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Received: 25/07/25
Accepted: 29/09/25
Online: 10/10/25

ORIGINAL ARTICLE

Questionnaire to assess knowledge of electrocardiogram interpretation among medical interns

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Keywords:
knowledge; coronary disease; electrocardiogram; medical student; validation study (source: MeSH-NLM).

ABSTRACT

Objectives. To validate a questionnaire designed to assess the level of knowledge regarding electrocardiogram (ECG) interpretation among medical interns. **Methods.** An observational study conducted in 2023. A questionnaire was developed, and its content validity was assessed through expert judgment using Aiken's V coefficient. Reliability was determined using Cronbach's alpha based on a virtual survey administered to final-year medical students. **Results.** The questionnaire consisted of 20 items distributed across three dimensions: knowledge of ECG acquisition, normal tracing, and abnormal tracing. Content validity reached an Aiken's V coefficient of 0.978. Forty medical interns participated, with a median age of 26 years; 52.5 % were women. The level of knowledge regarding ECG interpretation was moderate in 62.5 % of interns, high in 22.5 %, and low in 15.0%. Four items were excluded due to low reliability, resulting in a final 16-item questionnaire with a Cronbach's alpha of 0.745. **Conclusions.** The 16-item questionnaire developed to assess the level of knowledge regarding ECG interpretation among final-year medical students demonstrated adequate content validity and good reliability.

Cuestionario para evaluar conocimientos sobre la interpretación del electrocardiograma en internos de Medicina

Palabras clave:
conocimientos; enfermedad coronaria; electrocardiograma; estudiante de Medicina; estudio de validación (fuente: DeCs-BIREME).

RESUMEN

Objetivos. Validar un cuestionario para evaluar el nivel de conocimientos sobre la interpretación del electrocardiograma (ECG) en internos de Medicina. **Métodos.** Estudio observacional realizado el 2023. Fue diseñado un cuestionario y evaluada su validez de contenido mediante juicio de expertos con el coeficiente V de Aiken. La confiabilidad fue determinada mediante el coeficiente alfa de Cronbach a través de una encuesta virtual aplicada en estudiantes de Medicina del último año. **Resultados.** El cuestionario estuvo conformado por 20 ítems distribuidos en tres dimensiones: conocimientos sobre la toma del ECG, trazado normal y trazado anormal. La validez de contenido alcanzó un coeficiente V de Aiken de 0,978. Participaron 40 internos de Medicina, con una mediana de edad de 26 años; el 52,5 % fueron mujeres. El nivel de conocimientos sobre interpretación del ECG fue de nivel medio en el 62,5 % de los internos, alto en el 22,5 % y bajo en el 15,0 %. Fueron excluidos cuatro ítems por baja confiabilidad, obteniéndose un cuestionario final de 16 preguntas con un alfa de Cronbach de 0,745. **Conclusiones.** El cuestionario de 16 ítems elaborado para evaluar el nivel de conocimientos sobre la interpretación del ECG en estudiantes de Medicina del último año presentó adecuada validez de contenido y buena confiabilidad.

Cite as: Aymituma-Acosta E, Valenzuela-Rodríguez G, Amado-Tineo J. Questionnaire to assess knowledge of electrocardiogram interpretation among medical interns. Rev Peru Cienc Salud. 2025;7(4):330-42. doi: https://doi.org/10.37711/rpcs.2025.7.4.5

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INTRODUCTION

According to the World Health Organization (WHO), nearly 17.9 million people died from cardiovascular diseases in 2019, representing 32% of all deaths worldwide [1]. In the United States, heart disease is the leading cause of death and, approximately, one person suffers a heart attack every 40 seconds; in addition, the annual direct and indirect cost attributable to this condition was USD 228.7 billion during the 2017-2018 period [2]. A similar situation occurs in Spain, where 26.4% of deaths recorded in 2021 were due to cardiovascular diseases [3]. In Peru, cardiovascular disease has been reported in 28% of the population [4], with a high prevalence among hospitalized patients, reaching up to 51.6 % [5].

The electrocardiogram (ECG) is a noninvasive, rapid, and low-cost test performed at the patient's bedside that allows the identification of potentially serious cardiovascular conditions. Conventionally, it records electrical activity through 12 leads or "views," making it possible to detect arrhythmias, blocks, structural abnormalities, and acute ischemic events [6,7].

The ECG can be interpreted by primary care physicians, and it has even been reported that medical students, when adequately trained, significantly improve their ability to interpret this ancillary test [8,9]. Likewise, studies have shown that students from other health sciences disciplines, outside of medicine, are also capable of acquiring an acceptable level of knowledge in ECG interpretation [7,10].

In Peru, a moderate level of knowledge about ECG has been described in 88% of students at a private university in Lima [11]. In contrast, studies conducted in South Africa report a low level of knowledge, even in the final years of medical training [12], while other international studies describe an intermediate level of competence in ECG interpretation [13-16].

However, no fully accepted instrument has been identified to uniformly assess knowledge of electrocardiogram interpretation. Therefore, the aim of this study was to validate a questionnaire to assess the level of knowledge of ECG interpretation among final-year medical students.

METHODS

Study type and area

An observational study was conducted between January and March 2023. The process was conducted in three stages: 1) questionnaire development, 2) content validation, and 3) evaluation of the instrument's reliability.

