

# An Innovative Approach to Identifying the Location of Myocardial Infarction Using the Einthoven Triangle

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## ABSTRACT/

### Article History:

Received : 28-10-2025

Revised : 08-01-2026

Accepted : 28-01-2026

Online : 31-01-2026

### Keyword:

Einthoven's triangle illustration;  
myocardial infarction localization;  
clinical competence;



**Introduction.** One of the essential competencies for nursing students is the ability to determine the location of myocardial infarction in cases of Acute Coronary Syndrome (ACS). This learning material is considered complex; therefore, specific strategies are needed to help students understand it more easily. The purpose of this study was to determine the effectiveness of the Einthoven triangle illustration in improving nursing students' ability to identify the location of myocardial infarction. **Methods.** This study employed a one-group pre-test post-test design with a population of nursing students from the Faculty of Health Sciences, Tribhuwana Tungadewi University. The study included seventh-semester nursing students with active enrollment who had no prior education or training in infarction localization. A total of 50 respondents were randomly selected. The Einthoven triangle illustration served as the independent variable, and the ability to determine the location of myocardial infarction served as the dependent variable. Data were collected using a test sheet and analyzed using the Wilcoxon test with a significance level of  $\alpha = 0.05$ . **Results.** There was a twofold improvement in students' ability to identify infarction sites before and after being taught using the Einthoven triangle method (median = 2 vs. 4). The Einthoven triangle illustration was proven effective in enhancing nursing students' ability to determine the location of myocardial infarction ( $p = 0.000$ ). **Conclusion.** To effectively deliver complex learning materials, it is essential to present them in simplified formats—such as diagrams, animated videos, or other visual aids—to facilitate students' understanding.

## ABSTRAK

Salah satu kompetensi mahasiswa keperawatan ialah mampu menentukan lokasi infark miokard pada kasus *Acute Coronary Syndrome* (ACS). Materi pembelajaran ini tergolong kompleks, sehingga diperlukan trik yang memudahkan peserta didik untuk mempelajarinya. Tujuan penelitian ini ialah membuktikan efektivitas gambar segitiga Einthoven terhadap kemampuan mahasiswa keperawatan dalam menentukan lokasi infark miokard. Metode. Desain penelitian menggunakan one group pre-test post-test design dengan populasi mahasiswa keperawatan Fakultas Ilmu Kesehatan Universitas Tribhuwana Tungadewi. Sampel sebanyak 50 responden diambil secara acak. Gambar segitiga Einthoven sebagai variabel independen dan kemampuan menentukan lokasi infark miokard sebagai variabel dependen. Data dikumpulkan menggunakan lembar test. Data dianalisis menggunakan uji Wilcoxon dengan  $\alpha=0,05$ . Hasil. Ada peningkatan kemampuan mahasiswa dalam menentukan lokasi infark dua kali lipat antara sebelum dengan setelah diberikan materi cara menentukan lokasi infark menggunakan segitiga Einthoven (median= 2 vs 4). Gambar segitiga Einthoven juga terbukti efektif untuk membentuk kemampuan mahasiswa keperawatan dalam menentukan lokasi infark miokard ( $p=0,000$ ). Kesimpulan. Untuk menyampaikan materi yang

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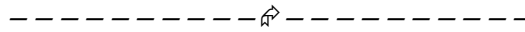
kompleks, perlu disajikan dalam bentuk yang sederhana sehingga mudah dipahami peserta didik, baik dalam bentuk gambar, video animasi maupun lainnya.

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## A. INTRODUCTION

Myocardial infarction is a frequently occurring condition in the community (Astuti et al., 2024; Barangkau et al., 2023; Martin et al., 2024; Suhestin et al., 2024). It is one of the major cardiac emergencies (Wibawa & Rahadiyan, 2023) and remains a leading cause of death worldwide (Salari et al., 2023). Nursing students are required to study myocardial infarction in order to provide appropriate and effective care for affected patients (AIPNI, 2021). One of the key aspects of learning about myocardial infarction is interpreting electrocardiogram (ECG) readings and identifying the infarction site (Rosdiana et al., 2022). The location of a myocardial infarction can be determined through the interpretation of 12-lead ECG recordings (Bozbeyoğlu et al., 2019; Chang et al., 2021; Fu et al., 2020; Kim et al., 2024). Typical ECG manifestations of myocardial infarction include ST-segment elevation (STEMI) or ST-segment depression (NSTEMI) (Salari et al., 2023; Wibawa & Rahadiyan, 2023). Several types of learning media are commonly used to study infarction site identification, including online modules or interactive e-learning (Pourmand et al., 2015), educational videos (audiovisual media) (Dhawan et al., 2008), animations (Cardoso Pinto et al., 2024), and printed materials or diagrams (Jin et al., 2012). Despite the availability of various learning media for ECG education, the complexity of the topic often results in many nursing graduates still struggling to accurately interpret ECGs—especially when determining the location of myocardial infarction (Rosdiana et al., 2022; Wardani et al., 2022).

