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ORIGINAL RESEARCH

Incidence and Predictors of Cardiac Arrest Among Patients Admitted to the Intensive Care Units of a Comprehensive Specialized Hospital in Central Ethiopia

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Background: Cardiac arrest (CA) is a common public health problem. Worldwide, cardiac arrest ranks highly among hospitalised patients' public health concerns, particularly in low-income nations. Data on cardiac arrest in intensive care units in low-income countries are relatively scarce. Determining the incidence and predictors of cardiac arrest among ICU patients will be a very crucial and fruitful clinical practice in resource-limited areas like Ethiopia.

Methods: A retrospective cohort study was conducted by reviewing charts of 422 systematically selected patients admitted to the ICU from 2018 to 2022 in Wachemo University Comprehensive Specialized Hospital. The extraction tool was used for the data collection, Epi-data version 4.6.0 for data entry, and STATA version 14 for data cleaning and analysis. Kaplan-Meier, log rank test, and life table were used to describe the data. The Cox proportional hazard regression model was used for analysis.

Results: The findings of this study revealed that the overall occurrence of cardiac arrest among critically ill ICU patients was 27% (95% CI: 23, 32). The incidence density rate of cardiac arrest among intensive care unit patients was 19.6 per 1000 person-days of observation. In a multivariable analysis, patients with chronic kidney disease, oxygen saturation <90%, delirium, intubation, and patients admitted to the ICU with cardiovascular disease were found to be independent predictors of cardiac arrest in the Intensive Care Unit.

Conclusion: The incidence density rate of cardiac arrest among intensive care unit patients was high. This study also revealed that chronic kidney disease, delirium, intubation, oxygen saturation level below 90% and patients admitted with cardiovascular disease were independent predictors of the occurrence of cardiac arrest among intensive care unit patients. Finally, we recommend that clinician pays attention to those identified as preventable risk factors for early interventions to improve the recovery process of patients in the ICU.

Keywords: cardiac arrest, intensive care unit, incidence, predictors, Ethiopia

Introduction

Cardiac arrest (CA) is a common public health problem. Nearly 20% of all mortality in industrialized countries is due to cardiac arrest.[1] Around 17 million deaths worldwide are attributed to cardiovascular disease, making it the leading cause of mortality.[2,3] In developed countries, cardiac arrest accounts for 15–20% of all adult natural deaths. Cardiac arrest, accounts for over 50% of deaths from cardiovascular disease.[4,5] In the USA, there are

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an estimated 200,000 sudden cardiac arrests annually that require advanced cardiac life support.[6] The incidence of cardiac arrest in intensive care (ICU) has not been adequately reported worldwide. Critically ill patients in emergency departments and intensive care units can commonly suffer from cardiac arrest, a high risk of mortality in the hospital.[7,8] Cardiac arrest victims are at high risk of mortality and poor outcomes in the intensive care unit.[9–11] Worldwide, cardiac arrest ranks highly among hospitalised patients' public health concerns, particularly in low-income nations. It is one of the most common potentially fatal issues that ICU patients face.[12] However, body of evidence data regarding the incidence and predictors of cardiac arrest in low-income contents, like Africa, is lacking.

Several reviewed types of literature demonstrated multifactorial factors associated with cardiac arrest, and aetiology and risk factors for sudden cardiac arrest in the ICU vary geographically and in settings of health facilities. Previously reported studies indicated age, gender, body mass index, smoking, occupation, marital status admission diagnosis, diabetic mellitus, hypertension, sedation drug, known cardiovascular disease, vasoactive drugs, renal failure, and baseline clinical characteristics.[3,13–16] However, these factors were reported in the developed countries, whereas data in the developing countries was not well reported.

In the intensive care unit (ICU-CA), cardiac arrest is a common and highly morbid event. Several studies have been conducted to assess its incidence, outcome, and preventability. According to a meta-analysis and systematic review, there is an incidence of 22.7 Intensive Care Unit cardiac arrest for every 1000 patients, and 17% of patients survive to be discharged from the hospital.[7] However, data on cardiac arrest in patients receiving treatment in intensive care units in low-income countries are relatively scarce. This makes it challenging to improve ICU patient outcomes and practice clinical transformation. Prior research was published in developed countries. Thus, the incidence and identification of risk factors for preventing premature cardiac arrest in patients receiving intensive care unit treatment will continue to be researched in the future.