Population and sample

Two specialist physicians (a cardiologist and an internist) participated in the development of the questionnaire. In the validation process, nine cardiologists with more than five years of work experience in teaching hospitals participated by completing the evaluation form.

For the reliability assessment, 40 medical interns (students in the final year of the medical degree program) from a level II-2 public hospital in Lima, Peru, participated. Those interns who had a second profession related to hospital work or who did not complete the questionnaire were excluded. No sample size calculation was performed; instead, all interns at the hospital who met the selection criteria were included.

Variable and data collection instruments

A questionnaire was developed to assess knowledge of ECG interpretation, considering five dimensions based on two previous questionnaires: theoretical knowledge about ECG performance, normal tracing, graphical representation of tracings, interpretation of a normal electrocardiogram, and interpretation of pathological ECGs [15,16].

The items assessed to determine content validity included: sufficiency of the information, adequate number of items, presence of ambiguous items, structure of the instrument, and the need to incorporate new items.

Data collection techniques and procedures

Coordination with the specialist physicians who validated the questionnaire was performed via email, through the sending of the developed questionnaire and the validation criteria form. Responses were received through the same means, and any questions or clarifications were resolved by telephone communication.

For the reliability analysis, a virtual survey was administered by creating a Google Forms questionnaire with the items included in the instrument (see Appendix 1), which was shared individually with participants by email or direct communication.

Data analysis

Content validity was determined using Aiken's V coefficient, considering values greater than 0.8 as

Table 1. Content validation of a questionnaire to assess the level of knowledge of electrocardiogram interpretation among medical interns, 2023

Criterion	Ev1	Ev2	Ev3	Ev4	Ev5	Ev6	Ev7	Ev8	Ev9
Sufficient information	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adequate number of items	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ambiguous items	No	No	No	No	No	No	No	No	No
Appropriate structure	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Consider inclusion of additional items	No	No	No	No	No	No	No	No	No

Ev: Evaluator

adequate. Questionnaire reliability was assessed using Cronbach's alpha coefficient, with values greater than 0.7 considered acceptable. The responses provided by the medical interns were tabulated and coded, and descriptive data were processed using Microsoft Excel. A score was assigned to each correct answer, and three levels of knowledge were established according to the total score: low (0-6 points), intermediate (7-13 points), and high (14-20 points). Finally, the association between the level of knowledge of ECG interpretation and sociodemographic and academic variables was evaluated using Pearson's chi-square test, with a statistical significance level of $p < 0.05$, using SPSS version 27.0.

Ethical considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all participants, and the confidentiality of the information was guaranteed. The study was approved by the Research Ethics Committee of the Faculty of Medicine of the Universidad Nacional Mayor de San Marcos (EC No. 0027-2023).

RESULTS

Questionnaire development and validation

Initially, a 32-item questionnaire grouped into five dimensions was proposed. It was then submitted to expert judgment, and the experts suggested reducing it to 20 questions grouped into three dimensions (knowledge of ECG acquisition, normal tracing, and abnormal tracing) (see Table 1). The Aiken's V validity coefficient obtained was 0.978 (95 % confidence interval: 0.88-1.00), and was therefore interpreted as adequate.

Questionnaire administration

The questionnaire was distributed among medical interns at a general hospital, achieving a response rate of 87.0 % for the virtual survey. A total of 40 medical interns were included; none met the study's exclusion criteria. Of these, 19 were male (47.5 %) and 21 female (52.5 %), with a median age of 26 years (see Table 2).

Questionnaire reliability

A reliability analysis was performed on the correct and incorrect responses to the 20 items of the

Table 2. Characteristics of medical interns from a general hospital who participated in the evaluation of a questionnaire on knowledge of electrocardiogram interpretation

Characteristic	fi	%
Age (years)		
21-23	1	2.5
24-26	19	47.5
27-29	10	25.0
≥30	10	25.0
Sex		
Female	21	52.5
Male	19	47.5
University		
Public	10	25.0
Private	30	75.0
Rotation service		
Surgery	12	30.0
Internal medicine	9	22.5
Gynecology–obstetrics	8	20.0
Pediatrics	11	27.5
Specialty orientation		
Surgical	21	52.5
Clinical	19	47.5

 https://doi.org/10.37711/rpcs.2025.7.4.5

Table 3. Reliability analysis of the questionnaire assessing knowledge of electrocardiography in medical interns from a general hospital in Lima, Peru, 2023

Item	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted
P1	7.68	10.635	0.467	0.719
P2	7.78	11.256	0.253	0.740
P3	7.85	11.721	0.114	0.753
P4	7.80	11.497	0.179	0.747
P8	8.00	10.821	0.437	0.723
P9	7.53	11.435	0.264	0.738
P10	7.58	10.969	0.399	0.726
P11	7.90	10.554	0.487	0.717
P12	7.83	11.379	0.215	0.743
P14	7.83	11.122	0.294	0.736
P15	7.60	11.272	0.283	0.737
P16	7.93	10.328	0.572	0.709
P17	7.60	10.503	0.549	0.712
P18	7.78	10.538	0.480	0.717
P19	8.05	11.741	0.145	0.748
P20	7.80	11.138	0.288	0.736

*Summary statistics: mean = 0.519; minimum = 0.250; maximum = 0.775; variance = 0.023; number of items = 16.

validated questionnaire, using the alpha model and descriptive statistics by item, scale, and scale if an item was deleted. Four of the evaluated items showed negative or low corrected item-total correlation (ranging from −0.37 to 0.11), which significantly reduced the overall reliability of the test; therefore, these items were removed from the questionnaire.

