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Prevalence and associated factors of preoperative abnormal electrocardiography among older surgical patients in southern Ethiopia: Multicenter cross-sectional study

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Abstract

Background The prevalence of abnormal electrocardiography (ECG) increases with aging, and these abnormalities may have an impact on anesthesia management. Although a normal ECG does not guarantee a healthy heart, an abnormal ECG can quickly identify a patient who is at high risk of cardiac complications.

Objective The aim of this study was to determine the prevalence and associated factors of preoperative abnormal electrocardiography among older surgical patients at selected teaching hospitals in southern Ethiopia, from February 15 to June 15, 2022.

Methodology A multicenter cross-sectional study was conducted at three randomly selected teaching hospitals in southern Ethiopia on 246 elderly surgical patients recruited consecutively. Data were entered into Epidata version 4.6, then exported and analyzed in STATA version 16. A binary logistic regression model was used to examine factors associated with abnormal ECG, and variables with a P-value < 0.2 were entered into the multivariate analysis to identify independent factors. Both crude and adjusted odds ratios were reported, and a P-value < 0.05 was considered statistically significant. The data were presented using frequencies, tables, charts, and figures.

Result In the current study, 120 (48.78%) of older surgical patients had abnormal preoperative ECGs. In terms of severity, 55.3% were classified as minor, while 44.16% were major ECG abnormalities. The most common ECG abnormalities were left axis deviation (LAD), left ventricular hypertrophy (LVH), and ST segment changes. The presence of comorbidity (AOR = 3.44, $P = 0.001$), age ≥ 70 years (AOR = 2.5, $P = 0.011$), history of angina (AOR = 5.9, $P = 0.011$), history of smoking (AOR = 5.07, $P = 0.024$) and urban residency (AOR = 1.89, $P = 0.039$) were the strongest risk factors for an abnormal ECG.

Conclusion and recommendation Our study shows that older patients are more likely to have an abnormal ECG before surgery, regardless of symptoms or risk factors. Therefore, it is suggested that all older patients undergo

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preoperative ECG screening. Further prospective cohort studies are needed to investigate the impact and outcome of patients with preoperative abnormal ECG.

Keywords Abnormal ECG, Older, Preoperative, Surgical

Background

Aging is a universal and progressive physiological process characterized by changes in organ and tissue structure as well as functional status [1]. As people get older, their hearts and arteries go through a variety of anatomical and functional changes. Moreover, the prevalence of cardiovascular diseases such as systemic hypertension, atherosclerosis, acute myocardial infarction, and congestive heart failure has increased, further limiting the cardiovascular system's function [2].

Surgical interventions in elderly patients are associated with increased rates of morbidity and mortality, possibly due to an increased prevalence of comorbidities, decreased physiological reserve, or both [3]. The aim of the preoperative assessment is to reduce perioperative surgical and anesthetic complications and to optimize them as early as possible through history, clinical examination, and investigations [4, 5].

According to the American Society of Anesthesiologists (ASA) task force on preanesthesia evaluation preoperative investigations are classified as routine and indicated. Routine tests are those performed without any special clinical rationale or aim including a panel of blood, urine tests, and chest x-ray, and ECG) and Indicated tests are those performed for a specific clinical indication or goal, such as confirming a clinical diagnosis, assessing the severity and the progression of disease, or determining the efficacy of medication [6].

Of all investigations, ECG was commonly ordered investigation for the elderly due to the prevalence of age-related cardiovascular changes. ECG is a sophisticated galvanometer and sensitive electromagnet that can detect and record changes in electromagnetic potentials. The ECG (12-lead) is the primary clinical tool for noninvasive assessment of cardiac electrical function and is one of the most widely used, inexpensive, and convenient assessment modalities used to screen for cardiovascular disease [7, 8].

Due to their age and the prevalence of multiple comorbidities, elderly surgical patients are at increased risk of preoperative ECG abnormalities. Elderly patients are more likely to have cardiovascular disease, cerebrovascular disease, and diabetes mellitus, all of which increase the overall risk of the cardiovascular system [3].