This study aimed to determine the incidence and predictors of cardiac arrest among ICU patients and will be a very crucial and fruitful clinical practice to prioritize resources based on the prediction of cardiac arrest, particularly in resource-limited areas like Ethiopia. It aimed to fill the knowledge gap regarding the risk factors and incidence burden of cardiac arrest in the ICU when the clinicians' interventions became fully integrated for the better outcome of ICU patients.

Methods

Study Area and Period

The study was conducted at Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital, which is located in the Central Ethiopia Region of Ethiopia. It is one of the teaching hospitals in Ethiopia. It is found in Hosanna, which is the capital city of the region, 230 km away from Addis Ababa and the capital city of Ethiopia. The hospital provides services for more than 5 million people, both outpatients and inpatients, including emergency and intensive care units. The data was collected from June 1 to 30, 2023, by reviewing 5 years of follow-up data on charts of ICU patients who were admitted from 2018 to 2022.

Study Design

An institutional-based retrospective follow-up study was conducted among patients who were admitted to the intensive care unit of Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital (WCUNEMMCSH).

Source of Population

All patients who were attending the Intensive Care Unit of Wachemo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital.

Study Population

All adult patients whose age is greater than or equal to 18 years, admitted to the ICU from January 1, 2018, to January 1, 2022, were selected using a systematic sampling technique in the Intensive Care Unit of Wachemo University Comprehensive Specialized Hospital.

Eligibility Criteria

All adult patients whose age is greater than or equal to 18 years, admitted to ICU from January 1, 2018, to January 1, 2022, at Wachemo University Comprehensive Specialized Hospital, and whose chart is complete and available during data collection time were included in the study. Charts of ICU patients with incomplete data that was not available during data collection were excluded from the study.

Sample Size Determination and Sampling Procedure

To determine the sample size, a single population proportion formula was used. Since there was no previous study done similar to this topic, we took a proportion of 50% by assuming a 95% CI with a 5% margin of error, and finally the sample size for the study was calculated.

$$n = \frac{(Z_{\alpha/2})^2 x\ P(1-P)}{d^2}$$

Where, n=the desired sample size; Z=standard normal distribution usually sets us 1.96 (corresponds to 95% CI); P=population proportion (50%, 0.5), q is 1–0.5=0.5, and d=degree of accuracy desired (marginal error is 5%, =0.05); then the sample size was

$$n = \frac{(1.96)^2 x\ 0.5(1-0.5)}{(0.05)^2} = 384$$

By adding 10% of incomplete data, the final retried sample size was 422. Finally, a systematic sampling technique was applied to select charts to be reviewed, including every two charts after determining the first case by lottery methods. Subsequent charts were considered if it appeared that any charts had been missed or had incomplete data.

Operational Definition and Measurements

Cardiac arrest (CA) is defined as sudden cessation of cardiac activities, which results in unresponsiveness with no sign of circulation or no heart rhythm activities on Electrocardiograph monitoring. Cumulative fluid balance using the percentage (%) from the date of ICU admission until the end of the follow-up (event or censored). Therefore, using the daily cumulative fluid balance (%) subtraction of daily input to output in litres divided by admission weight and multiplied by 100 for every ICU patient, we classified the patient's fluid balance as positive if the patient recorded a cumulative fluid balance >0% and negative if the patient recorded a fluid balance of <0% if the patient fluid balance recorded above 10% considered as fluid overload.[17] The event was considered when cardiac arrest occurred on follow-up after 24 hr of Intensive Care Unit admission to the end of the follow-up period, while those patients who were alive remained on follow-up during the study period, transferred out, and those whose death was not due to Cardiac arrest during the follow-up period were considered censored. Survival time was the time measured in days from the admission of ICU to the development of cardiac arrest or censored. Cardiovascular disease is described in the current study if the patient is admitted to the ICU with at least one of the following conditions: congestive heart failure, myocardial infarction, or coronary artery disease.

Data Collection and Procedure

First, the information on the patient charts was reviewed and an appropriate data extraction checklist was prepared in English language. The checklist was adapted from intensive care unit patient monitoring, and triage sheets, and by reviewing different related articles.[18–21] The tool comprised socio-demographic details, the date of the patient's admission to the intensive care unit (ICU), the diagnosis, the baseline vital signs, the baseline laboratory results, comorbidities,

the medication administered, the vital signs at the end of the follow-up, the laboratory results at the end of the follow-up, complications, the date of the last follow-up (the date of the developing Cardiac Arrest, patient's recovery or death from the ICU or stayed in the ICU after 24 hr of ICU admission). Using the patients' medical record numbers (MRNs), the list of charts was retrieved from the database in the electronic recording systems and ICU registration logbooks. Three data collectors and one supervisor were employed, and data collection was accomplished within four weeks from June 1 to 30, 2023.