Finally, 16 items with adequate correlation remained and, as a whole, yielded a Cronbach's alpha coefficient of 0.745, interpreted as good (see Table 3). Following this analysis, the questionnaire was restructured to 16 items (see Appendix 1), obtaining a median score of 8 points and a standard deviation (SD) of 3.5 (see Figure 1). Regarding knowledge levels, 62.5 % were intermediate, 22.5 % high, and 15.0 % low (see Figure 2).

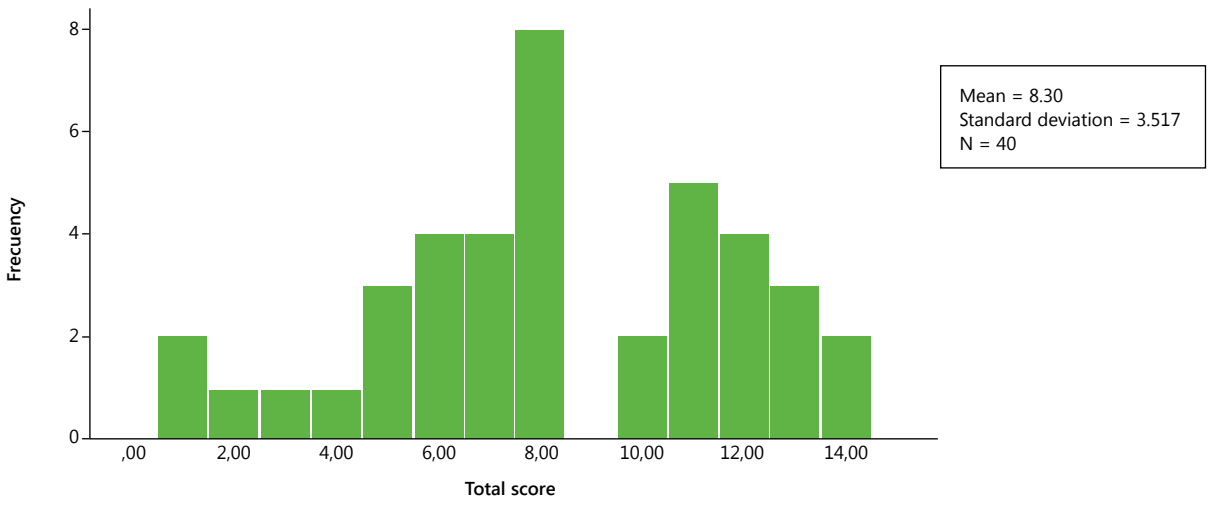

Figure 1. Distribution of scores for knowledge of electrocardiogram interpretation among medical interns, 2023

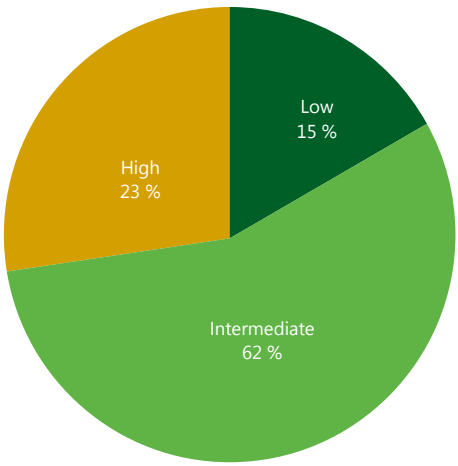

Figure 2. Level of knowledge of electrocardiogram interpretation among medical interns, 2023

When analyzing some factors associated with the level of ECG knowledge, no significant differences were found with respect to sex, age, current rotation, or orientation toward a medical or surgical specialty; however, a statistically significant difference was found between knowledge level and type of university attended (see Table 4).

DISCUSSION

This study developed and validated a questionnaire to assess the level of knowledge of ECG interpretation among final-year medical students, resulting in a 16-item instrument with adequate content validity and good reliability. Although multiple national [11,15-18] and international [7,8,12-14] studies have evaluated this competence in students, physicians, and other health professionals, these have generally used questionnaires without comprehensive reports of validity and reliability. In this sense, the proposed instrument represents a methodological contribution that enables standardized assessment of ECG interpretation knowledge in this population.

Previous studies have employed questionnaires with a larger number of items organized into five dimensions [15,16], primarily based on theoretical

Table 4. Level of knowledge of ECG interpretation among medical interns from a general hospital according to sociodemographic and academic characteristics

Characteristic	Level of knowledge of electrocardiogram			*p*-value*
	High (9)	Intermediate (25)	Low (6)	
Sex				
Female	5	13	3	0.975
Male	4	12	3	
Age				
21 - 26	4	13	3	0.927
≥27	5	12	3	
Rotation specialty				
Surgical	4	13	3	0.927
Medical	5	12	3	
Type of university				
Public	4	3	3	0.017
Private	5	22	3	
Specialty orientation				
Surgical	5	16	3	0.830
Medical	4	15	3	

*Pearson's chi-square test.

frameworks and lacking formal statistical analyses of validity and reliability. In contrast, the questionnaire developed in this study is more concise, structured into three dimensions, and supported by statistical analysis and expert evaluation, which may facilitate its application in both academic and clinical settings, as well as improve participant acceptance.