Abnormal electrocardiograms become more common as people get older. Evidence showed that the prevalence of abnormal ECG is high in the elderly population. Studies conducted in the United States, China, Brazil, and Nigeria showed that the prevalence of abnormal ECGs was 75.2%, 75.2%, 88.85%, and 70%, respectively [9–12].

According to the American College of Cardiology/American Heart Association (ACC/AHA) guideline, Surgical procedures are classified as low (<1%), intermediate (1–5%), or high (>5%) risk for the development Perioperative Cardiac Events (PCE) within 30 days after surgery. Preoperative ECG is not recommended for patients undergoing low-risk surgery but is indicated for patients with risk factors such as known heart disease, peripheral arterial disease, cerebrovascular disease, or other significant structural heart disease [13].

Previous studies in this area have had inconsistent results on the prevalence and associated factors of abnormal ECG. In addition, no consensus on the lowest age for routine preoperative ECG in elderly patients presenting for surgery, particularly in patients without specific risks. The present study aimed to evaluate the prevalence and contributing factors of preoperative ECG abnormalities in elderly surgical patients aged 50 years and older.

Methods

A multi-center cross-sectional study was conducted from February 15, 2022 to June 15, 2022. Ethical clearance was obtained from the institutional review board. Patients aged over 50 years scheduled for elective surgery during study period who have the willingness to participate in this study at selected hospitals in southern Ethiopia were included.

Patients presenting for minor surgery requiring only local anesthesia, older patients who were mentally impaired and unable to give information, patients undergoing emergency surgery, and patients who underwent two or more operations if the ECG was assessed during the first surgery were excluded from the study.

Sample size and sampling procedure

The sample size was calculated using software Epiinfo version 7 based on the objectives of the study. A previous study published in 2014, and conducted in, Ibadan, Nigeria on elderly patients revealed that, the prevalence of abnormal ECG was 70% [12]. By taking proportion 70%, 95% confidence interval, and margin of error=5%. Finally, the sample size becomes 323.

Since the total source population was less than 10,000(number of older surgical patients undergoing surgery at selected hospitals (N=850) by making adjustment: nf=n (1+ (n/N)=323 / (1+ (323/850))=234.05≈234 patients. Adding 5% of the non-response rate gives a final

sample size of 246 patients. From the situational analysis, the total number of older surgical patients in the last year at Hawassa University Comprehensive Specialized Hospital (HUCSH), Dilla University Referral Hospital (DURH), and Wolayta Sodo University Comprehensive Specialized Hospital (WSUCSH) were 406, 140, and 304 respectively.

The study populations were taken from each hospital with a proportion allocation formula by dividing the number surgery in each hospital by the total number of surgery at three hospitals multiplied by the sample size (n=246). H=n1/N * n, D=n2/N* n, and W=n3/N*n where n1, n2, and n3 were the total number of surgery in older patients in the last one Year at HUCSH, DURH, and WSUCSH respectively. So the final study populations selected from three hospitals were 118, 40, and 88 at HUCSH, DURH, and WSUCSH respectively.

Data collection procedures

The data was collected from patient's history, medical charts, and preoperative anesthesia record through interviewer administered standardized questionnaire adopted from previous literatures [14–17]. All ECGs for older patients planned for elective surgery who fulfill the inclusion criteria at selected hospitals was reviewed preoperatively by the data collectors after the assigned anesthetist do his preoperative anesthesia evaluation.

The result was interpreted in terms of normal and abnormal by the staff internist. To minimize bias the investigator and data collectors were not involved in the interpretation of patients ECG results at all three sites and ECG findings were classified as normal and abnormal according to the Minnesota Code classification [16]. Further, the ECG was classified as major and minor abnormalities.

Operational definition

Older surgical patient: Patients aged ≥ 50 years undergoing surgery [18].