Data Quality Control

The checklist was pretested on 21 (5% of the participants) in randomly selected patient charts to maintain data quality before starting the actual data collection period. Two days of training were given for data collectors and a supervisor working outside of the study area regarding the data collection process and tools before data collection began. Supervisors and principal investigators monitored the data collection procedure daily for completeness and consistency of collected data.

Data Processing and Analysis

At the end of data collection, the collected data were checked for incompleteness, and then data were entered into Epi-data Manager version 4.6.0.6 and exported to STATA version 14 for cleaning, editing, coding, and analysis. Explanatory data analysis was done to determine missing values, normality tests, and the presence of outliers before data analysis. Then data were described using relative frequency, percent, mean with standard deviation, and median based on the applicability. A life table was used to estimate the cumulative probability of early cardiac arrest at different time intervals. Kaplan-Meier's survival curve was used to estimate median survival time during the follow-up period and log rank tests were also used to compare survival curves for the presence of differences in the incidence of cardiac arrest (CA) among the groups.

Bi-variable analysis was computed to identify possible associations between cardiac arrest and each dependent variable using the Cox proportional hazard model. Variables, significant at $p \leq 0.25$ level in the bi-variable analysis, were collectively included in the multi-variable analysis, to identify independent predictors of Cardiac Arrest.

Using variable inflation factors (VIF) between independent variables, multi-co-linearity was checked, and all outputs fell within the acceptable range (mean VIF=1.12). The proportional hazard assumptions were also checked using the global test with a value of p=0.2476, which was insignificant. The Cox-Snell residuals were also used to assess the Cox regression model's fitness to the data. Finally, we could conclude that the final model fits successfully. In multi-variable analysis, any variable was considered statistically significant at $p<0.05$. The association between the incidence of cardiac arrest and independent variables was declared using an adjusted hazard ratio (AHR) with a 95% confidence interval. Finally, data were presented using tables, frequency, graphs, and texts.

Ethical Consideration

Ethical consideration was obtained from the institutional review board of Wachemo University (protocol number=WCU-IRB 021/23). After approval by IRB, official letters of cooperation were written for the hospital administrators. Then, data were collected after getting permission from hospital administrators on behalf of the patients since the study was conducted retrospectively. Data coding aggregates were used to ensure anonymity and confidentiality.

Result

A total of 656 patients were admitted to the ICU during the study period, of which 422 patients' charts of the intensive care unit were included for analysis. Two hundred and thirty-four charts were excluded during data extraction; two hundred and three were for those aged below 18 years, ten for incomplete data, and twenty-one were due to missed charts at the time of data collection. In this case, the patient's medical record numbers next to the incomplete data or those missed charts were incorporated for review.

Socio-Demographic Characteristics

In this study, 239 (56.6%) of the study subjects were males, of which 63 (26.4%) patients developed cardiac arrest (CA), whereas 51 (27.9%) developed cardiac arrest. Regarding the age of the participants ≥60 years, 56 (28.8%) developed cardiac arrest. The

mean age of study participants was 55 years (SD=18.1). Based on the findings, above half of 225 (53.3%) study participants were from urban areas. The study findings showed that 77.2% of the study subjects' respiratory rate was recorded as greater than or equal to 24 breaths per minute, of which 27.3% of the participants developed cardiac arrest. According to the study results, the proportion of hypoxia was higher than 224 (53.1%) of the study participants, of which 37% of the patients developed cardiac arrest. Among 176 (41.7%) patients who were admitted to ICU with severe Glasgow coma scale, of which 45 (25%) developed cardiac arrest (Table 1).

Diseases-Related Variables of ICU Patients

The study results showed that 57 (13.7%) study subjects were diagnosed with severe pneumonia, of which 27 (47.4%) developed cardiac arrest. The majority of the participants, 253 (60%), were diagnosed with shock during ICU admission, among those 26.1% who developed cardiac arrest in the ICU. This study results revealed that 24.2% (102/422) of study subjects were admitted to the ICU with cardiovascular diseases. Moreover, the proportion of reasons for ICU admission among patients with thoracoabdominal injury, traumatic brain injury, Diabetic ketoacidosis, and post-operative was 16%, 15.9%, 10%, and 9%, respectively.