Previous studies have shown that the accuracy rate of ECG interpretation among nursing students was 42%, among residents 56%, and among practicing physicians 69% (Chaumont et al., 2024). Another study reported that the overall ability of participants from various professions to accurately interpret ECGs averaged 56.4% (Paul & Jacob, 2023). Similarly, research has indicated that the accuracy of ECG interpretation among emergency department nurses remains low, at only 43.5% (Ayasreh et al., 2024). Medical students also face considerable difficulties in learning ECG interpretation. Findings revealed that 18.2% had difficulty remembering, 28.4% had difficulty understanding ECGs, 15.1% struggled with analysis, and 17.8% had difficulty interpreting ECG results (Ohn et al., 2020). Another study among medical students showed that only 60% of respondents expressed confidence in accurately interpreting ECGs in routine situations, which dropped to 40% in emergency conditions (Chaumont et al., 2024). However, these findings differ somewhat from a study conducted among third-year nurse anesthetists, in which 90% demonstrated good proficiency in ECG interpretation (Tripayana et al., 2025).

The limited ability of nurses and nursing students to interpret ECGs is often attributed to a lack of participation in ECG-related training, workshops, or seminars (Huitema et al., 2019). The complexity of ECG material also contributes to decreased motivation among students to

learn it (Antit et al., 2020; Ohn et al., 2020). Furthermore, nurses' and nursing students' ability to interpret ECGs is influenced by several factors, including confidence and personal values, skills, experience, personal characteristics, motivation, emotional issues, and intellectual capacity (Rosdiana et al., 2022). In addition, the use of inappropriate teaching methods can further reduce students' motivation to study ECGs (Antit et al., 2020). Therefore, new approaches are needed to enhance learning outcomes in ECG interpretation (Chaumont et al., 2024).

There are various ways nursing students can learn to identify the location of myocardial infarction, including studying textbooks, scientific journals, learning modules, or instructional videos (Wulandari et al., 2023). However, this approach tends to promote student passivity, which may ultimately limit the development of critical thinking abilities, depth of conceptual understanding, and clinical skill competence. The topic of ECG interpretation—particularly in determining myocardial infarction sites—can also be learned using the Einthoven triangle illustration (Paul & Jacob, 2023). The Einthoven triangle depicts the electrical axis or vectors of the heart (Gargiulo et al., 2018; Zhao et al., 2021). These directions indicate the myocardial infarction locations, including lateral (leads I, aVL, V5, and V6), inferior (leads II, III, and aVF), septal (V1 and V2), anterior (V3 and V4), anteroseptal (V1, V2, V3, and V4), anterolateral (leads I, aVL, V3, V4, V5, and V6), and inferolateral (leads I, II, III, aVL, aVF, V5, and V6) (Fu et al., 2020; Kim et al., 2024).

Based on the aforementioned issues, the researchers developed a learning medium in the form of the Einthoven triangle illustration to explain the location of myocardial infarction and sought to determine its effectiveness in improving nursing students' ability to identify the site of myocardial infarction.

## B. METHODS

This study was an experimental research employing a one-group pre-test post-test design. The study was conducted among nursing students of the Faculty of Health Sciences, Tribhuwana Tunggaladewi University. In this experimental study, which involved a numerical dependent variable, the sample size was determined based on the following formula:  $\{[(Z\alpha + Z\beta) \times SD] / (X_1 - X_2)\}^2$ . A total of 50 respondents were selected using a simple random sampling technique. The inclusion criteria were seventh-semester nursing students with active student status who had never learned about myocardial infarction locations, either in coursework or through training. The independent variable in this study was the Einthoven triangle illustration, while the dependent variable was the ability to determine the location of myocardial infarction. Participants were first given a pre-test to obtain baseline data, followed by a 30-minute instructional session explaining myocardial infarction locations using the Einthoven triangle illustration, and then a post-test was administered to obtain post-intervention data. Data were collected using a test sheet consisting of seven questions, each scored as one point, with a minimum score of 0 and a maximum of 7. All questionnaire items were valid ( $r > 0.632$ ) and demonstrated excellent reliability, with a Cronbach's alpha of 0.984. The collected data were analyzed using the Wilcoxon test with a significance level of  $\alpha = 0.05$ . This test was used because the Shapiro-Wilk test results indicated that the data were not normally distributed ( $p = 0.001$  and  $p = 0.000$ ).