Normal ECG: Absence of any alteration of the ECG.

Abnormal ECG: Any ECG change beyond normal sinus rhythm (ST-segment changes, T-wave change, AV nodal block, Bundle Branch Block (BBB), ventricular hypertrophy (VH), arrhythmias, prolonged QT, and others).

Minor ECG abnormalities: Include minor isolated Q-QS waves, minor isolated ST-T abnormalities, high R waves, incomplete RBBB, minor QT prolongation (QT interval > 112%), short PR interval, Left Axis Deviation (LAD), Right axis Deviation (RAD), frequent Premature ventricular beat, and other minor abnormalities [19].

Major ECG abnormalities: Included major ventricular conduction defect; definite myocardial infarction MI (defined as the presence of major Q-wave abnormalities); possible MI (defined as the presence of minor Q-QS wave plus major ST-T abnormalities); major isolated ST abnormalities; Left Ventricular hypertropy plus major ST-T abnormalities; major Atrioventricular(AV) conduction abnormalities; and major QT prolongation (QT interval > 116% or if QRS interval > 120 ms), and other major arrhythmias [19].

Data analysis procedure

Once data was collected it was entered with Epidata version 4.6 then exported and analyzed by STATA version 16. The data analysis was carried out using both descriptive and inferential statistics, describing qualitative variables as frequencies and percentages, and quantitative variables as mean and standard deviation (SD). Normality was checked using Kolmogorov–Smirnov test and outliers were checked by both graphical and non-graphical methods. Bivariate analysis was done by binary logistic regression.

Variables that showed an association with preoperative abnormal ECG in bivariate analysis (p-value < 0.2) were entered into a multivariate logistic regression model to identify preoperative abnormal ECG independent factors. A backward stepwise elimination technique was used to build the logistic regression model. The model fitness was evaluated using the Hosmer-Lemeshow goodness of fit test. Multicollinearity between independent variables was checked using variance inflation factor (VIF before entering the multivariable model, and the mean VIF was =1.19. To determine statistical significance, a p-value of less than 0.05 was used. For both the crude and adjusted odds ratios, a 95% confidence interval was provided. The data was presented using numbers, frequencies, tables, charts, and figures as appropriate.

Ethics approval and informed consent

Prior to data collection, ethical approval was granted by Dilla University's Institutional Review Board under Ref. No: duchm/irb/048/2022 and protocol unique number of: duirb/048/22−02. Permission to access patient data was requested through a letter of support sent to each university hospital. Informed consent was obtained from all participants, outlining the research's objectives and procedures. Confidentiality and anonymity were upheld throughout the study. Participants were informed of their right to withdraw from the study at any point.

Results

Sociodemographic characteristics

A total of 246 elderly surgical patients, aged 50 years and older, appointed for elective surgery and who had a preoperative ECG were enrolled in this study. The minimum age of the patients was 50 years and the maximum age was 98 years. The median age was 61.5 (IQR; 56, 70), with the majority of 102 (41.46%) being in the second

(60–69) age group. The majority of patients 167(67.89%) were males, 196(80%) patients have normal weight, 142(57.72%) resided rurally and 91(36.99%) were farmers.

Preoperative baseline characteristics and health conditions of study participants

Regarding the preoperative baseline characteristics, the majority of the study participants (139 (56.5%) were ASA II, followed by ASA I (92 (37.3%), 200 (81.3%) of the patients have a MET Equivalent of 4–10, 55 (22.36%) of the elderly patients were frail and on the base of surgical complexity nearly half 126 (51.22%) of the patients had SHAPE III surgery. Additionally, 16 (6.5%) patients were former smokers, 41 (16.4%) patients had a history of alcohol, 20 (8.13%) had a history of angina, and 28 (11.38%) had a family history of CAD.