The findings showed that 183 (43.6%) study subjects had at least one comorbid condition, of which 58 (31.5%) had developed cardiac arrest. This study's findings revealed that the most frequently recorded comorbidities were Obesity 125 (29.6%), Hypertension 103 (24.4%), Diabetics Mellitus 94 (22.3%), Cardiovascular Disease 81 (19.2%), and chronic kidney disease 63 (14.9%). The proportion of cardiac arrest was much higher among patients having chronic kidney disease (CKD) (55.6%, n=63) compared to patients who were free of CKD (22%, n=359) (Table 2).

Table 1 Distribution of Socio-Demographic Characteristics and Vital Signs at Baseline Among Patients Admitted to the Intensive Care Unit of Wachemo University Comprehensive Hospital in Central Ethiopia, 2023

Variables	Categories	Outcome		
		Event n (%)	Censored n (%)	Total n (%)
Age	<60 years	58(25.7%)	168(74.3%)	226(53.6%)
	≥ 60 years	56(28.6%)	140(71.4%)	196(
Sex	Male	63(26.4%)	176(73.6%)	239(56.6%)
	Female	51(27.9%)	132(72.1%)	183(43.4%)
Residency	Rural	37(18.9%)	160(81.2%)	197(46.7%)
	Urban	77(34.2%)	148(65.8%)	225(53.3%)
Respiratory rate	<24 breaths per minute	25(26.0%)	71(74.0%)	96(22.8%)
	≥24 breaths per minute	89(27.3%)	237(72.7%)	326(77.2%)
Pulse rate at baseline	<60 beats per minute	11(26.2%)	31(73.8%)	42(10.0%)
	60–100 beat per minute	33(24.8%)	100(75.2%)	133(31.5%)
	>100 beats per minute	70(28.3%)	247(58.5%)	247(58.5%)
Temperature at baseline ($^{\circ}C$)	<36.5$^{\circ}C$	27(26.5%)	75(73.5%)	102(24.2%)
	36.5–37$^{\circ}C$.5	29(25.7%)	84(74.3%)	113(26.8%)
	>37.5$^{\circ}C$	58(28.0)	149(72.0%)	207(49.0%)
Mean Arterial pressure	≥65 mmHg	33(15.5%)	180(84.5%)	213(50.5%)
	<65mmHg	81(38.8%)	128(61.2%)	209(49.5%)
Oxygen saturation %	<90%	83(37.0%)	141(63.0%)	224(53.1%)
	≥90%	31(15.7%)	167(84.3%)	198(46.9%)
Glasgow coma scale at admission	14–15 (Mild)	22(40.7%)	32(59.3%)	54(12.8%)
	9–13 (Moderate)	47(24.5%)	145(75.5%)	192(45.5%)
	≤8 (Severe)	45(25.6%)	131(74.4%)	176(41.7%)
Triage Score at Admission	Mild	6(40.0%)	9(60.0%)	15(3.6%)
	Moderate	8(29.6%)	19(70.4%)	27(6.4%)
	Severe	100(26.3%0	280(73.7%)	380(90.0%)

Notes: °C, degree Celsius; mmHg, mill meter of mercury, n=63) compared to patients who were free of CKD (22%, n=359) (Table 2).

Table 2 Reason for ICU Admission and Comorbidities Among Patients Admitted to the Intensive Care Unit of Wachemo University Comprehensive Specialized Hospitals in Central Ethiopia, 2023