A systematic review has identified deficiencies in ECG interpretation among both general practitioners and specialists, even after training programs [8,19,20], highlighting the need for structured, continuous, and level-specific educational strategies. These findings reinforce the importance of having valid and reliable instruments that allow objective evaluation of the impact of ECG training programs.

The level of knowledge identified in this study shows that less than one-third of the evaluated students had a high level of knowledge of ECG interpretation, similar to findings reported in other regions of Peru in comparable populations [17,18,21]. Likewise, an association was observed between knowledge level and type of university attended, suggesting heterogeneity in training programs between public and private universities.

This result is consistent with international reports [14] and should be interpreted considering that the ECG is a diagnostic test that can determine therapeutic decisions and patient prognosis, even at the primary care level. Therefore, it is advisable that undergraduate curricula place greater emphasis on ECG training from early stages of medical education [6,11].

Although this questionnaire was validated in medical students, its use could be extended to practicing physicians and other health professionals to evaluate ECG training or educational programs in a standardized manner, as proposed in previous studies [10]. However, further validation studies in these populations will be necessary to confirm its psychometric performance.

Among the main limitations of the study, it should be noted that it was conducted with a small sample size from a single general hospital, which limits the generalizability of the results to other institutions and settings. Nevertheless, the study followed a clear and structured methodology that can be verified and replicated in larger samples. It would also be possible to include other professional groups with comparable roles, as reported in international studies [7,10].

From an applicability standpoint, the validated questionnaire can be used as a screening tool to identify knowledge gaps in ECG interpretation among final-year medical students, as well as to monitor teaching–learning processes and evaluate educational interventions. Future studies could expand its validation across other universities and different groups of health professionals.

Conclusions

The 16-item questionnaire developed to assess the level of knowledge of electrocardiogram interpretation among final-year medical students demonstrated adequate content validity and good reliability, making it a valid tool for the objective evaluation of this diagnostic competence in academic settings.

Acknowledgments

We thank the specialist physicians and medical interns who contributed to the development and validation of this questionnaire, generously offering their time and willingness to support this research.

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Authorship contribution

EAA: Conceptualization, Methodology, Investigation, Data curation, Writing – original draft, Writing – review & editing.

GVR: Conceptualization, Formal analysis, Data curation, Writing – review & editing.

JAT: Conceptualization, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Supervision.

Funding sources

Self-funded.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

The thesis on which this article is based was defended in partial fulfillment of the requirements for the professional degree of Medical Doctor at the Universidad Nacional Mayor de San Marcos, Peru.

APPENDICES

Appendix 1. Questionnaire to assess knowledge of electrocardiogram (ECG) interpretation among medical students, 2023

Instructions: You will be presented with a multiple-choice questionnaire. Please select the answer you consider correct:

Dimension 1. ECG acquisition

1. What is the standard speed for recording an ECG?

a. 25 mm/s.

b. 20 mm/s.

c. 15 mm/s.

d. I do not know.

2. On the ECG calibration strip, what voltage corresponds to an amplitude of 10 mm?

a. 1 mV.

b. 10 mV.

c. 2 mV.

d. I do not know.

3. Which of the following statements regarding the placement of precordial electrodes during ECG acquisition is false?

a. V1: located at the fourth intercostal space at the right sternal border. V2: at the fourth intercostal space at the left sternal border.

b. V3: located midway between V2 and V4. V4: at the fifth intercostal space along the midclavicular line.

c. V6: on the same horizontal plane as V4 and V5, but at the anterior axillary line.

d. I do not know.

Dimension 2. Normal electrocardiogram

4. How is the P wave represented on an ECG in sinus rhythm?

a. The sinus P wave is always positive in all leads, except in lead aVL, where it is negative, and in V2, where it should be isobiphasic.

b. The sinus P wave is always positive in all leads, except in lead aVF, where it is negative, and in V1, where it should be isobiphasic.

c. The sinus P wave is always positive in all leads, except in lead aVR, where it is negative, and in V1, where it should be isobiphasic.

d. I do not know.

5. How can heart rate be measured in the case of an irregular (arrhythmic) ECG?

a. Count the number of QRS complexes in 6 seconds and multiply by 10.