In terms of preoperative health status (Fig. 1), 70 (28.46%) of study participants had a history of comorbid conditions, with hypertension being the most common (present in 34 (48.57%) patients, followed by diabetes mellitus (20 (29.11%)). When we see the distribution of cases according to the surgical specialty (Fig. 2) the majority of cases (87.37%) were referred from urology, followed by general surgery (63.11%) and orthopedics (42.07%).

Prevalence of preoperative ECG abnormality

In the current study, the prevalence of preoperative abnormal ECG (Fig. 3) in elderly surgical patients was 48.78, with males accounting for 33.33%. In terms of severity, 67 (55.3%) of all abnormal ECGs were classified as minor, while 53 (44.16%) were classified as major ECG abnormalities.

Left axis deviation (12.18%), LVH (11.67%), and ST segment changes (9.13%) were the most common ECG abnormalities observed in descending order of frequency. Forty-three (35.8%) patients had more than one ECG abnormality (Table 1).

In addition, the first age group (50–59 years) had a greater prevalence of ST abnormalities (4.06%), LVH (2.53%), and T-wave inversion (3.03%), while the second (60–69 years) and third age groups (70–79 years) had a higher prevalence of LAD (6.08%), RAD (3.03%) and right BBB (4.56%). The fourth age group (80 years and older) has a higher prevalence of poor R-wave progression (1.01%) and fascicular block (1.01%).

Associated factors of preoperative abnormal ECG

The bivariate analysis for this study revealed that age greater or equal to 70 years, place of residence, ASA III-IV, MET equivalent less than four, frailty, history of comorbid disease, duration of comorbid disease greater than 5 years, smoking history, history of alcohol intake, history of angina and family history of CAD were significantly associated with preoperative abnormal ECG.

A Multivariate logistic regression analysis (Table 2) found that history of comorbid disease (3.44(1.65–7.18)), Age≥70 years (2.5(1.23-5.0)), History of angina (5.9(1.49–23.47)), History of smoking (5.07(1.24–20.7)), and urban residence (1.89(1.03–3.48)) were independently associated with preoperative abnormal ECG.

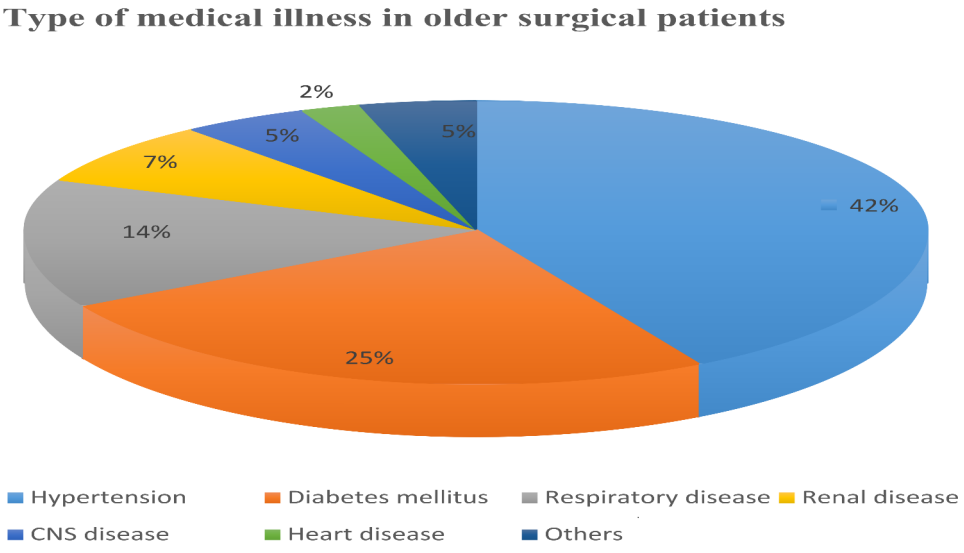


Fig. 1 Type of medical illness present in older surgical patients operated at selected hospitals of southern Ethiopia, February 15-June 15, 2022 ($n=246$)