Variables	Categories	Outcome Status		
		Event	Censored	Total n (%)
Reason for ICU admission				
Severe Pneumonia	No	87(23.8%)	278(76.2%)	365(86.5%)
	Yes	27(47.4%)	30(52.6%)	57(13.5%)
Shock	No	48(28.4%)	121(71.6%)	169(40.0%)
	Yes	66(26.1%)	187(73.9%)	253(60.0%)
Traumatic brain injury	No	97(27.3%)	258(72.7%)	355(84.1%)
	Yes	17(25.4%0	50(74.6%)	67(15.9%)
Thoraco abdominal injury	No	101(28.5%)	253(71.5%)	354(83.9%)
	Yes	13(19.1%)	55,9(80.9%)	68(16.1%)
Cardiovascular disease(CHF, CAD, MI)	No	71(22.2%)	249(77.8%)	320(75.8%)
	Yes	43(42.2%)	59(57.8%)	102(24.2%)
DKA	No	105(27.6%)	275(72.4%)	380(90.0%)
	Yes	9(21.4%)	33(78.6%)	42(10.0%)
Post-Operative	No	94(24.5%)	289(75.5%)	383(90.8%)
	Yes	20(51.3%)	19(48.7%)	39(9.2%)
Meningitis	No	105(26.2%)	296(73.8%)	401(95.0%)
	Yes	9(42.9%)	12(57.1%)	21(5.0%)
Bronchial Asthma	No	100(25.5%)	293(74.5%)	393(93.1%)
	Yes	14(48.3%)	15(51.7%)	29(6.9%)
Comorbidity				
At least one Comorbidities	No	56(23.5%)	182(68.5%)	238(56.4%)
	Yes	58(31.5%)	126(68.5%)	184(43.6%)
Diabetics Mellitus	No	85(25.9%)	243(74.1%)	328(77.7%)
	Yes	29(30.9%)	65(69.1%0	94(22.3%)
Hypertension	No	67(21.0%)	252(79.0%)	319(75.6%)
	Yes	47(45.6%)	56(54.4%0)	103(24.4%)
Malignancy	No	107(26.9%)	291(73.1%)	398(94.3%)
	Yes	7(29.2%)	17(70.8%)	24(5.7%)
Stroke	No	98(25.7%)	283(74.3%)	381(90.3%)
	Yes	16(27.0%)	25(73.0%)	41(9.7%)
Chronic kidney disease	No	79(22.0%)	280(78.0%)	359(85.1%)
	Yes	35(55.6%)	28(44.4%)	63(14.9%)
HIV/AIDS	No	107(27.7%)	280(72.3%)	387(91.7%)
	Yes	7(20.0%)	28(80.0%)	35(8.3%)
COPD	No	108(27.3%)	288(72.7%)	396(93.8%)
	Yes	6(23.1%)	20(76.9%)	26(6.2%)
Bronchial Asthma	No	109(28.3%)	276(71.7%)	385(91.2%)
	Yes	5(13.5%)	32(86.5%)	37(8.8%)
Cardiovascular disease	No	99(29.0%)	242(71.0%)	341(80.8%)
	Yes	15(18.5%)	66(81.5%)	81(19.2%)
Obesity	No	72(24.2%)	225(75.8%)	297(70.4%)
	Yes	42(33.4%)	83(66.4%)	125(29.6%)

Abbreviations: DKA, diabetic ketoacidosis; COPD, chronic obstructive pulmonary disease; HIV, human immune Virus; AIDS, acquired immune deficiency syndrome.

Baseline Laboratory Findings Among ICU Patients

Regarding the baseline laboratory findings, the most prevalent recognized abnormalities in this study were leukocytosis 55.5%, hyponatremia 37%, hyperkalemia 35.6%, thrombocytopenia 27.3%, and elevated serum creatinine level 24.6%. Among those study participants with leukocytosis, of which 25.6% (60/234) developed cardiac arrest at the end of follow-up. Nearly two-thirds of 73% (307/422) study participants had greater than or equal to 150,000 platelet count at baseline, of which 25.7% developed CA as 30.4% of the patients with below 150,000 c/μL platelet count developed cardiac arrest. Moreover, 69 (16.4%) patients were identified with elevated blood urea nitrogen (BUN ≥45mg/dl) at admission (Table 3).

Management and Complication-Related Variables

According to the study result, 232 (55.0%) study subjects were intubated, of which 40.5% (94/232) developed Cardiac Arrest (CA). In contrast, the remaining 45% of the patients were not intubated, of which only 10.5%) (20/190) of the participants developed CA. The proportion of cardiac arrest was higher (39.4%) among patients who had blood transfusions than those who did not receive blood transfusions. The majority of study participants 374 (88.6%) took thromboprophylaxis during their ICU stay, of which 103 (27.5%) study subjects developed CA. Furthermore, findings revealed that 71.0% (300/422) of study participants had at least one ICU complication. Acute Kidney Injury (AKI) (60.4%, n=422), hospital Acquired Infections (HAIs) (38.6%, n=422), Delirium (29%, n=317), electrolyte imbalance (23.2%, n=422), and thromboembolism (23%, n=422) were the most prevalent recorded ICU complications among study participants. The study findings also showed that the occurrence of cardiac arrest among patients who have ICU complications was 30.7% (n=300). Conversely, 22 (18.0%) (22/122) of the study subjects who did not have any ICU complication developed CA during their ICU stay (Table 4).