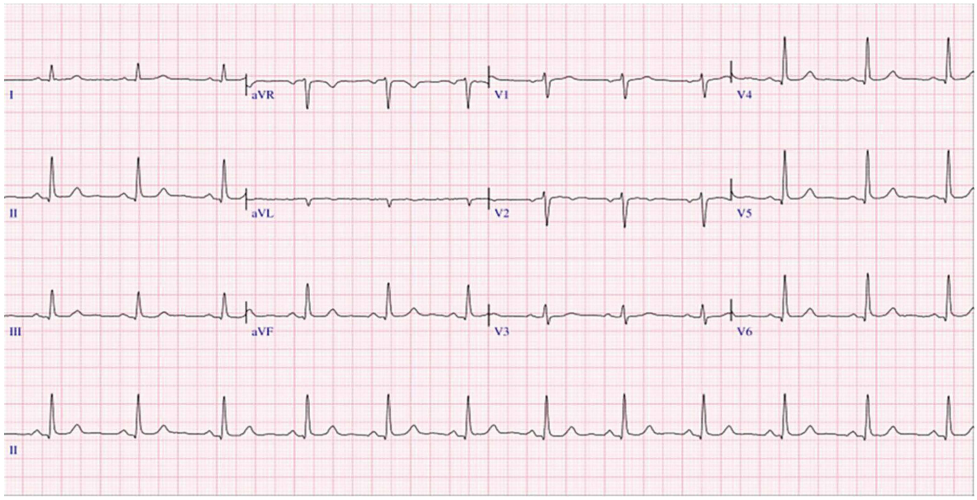
b. Measure the number of "large squares" between consecutive R waves and divide 300 by that number.

c. Measure the number of "large squares" between consecutive R waves and divide 100 by that number.

d. I do not know.

6. What is the correct sequence of waves and intervals in a normal ECG?
   a. P wave, PR interval, QRS complex, ST segment, T wave.
   b. T wave, P wave, QRS complex, ST segment, U wave.
   c. QRS complex, P wave, T wave, ST segment, U wave.
   d. I do not know.

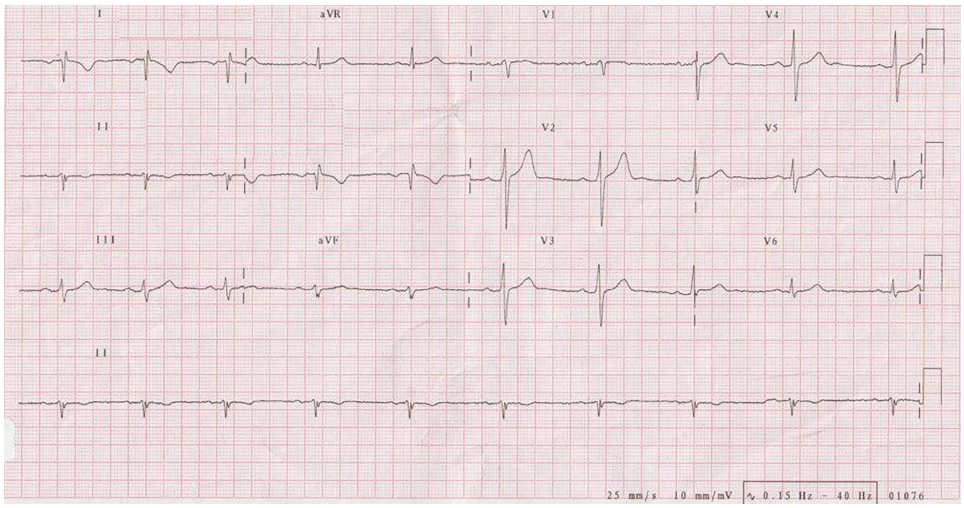
7. What is the correct interpretation based on the reading of the following ECG?



   a. Normal sinus rhythm.
   b. Ventricular tachycardia.
   c. Sinus tachycardia.
   d. I do not know.

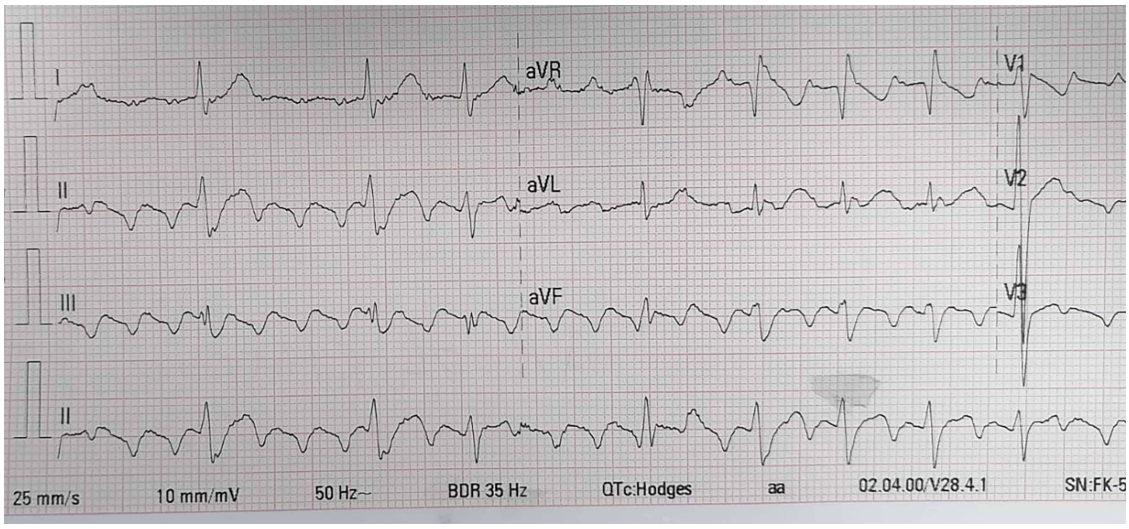
Dimension 3. Abnormal electrocardiogram

8. A medical intern performs an ECG on an asymptomatic young patient scheduled for surgery. What can be observed in the following ECG?