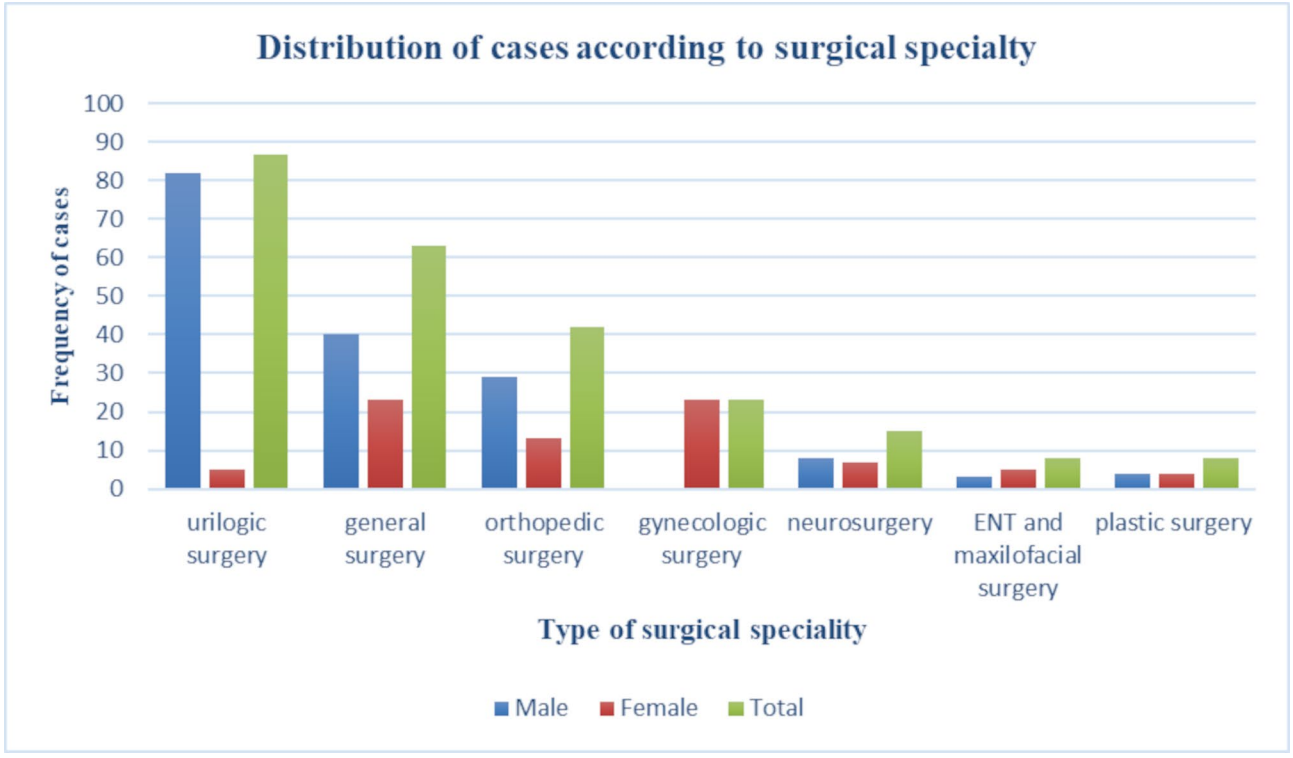


Fig. 2 : Distribution of cases according to surgical specialty and gender among older surgical patients operated at selected teaching hospitals of southern Ethiopia, February 15-June 15, 2022 (*n* = 246)