Kaplan-Meier Survival Estimation of Cardiac Arrest

Kaplan-Meier survival curve decreases stepwise and crosses the survival function at a survival probability of 0.5 (50%). Overall Kaplan Meier estimates identified that the probability of developing cardiac arrest in patients admitted to the ICU is low on the first day of admission, which relatively increases as follow-up time increases. The overall median time of developing CA of admitted ICU patients in this study was 37 (95% CI: 32, 41) days. During the first day of hospital stay, a 98.82% survival probability was observed (95% CI: 0.9718, 0.9951) (Figure 1).

Table 3 Baseline Laboratory Results Related Variables Among Patients Admitted to the Intensive Care Unit of Wachemo University Comprehensive Specialized Hospital in Central Ethiopia, 2023

Variables	Category	Outcome Status		
		Event	Censored	Total
WBC Baseline	<=11,000	54(28.7%)	134(71.3%)	188(44.5%)
	>11,000	60(25.6%)	174(74.4%)	234(55.5%)
Hgb baseline	<12mg/dl	24(25.0%)	72(75.0%)	96(22.8%0
	≥12mg/dl	90(27.6%)	236(72.4%)	326(77.2%)
Platelet baseline	<150,000	35(30.4%)	80(69.6%)	115(27.3%)
	≥150,000	79(25.7%)	228(74.3%0	307(72.7%)
Cr. level baseline	<=1.2mg/dl	87(27.4%)	231(72.6%)	318(75.4%)
	>1.2md/dl	27(26.0%)	77(74.0%)	104(24.6%)
BUN at the baseline	<45mg/dl	87(24.6%)	266(75.4%)	353(83.6%)
	≥45mg/dl	27(39.1%)	42(60.9%)	69(16.4%)
Serum Sodium at baseline	<135 mEq/l	39(25.0%)	117(75.0%)	156(37.0%)
	135–148 mEq/l	75(28.2%)	191(71.8%)	266(63.0%)
Serum Potassium at baseline	<3.5mEq/l	12(31.6%)	26(68.4%)	38(9.0%)
	3.5–5mEq/l	44(18.8%)	190(81.2%)	234(55.5%)
	>5mEq/l	58(38.7%)	92(61.3%)	150(35.6%)

Abbreviations: BUN, blood urea nitrogen; Cr, creatinine; Hgb, hemoglobin; mg/dl, mill gram per deci liter; WBC, white blood cells.

Table 4 Interventions and Complications Related Variables Among Patients Admitted to the Intensive Care Unit of Wachemo University Comprehensive Specialized Hospital in Central Ethiopia, 2023

Variables	Categories	Outcome		
		Event	Censored	Total
Management related variables				
Intubation	No	20(10.5%)	170(89.5%)	190(45.0%)
	Yes	94(40.5%)	138(59.5%)	232(55.0%)
Blood transfusion	No	88(24.7%)	268(75.3%)	356(84.4%)
	Yes	26(39.4%)	40(60.0%)	66(15.6%)
Systematic steroid	No	80(26.7%)	220(73.3%)	300(71.1%)
	Yes	34(27.9%)	88(72.1%0	122(28.9%)
Thromboprophylaxis	No	11(22.9%)	37(77.1%)	48(11.4%)
	Yes	103(27.5%)	271(72.5%)	374(88.6%)
Vasopressors	No	54(20.2%)	213(79.8%)	267(63.3%)
	Yes	60(38.7%)	95(61.3%)	155(36.7%)
Sedation	No	39(17.0%)	191(83.0%)	230(54.5%)
	Yes	75(39.0%)	117(61.0%)	192(45.5%)
Diuretics	No	90(29.5%)	215(70.5%)	305(72.3%)
	Yes	24(20.5%)	93(79.5%)	117(27.7%)
Complications				
At least one complication	No	22(18.0%)	100(82.0%)	122(29.0%)
	Yes	92(30.7%)	208(69.3%)	300(71.0%)
Acute kidney injury	No	22(8.2%)	246(91.8%)	268(63.5%)
	Yes	92(59.7%)	62(40.3%)	154(36.5%)
Electrolyte imbalance	No	85(26.2%)	239(73.8%)	324(76.8%)
	Yes	29(29.6%)	69(70.4%)	98(23.2%)
Hospital-acquired infection	No	44(17.0%)	215(83.0%)	259(61.4%)
	Yes	70(42.9%)	93(57.1%)	163(38.63%)
Thromboembolism	No	91(28.4%)	230(71.6%)	321(76.1%)
	Yes	23(22.8%)	78(77.2%)	101(23.9%)
Acute lung injuries	No	97(27.6%)	230(71.6%)	321(76.1%)
	Yes	23(22.8%)	78(77.2%)	101(23.9%)
Delirium	No	72(24.0%)	228(76.0%)	300(71.0%)
	Yes	42(34.4%)	80(65.6%0	122(28.9%)
Fluid overload	No	79(23.5%)	257(76.5%)	336(79.6%)
	Yes	35(40.5%)	51(59.3%)	86(20.4%)
Acute liver injury	No	99(26.2%)	279(73.8%)	378(89.6%)
	Yes	15(34.1%)	29(65.9%)	44(10.4%)
Others	No	110(27.9%)	284(72.1%)	394(93.4%)
	Yes	4(14.3%)	24(85.7%)	28(6.6%)