## C. RESULT AND DISCUSSION

### 1. Result

The results of this study demonstrated that the Einthoven triangle illustration was effective in improving nursing students' ability to identify the location of myocardial infarction ( $p = 0.000$ ). This finding was supported by a significant difference in the median scores before and after the intervention (2 vs. 4).

**Table 1.** The Effect of the Einthoven Triangle Illustration on Nursing Students' Ability to Determine the Location of Myocardial Infarction

Variable	Median	Min-Max	<i>p</i>
Ability to Determine the Location of Myocardial Infarction (pre)	2	0-7	0,000
Ability to Determine the Location of Myocardial Infarction (post)	4	1-7	

### 2. Discussion

Research investigating the use of Einthoven's triangle to enhance the ability to localize myocardial infarction remains limited. The findings of this study demonstrate that Einthoven's triangle is an effective instructional tool for improving students' ability to localize myocardial infarction, with observed performance increasing approximately twofold following the intervention. Einthoven's triangle illustrates the cardiac electrical vector derived from both bipolar and augmented unipolar leads, enabling infarct localization based on the presence of ST-segment elevation in the corresponding leads. The results of this study are supported by previous research showing that nursing students at the Faculty of Nursing, Syiah Kuala University, still lack competence in ECG interpretation, with only 54.7% achieving satisfactory skills (Rosdiana et al., 2022). Another study conducted in Jordan reported that the mean competency score of nurses in emergency units for ECG interpretation was only 4.35 out of a maximum score of 10 (Ayasreh et al., 2024). Research on healthcare professionals and medical students at Ardabil University found that the mean ECG interpretation competency score was 5.13 out of 10 (Amini et al., 2022). A study among nurses at Airlangga University Hospital revealed that 64.3% of respondents had low ability in ECG interpretation (Nursalam et al., 2024). Furthermore, research on critical care nurses in Saudi Arabia showed that 35.5% of respondents were unable to correctly interpret ECGs (Aljohani, 2022).

Einthoven's triangle is a conceptual model that depicts the three limb electrodes (leads I, II, and III) as the vertices of an imaginary triangle representing the orientation of the heart's electrical vector in the frontal plane. This model facilitates the understanding of the direction and magnitude of potentials recorded by each lead on the electrocardiogram (ECG) (Paul & Jacob, 2023; Rahman et al., 2024; Zhao et al., 2021). Therefore, Einthoven's triangle serves as the basis for mapping myocardial injury locations; morphological changes such as ST-segment elevation, the formation of pathological Q waves, and axis deviation in specific lead combinations can indicate the site of myocardial infarction (Juniawan et al., 2023; Kim et al., 2024). ST-segment elevation in leads II, III, and aVF suggests an inferior wall infarction; elevation in precordial leads V1-V2 indicates a septal wall infarction; elevation in leads V3-V4 typically reflects an anterior wall infarction; ST elevation in leads I, aVL, and V5-V6 implies a lateral wall infarction; elevation in leads V1-V4 indicates an anteroseptal infarction; elevation

in leads I, II, III, aVL, aVF, and V5–V6 indicates an inferolateral infarction; and elevation in leads I, aVL, and V3–V6 indicates an anterolateral infarction (Liu et al., 2022; Rus et al., 2025; Sariçam et al., 2023).

The Einthoven triangle is not only a representation of the heart's electrical activity but can also serve as a practical and simple medium for learning how to identify the location of myocardial infarction. This is because the Einthoven triangle illustrates the direction of cardiac electrical activity, which corresponds to the infarction site when the lead oriented in that direction exhibits ST elevation or ST depression. ST elevation is defined when the junctional point is above the isoelectric line ( $>0.20$  mV in males and  $>0.15$  mV in females), whereas ST depression is defined when the junctional point lies below the isoelectric line. There are 14 limb and precordial leads that can be used to determine the location of myocardial infarction. Each infarction site is represented by at least two leads, and it is identified as an infarction site when a minimum of two leads show ST elevation or ST depression. Therefore, the Einthoven triangle diagram is effective in enhancing students' or nurses' ability to determine the location of myocardial infarction.

#### D. CONCLUSION AND SUGGESTIONS

Complex lecture materials are important to present using engaging media and simple language to facilitate understanding. The Einthoven triangle diagram has proven effective in developing nursing students' ability to determine the location of myocardial infarction, as it illustrates the direction of the heart's electrical activity, which indicates the infarction site.

#### E. ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to the Rector and the Dean of the Faculty of Health Sciences, Tribhuwana Tunggal University, for providing the opportunity to conduct research involving nursing students at Tribhuwana Tunggal University. It is hoped that the findings of this study will contribute to enhancing nursing students' ability to identify the location of myocardial infarction.

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