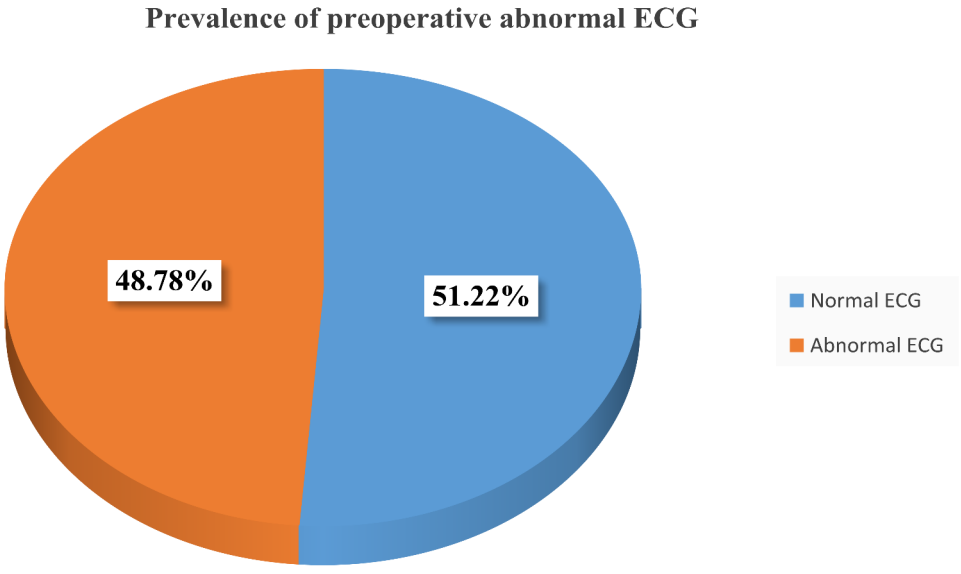


Fig. 3 Prevalence of preoperative abnormal ECG among older surgical patients at three teaching hospitals of southern Ethiopia, February 15-June 15, 2022 (*n* = 246)

Discussion

Abnormal ECGs become more common as people grow older due to physiological changes, the prevalence of comorbid disease, or both. The present study was conducted to determine the prevalence and associated factors of preoperative abnormal ECG among older surgical patients.

Our findings revealed that the prevalence of preoperative abnormal ECG in older surgical patients was 48.78%(CI 42–56%), which is lower than the findings of

Table 1 Type and number of preoperative ECG abnormality based on age groups among older surgical patients operated at selected teaching hospitals in southern Ethiopia – 2022GC

Common ECG abnormalities	Total number of abnormalities	50–59 years	60–69 years	70–79 years	≥ 80 years
LAD	24(12.18%)	3(1.52%)	9(4.56%)	7(3.55)	5(2.53%)
LVH	23(11.67%)	5(2.53%)	8(4.06%)	7(3.55)	4(2.03%)
ST segment changes	18(9.13%)	8(4.06%)	7(3.55)	3(1.52%)	0
Sinus bradycardia	17(8.62%)	2(1.01%)	6(3.04%)	7(3.55)	2(1.01%)
RBBB	13(6.59%)	4(2.03%)	6(3.04%)	3(1.52%)	0
T wave inversion	13(6.59%)	6(3.03%)	3(1.52%)	0	4(2.03%)
RAD	9(4.56%)	1(0.5%)	5(2.53%)	3(1.52%)	0
Sinus Tachycardia	9(4.56%)	5(2.53%)	1(0.5%)	3(1.52%)	0
RVH	8(4.06%)	3(1.52%)	4(2.03%)	1(0.5%)	0
Poor R-wave progression	7(3.55%)	1(0.5%)	1(0.5%)	4(2.03%)	2(1.01%)
Fascicular block	6(3.04%)	0	1(0.5%)	3(1.52%)	2(1.01%)
LBBB	6(3.04%)	1(0.5%)	2(1.01%)	3(1.52%)	0
AV block	4(2.03%)	0	2(1.01%)	1(0.5%)	1(0.5%)
Low voltage ECG	4(2.03%)	2(1.01%)	0	1(0.5%)	1(0.5%)
Others	36(18.24)	11(5.58%)	16(8.12%)	6(3.04%)	3(1.52%)

Table 2 Multivariate logistic regression-showing factors associated with preoperative abnormal ECG among older surgical patients at selected teaching hospitals in Southern Ethiopia, February 15 –June 15, 2022, ($n=246$)