Note: aspiration pneumonia, sepsis, and arrhythmia.

Survival Function and Incidence Density Rate of Cardiac Arrest

In this study, the patients were followed for a minimum of 1 day to a maximum of 51 days, with the median follow-up period being 37 days (95% CI: 32, 41). The total person-time observation was 5826 person-days. The finding of this study revealed that the overall occurrence of cardiac arrest among ICU critically ill patients was 114 (27%) (95% CI: 23, 32), and the rest 308 (73%) of the participants were censored with (95% CI: 69, 77). The incidence rate of cardiac arrest among intensive care unit patients was 19.6 (95% CI: 25.33, 35.8) per 1000 person-days observation. The cumulative probability of failure at the end of 12, 24, 36, and 51 days were 0.2118, 0.3535, 0.4984, and 0.7999, respectively.

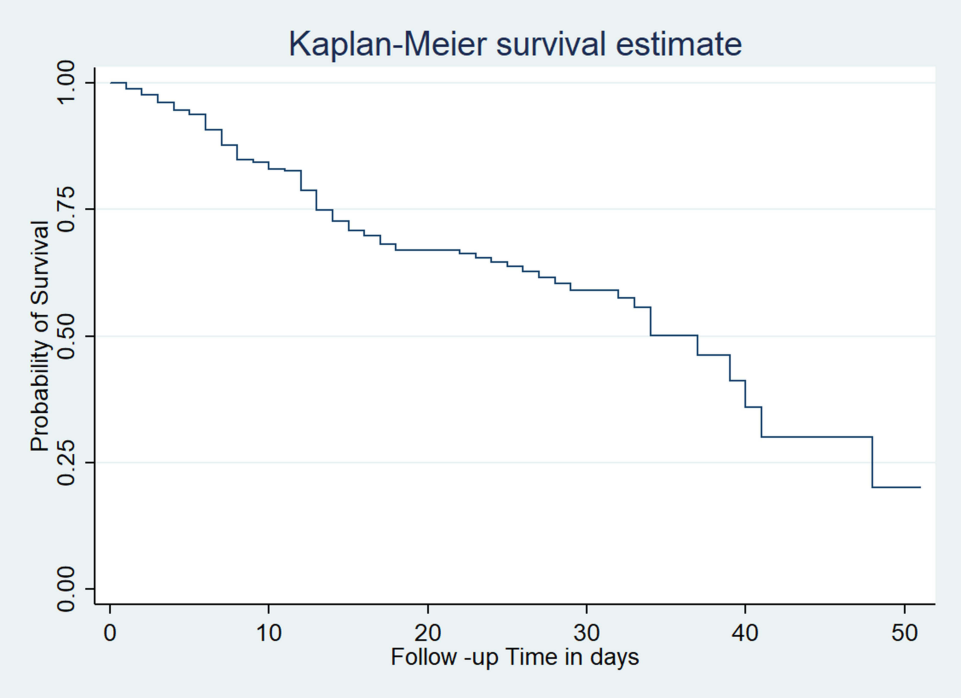

Figure 1 Overall Kaplan-Meier curve for critically ill ICU patients in the Wachemo University Comprehensive Specialized Hospital, Central Ethiopia, 2023 (N=422).

Predictors of Cardiac Arrest

After determining the nature of the data, the Kaplan-Meier (KM) curve and the life of tables were used for data descriptions. Then, a long-rank statistic test was used to identify the presence of significant differences in mean survival time between groups. Afterward, a bivariate analysis was conducted using Cox proportional hazard regression to identify variables that had an association with the dependent variable, and variables to be included in the final model for multivariate analysis were identified. Accordingly, in bivariable analysis, 12 variables were included, presence of comorbidities, known chronic kidney disease, Glasgow coma scale, intubation, fluid overload, acute kidney injury complication, delirium complication, sedation, oxygen saturation level, patients admitted with cardiovascular diseases, severe pneumonia, and post-operative collectively transferred to multivariate analysis. However, acute kidney injury was excluded since it violated the proportional hazard assumptions with a value of less than 0.05 during the Schoenfeld residual test.

