patients. Korean Circulation Journal. 2012;42(9):606.
11. Park JK, Shin JH, Kim SH, Lim Y-H, Kim K-S, Kim SG, et al. A Comparison of Cornell and Sokolow-Lyon Electrocardiographic Criteria for Left Ventricular Hypertrophy in Korean Patients. Korean Circulation Journal. 2012;42(9):606.
12. Su FY, Li YH, Lin YP, Lee CJ, Wang CH, Meng FC, et al. A comparison of Cornell & Sokolow-Lyon electrocardiographic criteria for left ventricular hypertrophy in a military male population in Taiwan: The cardiorespiratory fitness & hospitalization events in armed forces study. Cardiovascular Diagnosis and Therapy. 2017;7(3):244–51.
13. Lv T, Yuan Y, Yang J, Wang G, Kong L, Li H, et al. The association between ECG criteria and Echo criteria for left ventricular hypertrophy in a general Chinese population. Annals of Noninvasive Electrocardiology. 2021;26(5):1–10.
14. Rodrigues SL, D'Angelo L, Pereira AC, Krieger JE, Mill JG. Revision of the sokolow-lyon-rappaport and cornell voltage criteria for left ventricular hypertrophy. Arquivos Brasileiros de Cardiologia. 2008;90(1):44–51.
15. Bürger M. VI. Diagnostik. Einführung in die innere Medizin. 2018;544–5.
16. Schmitt VH, Billaudelle AM, Schulz A, Keller K, Hahad O, Tröbs SO, et al. Disturbed glucose metabolism and left ventricular geometry in the general population. Journal of Clinical Medicine. 2021;10(17).
17. Okin PM, Devereux RB, Gerdts E, Snapinn SM, Harris KE, Jern S, et al. Impact of diabetes mellitus on regression of electrocardiographic left ventricular hypertrophy and the prediction of outcome during antihypertensive therapy: The Losartan Intervention for Endpoint (LIFE) Reduction in Hypertension Study. Circulation. 2006;113(12):1588–96.
18. Wibisono S. Pedoman Petunjuk Praktis Terapi Insulin pada pasien Diabtes Melitus 2021. pertama. Indonesia: PB Perkeni; 2021. 70 p.
19. Soelistijo S. Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia 2021. Global Initiative for Asthma. 2021;46.
20. Haxha S, Pedersen-Bjergaard U, Nielsen JB, Pallisgaard J, Devereux RB, Okin PM, et al. Cornell voltage left ventricular hypertrophy predicts all-cause mortality better than Sokolow-Lyon voltage in patients with and without diabetes – data from 183,749 primary care ECGs. European Heart Journal. 2020;41(Supplement_2):3042.
21. Su FY, Li YH, Lin YP, Lee CJ, Wang CH, Meng FC, et al. A comparison of Cornell & Sokolow-Lyon electrocardiographic criteria for left

ventricular hypertrophy in a military male population in Taiwan: The cardiorespiratory fitness & hospitalization events in armed forces study. Cardiovascular Diagnosis and Therapy. 2017;7(3):244–51.
22. Galicia-garcia U, Benito-vicente A, Jebari S, Larrea-sebal A. Pathophysiology of Type 2 Diabetes Mellitus. :1–34.
23. Statement AHAS. Comprehensive Management of Cardiovascular Risk Factors for Adults With Type 2 Diabetes : A Scientific Statement From the American Heart. 2022.
24. Schwartz SS, Epstein S, Corkey BE, Grant SFA, Gavin JR, Aguilar RB. The time is right for a new classification system for diabetes: Rationale and implications of the β-cell-centric classification schema. Diabetes Care. 2016;39(2):179–86.
25. Martín-Timón I. Type 2 diabetes and cardiovascular disease: Have all risk factors the same strength? World Journal of Diabetes. 2014;5(4):444.
26. Kementerian Kesehatan RI. Infodatin tetap produktif, cegah, dan atasi Diabetes Melitus 2020. Pusat Data dan Informasi Kementerian Kesehatan RI. 2020. p. 1–10.