Variable	Category	COR (95%CI)	AOR(95% CI)	*P*-value
Age	50–69 years	1	1	**0.011****
	≥ 70 years	2.67(1.15,3.49)	2.5(1.23-5.0)	
Place of residency	Rural	1	1	**0.039****
	Urban	2.14(1.28–3.58)	1.89(1.03–3.48)	
History of comorbidity	No	1	1	**0.001****
	Yes	5.07(2.71,9.48)	3.44(1.65–7.18)	
History of smoking	No	1	1	**0.024****
	Yes	5.98(1.38,17.94)	5.07(1.24–20.7)	
History of angina	No	1	1	**0.011****
	Yes	6.78(1.93–23.73)	5.9(1.49–23.47)	

Key: **: significant in the Multivariate logistic regression (p-value < 0.05), 1: Reference, AOR adjusted odds ratio, COR crude odds ratio, CI confidence interval

Friedman, J et al. in New York (70.1%) [20], Souza et al. in Brazil (88.85%) [11], and Awana EE, et al. in Nigeria (70%) [12].

On the other hand, our finding is higher than a study conducted in India by Prabal Bharali et al., who reported a prevalence of abnormal ECG among elderly patients of 14.45% [21]and Ghimire et al. of 25% [22]. The discrepancy could be due to differences in the socio-economic status, age, selection criteria, study design, sample size, environmental and genetic variations.

The prevalence of LAD in our study was 12.18%. It was also observed that the prevalence increased with age, with 1.52% in the first age group (50–59 years), 4.56.21%, and 3.55% in the second and third age groups, respectively. Our findings are consistent with those of an Indian study by Khane et al. [23].

In addition, the current study revealed that the prevalence of LVH was 11.67%, which was greater in the second (60–69 years) and third age groups (70–79 years) 4.56%, and 3.55%, respectively than in the first age group (2.53%). The result of our study is in line with the Spanish study by Santos et al. [24]. which reports LVH as the second most prevalent abnormal ECG finding present in 11.8% of patients and increased with age. The increasing prevalence of LVH with age can be attributed to cardiac muscle hypertrophy [1].

Furthermore, this study found that the prevalence of ST segment changes was 9.13% and the majority of subjects were from the second age group (60–69 years) 4.06%. The result of the current study is almost comparable with the study done in Turkey which reports the prevalence of ST-segment abnormalities was 12% [25].

Patient histories in this study revealed that 28.46% of study participants had a history of comorbid disease and were taking medication. The two most common comorbidities observed in elderly surgical patients were hypertension (48.57%) and diabetes mellitus (29.11%), which is comparable to the Nigerian study by Awana EE, et al. [12] and the Spanish study by Santos et al. [24].

According to this study, smokers were 5 times more likely to have a preoperative ECG abnormality than non-smokers (AOR = 5.07). Smoking was found to be an

important predictor of preoperative ECG abnormalities, and our study's finding was supported by studies conducted in India [26] and china [27]. This is due to cardiac effects of nicotine a conduction system and electrophysiology which contributes to induce arrhythmias and other ECG changes [28].

Preoperative ECG abnormalities were associated with an older age of 70 years or more in our study. Patients 70 years and older were 2.5 times more likely to develop an ECG abnormality than patients 50 to 69 years of age (AOR=2.5 95% (1.23-5.0)). Our result agrees with a study by Correll et al. which reports that older age is an independent predictor of an abnormal ECG [29].

In terms of comorbid illnesses, our study revealed patients who have a history of comorbid disease were 3.4 times more likely to have preoperative abnormal ECG than those who do not have(AOR=. 3.44 & 95%CI (1.65–7.18) other studies done in China by Yu et al. [27], in Nigeria by Awana EE, et al. [12]. and Brazil by Gutiérrez, et al. [30]also confirmed that patients who have coexisting medical illness have a higher chance of having abnormal ECG. This finding is not surprising given that comorbid conditions like hypertension and diabetes mellitus are known to have long-term effects on cardiac function. Furthermore, drugs used in the treatment of comorbid illnesses can cause various types of ECG changes [2].