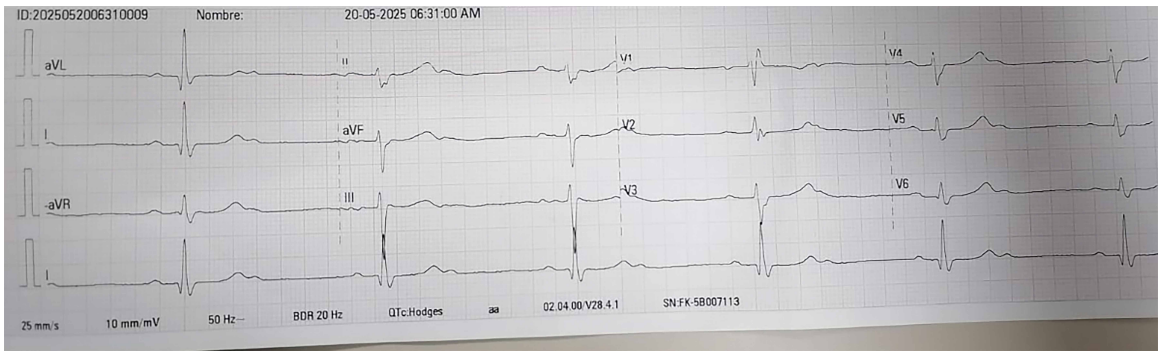
   a. Normal sinus rhythm.
   b. Myocardial ischemia.
   c. The ECG was probably incorrectly performed due to reversal of upper limb electrodes.
   d. I do not know.

9. You perform an ECG and observe the following tracing. What interpretation would you make?



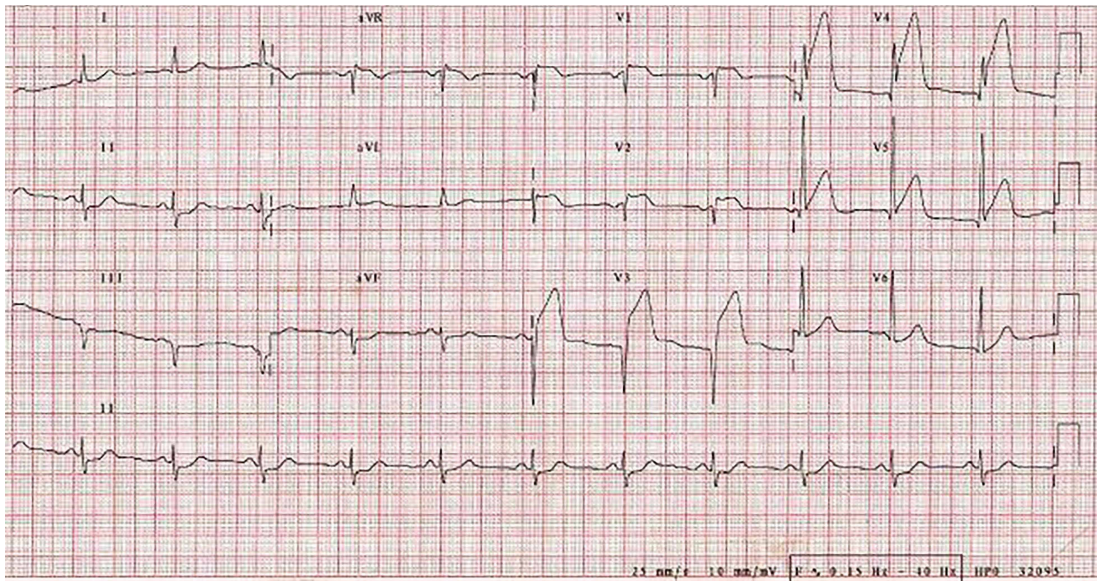
a. Third-degree block.
b. Atrial flutter.
c. Supraventricular tachycardia.
d. I do not know.

10. What condition do you think the patient has based on this ECG?



a. First-degree AV block.
b. No pathology.
c. Third-degree AV block.
d. I do not know.

11. You are in triage and a patient presents with moderate precordial pain. He reports that the pain began 2 hours ago after leaving an important meeting. He is 52 years old, hypertensive, and was diagnosed with type 2 diabetes mellitus a few months ago. A 12-lead ECG is performed and the following tracing is observed:



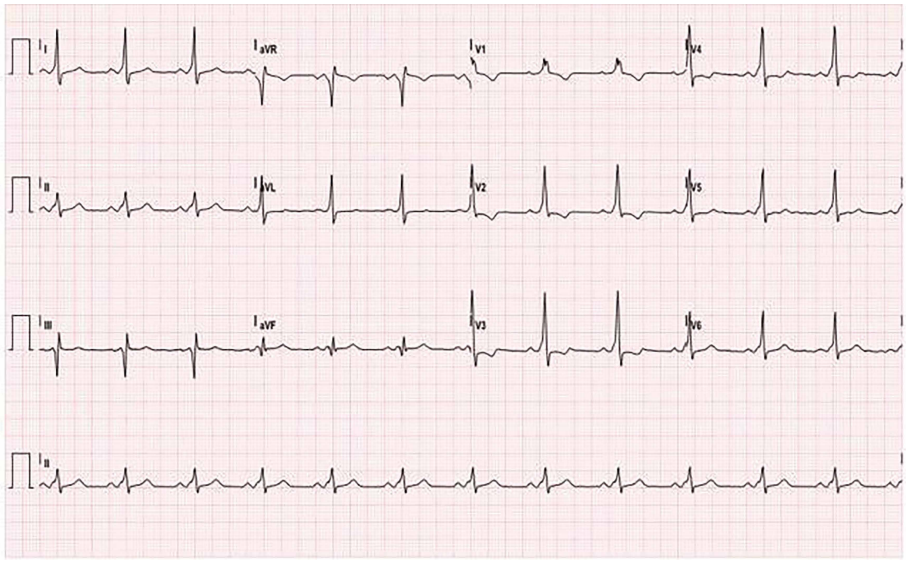
a. Supraventricular tachycardia.

b. Ventricular tachycardia.

c. ST-elevation myocardial infarction (anteroseptal).

d. I do not know.

12. A 24-year-old male, a regular athlete with a lean build, presents to the emergency department. He reports sharp pain in the left pectoral region after finishing exercise (3 hours ago). An ECG is performed and the following is observed:



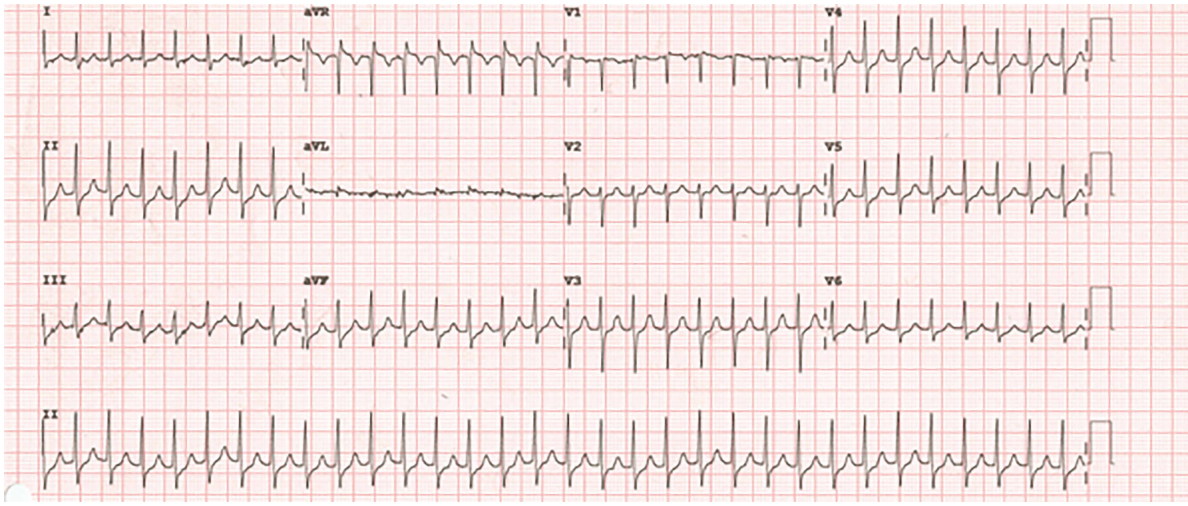
a. Sinus bradycardia.

b. Atrial fibrillation.

c. Wolff–Parkinson–White syndrome.

d. I do not know.

13. A 30-year-old woman presents to the emergency department with palpitations, dyspnea, and chest tightness. An ECG is performed and the following is observed:



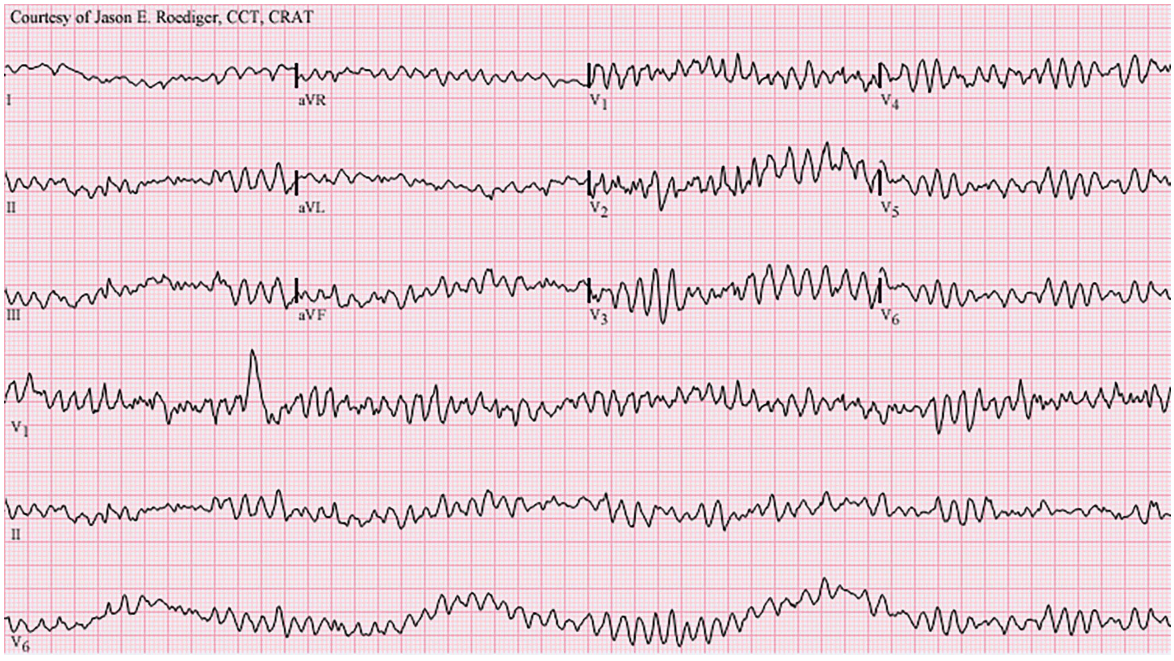
a. Ventricular tachycardia.