Our finding also indicated that patients who had a previous history of angina had an odd ratio of a 5.9 times higher risk of abnormal ECG than those who had no history of angina (AOR=5.9 95% CI (1.49–23.47). This is in agreement with a study conducted in the USA by Linda et al. [9]. , which reports a prior history of angina had a significant impact on preoperative abnormal ECG.

Regarding place of residence, our findings revealed that older patients in urban areas were 1.89 times more likely than those living in rural areas to have a preoperative abnormal ECG (AOR=1.89 95% CI (1.03–3.48). In contrast to our study a Chinese study found that living in rural areas was significantly associated with major arrhythmias [27]. This could be due to differences in the study population's lifestyles and socioeconomic status of patients living in the urban and rural areas.

Strength of the study

The first strength is that we included elderly surgical patients from a variety of surgical specialties in three different teaching hospitals in southern Ethiopia which increases generalizability. Second, since this is the first study of its kind in Ethiopia, it will serve as a baseline for future valuable research in the area of interest.

Limitation of the study

Our study is not without limitations, the following are the probable weaknesses of this study.

First, the professionals involved in reading and interpreting ECG results at all three sites were different, and the ECGs were performed on various electrocardiograph devices. This may have an impact on the interpretation of ECG results, resulting in bias even if we try to control this effect by utilizing a validated tool such as the Minnesota code of ECG classification.

Second, the hospital-based data collection limits the generalizability of our findings to the general population.

Third, since its cross-sectional study there was follow-up time to assess the outcome of patients with preoperative abnormal ECG.

Conclusion

The present study revealed that the prevalence of preoperative abnormal ECG increases with age. Nearly half (48.78%) of elderly patients appointed for elective surgery have an abnormal ECG. In terms of severity, more than half of (55.3%) abnormalities were classified as minor ECG abnormalities. Left axis deviation, LVH, ST segment alterations, and sinus bradycardia were the most common ECG abnormalities observed in descending order of frequency.

Furthermore, our findings show that history of comorbid disease, age≥70 years, angina history, smoking history, alcoholic history, and urban residence are the independent risk factors of preoperative abnormal ECG. This strengthens the importance of preoperative ECG in patients younger than 65 years, especially in those with risk factors like diabetes, hypertension, history of angina, and cardiovascular disease before any elective surgery.

Recommendation

Preoperative ECG is advisable in all older patients, including those under 65 years of age without risk factors because preoperative ECG allows for the detection of asymptomatic significant cardiac abnormalities. Further prospective cohort studies with a comparator group, is demanded to assess the perioperative implications and outcome of patients with preoperative abnormal ECG with an adequate follow-up time.

Abbreviations and acronomies

AF	Atrial fibrillation
ASA	American society of anesthesiologists
CAD	Coronary artery disease
DURH	Dilla University referral hospital
ECG	Electrocardiography
HUCSH	Hawassa University comprehensive specialized hospital
LAD	Left axis deviation
LBBB	Left bundle branch block
LVH	Left ventricular hypertrophy
MET	Metabolic equivalent
MI	Myocardial infarction

PCE	Perioperative cardiac events
RAD	Right axis deviation
RBBB	Right bundle branch block
RVH	Right ventricular hypertrophy
VF	Ventricular fibrillation
WSUCSH	Wolayita Sodo University comprehensive specialized hospital

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Author contributions
all investigators are engaged in Conception and design of the study, Data analysis and interpretation, Critical revision and intellectual input of the study.

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Data availability
Data and material can be available where appropriate.

Declarations

Human ethics and consent to participate
Ethical approval was made by Dilla University institutional review Board (IRB) and consent to participate was obtained from all the participants.

Competing interests
The authors declare no competing interests.

Provenance and peer review
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