b. Atrial extrasystole.

c. Paroxysmal supraventricular tachycardia.

d. I do not know.

14. What is your diagnostic impression based on the following ECG?



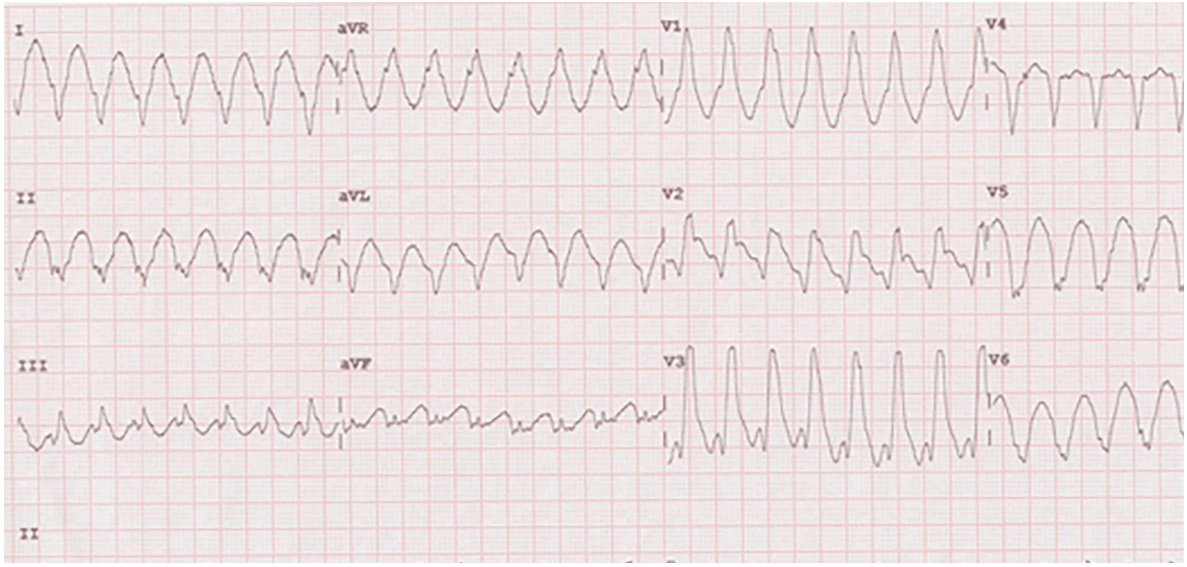
a. Ventricular fibrillation.

b. Sinus tachycardia.

c. Paroxysmal supraventricular tachycardia.

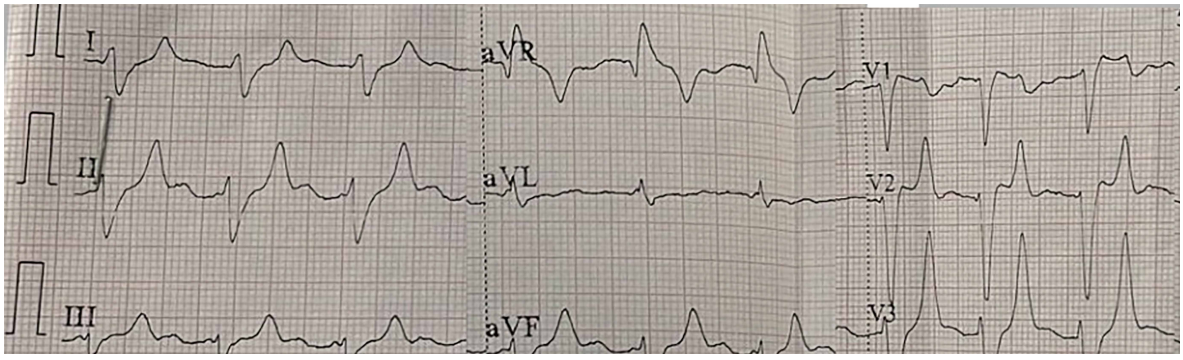
d. I do not know.

15. What condition do you think the patient has based on this ECG?



a. Ventricular fibrillation.
b. Sinus tachycardia.
c. Ventricular tachycardia.
d. I do not know.

16. What is the correct interpretation based on the following ECG?



a. Peaked T wave with probable hyperkalemia.
b. Peaked T wave with probable hypokalemia.
c. Sinus bradycardia.
d. I do not know.