In a multivariable analysis, patients having chronic kidney disease, hypoxia, delirium, and intubation, and patients admitted to the ICU with Cardiovascular disease were found to be independent predictors of cardiac arrest in the Intensive Care Unit at a 95% confidence interval. Patients who were admitted with chronic Kidney diseases had three times increased hazard of developing cardiac arrest compared to their counterparts (AHR=3.0; 95% CI: 1.98–4.73). The hazard of cardiac arrest was 2.9 times higher among intubated patients compared to patients who did not intubate (AHR=2.9; 95% CI: 1.64–4.73). The hazard of developing CA among patients who had hypoxia at admission to the ICU was 1.6 times higher compared to their counterparts (AHR=1.6; 95% CI: 1.03–2.46). Additionally, patients who had delirium while in ICU also revealed statistically a significant association with the occurrence of cardiac arrest (AHR=1.8; 95% CI: 1.15–2.66). The hazard of cardiac arrest among patients who were admitted to ICU with Cardiovascular diseases was 2 times (AHR=2.0; 95% CI: 1.27–2.85) higher than those who were admitted with other reasons of ICU admission (Table 5).

Discussion

To the best of our knowledge, the incidence of cardiac arrest in ICU patients has never been reported before in Ethiopia. The purpose of this retrospective study was to evaluate cardiac arrest incidence and its predictors in critically ill intensive care unit patients in central Ethiopia.

Table 5 Bivariate and Multivariate Analysis of Cox Proportional Hazard Regression Among Intensive Care Unit Patients Admitted to Wachemo University Comprehensive Specialized Public Hospital, Central Ethiopia, 2023 (n=422)

Covariate	Categories	Outcome		CHR 95% CI	AHR 95% CI	p-value
		Event	Censored			
Comorbidity	No	56(23.5)	182(68.5)	Reference	Reference	
	Yes	58(31.5)	126(68.5)	1.28(0.88–1.84)	0.94(0.64–1.40)	0.74
Severe pneumonia	No	87(23.8)	278(76.2)	Reference	Reference	
	Yes	27(47.4)	30(52.6)	2.50(1.62–3.88)	1.5(0.90–2.40)	0.125
Intubation	No	20(10.5)	170(89.5)	Reference	Reference	
	Yes	94(40.5)	138(59.5)	4.86(2.99–7.89)	2.9(1.64–4.73)	0.000*
CKD	No	79(22.0)	280(78.0)	Reference	Reference	
	Yes	35(55.6)	28(44.4)	3.25(2.18–4.86)	3.0(1.98–4.73)	0.000*
Sedation	No	39(17.0)	191(83.0)	Reference	Reference	
	Yes	75(39.0)	117(61.0)	2.49(1.70–4.69)	0.94(0.60–1.50)	0.77
Cardiovascular disease	No	71(22.2)	249(77.8)	Reference	Reference	
	Yes	43(42.2)	59(57.8)	2.21(1.51–3.24)	2.0(1.27–2.85)	0.000*
Oxygen saturation %	<90%	83(37.0)	141(63.0)	2.80(1.85–4.25)	1.6(1.03–2.46)	0.036*
	≥90%	31(15.7)	167(84.3)	Reference	Reference	
GCS at admission	14–15	22(40.7%)	32(59.3%)	Reference	Reference	
	9–13	47(24.5%)	145(75.5%)	0.58(0.35–0.97)	0.70(0.41–1.21)	0.202
	≤8	45(25.6%)	131(74.4%)	0.66(0.40–1.11)	0.81(0.47–1.38)	0.440
Delirium	No	72(24.0)	228(76.0)	Reference	Reference	
	Yes	42(34.4)	80(65.6)	1.56(1.06–2.28)	1.8(1.15–2.66)	0.009*
Post-Operative	No	94(24.5)	289(75.5)	Reference	Reference	
	Yes	20(51.3)	19(48.7)	2.42(1.49–3.93)	1.0(0.59–1.74)	0.947
Fluid overload	No	79(23.5)	257(76.5)	Reference	Reference	
	Yes	35(40.5)	51(59.3)	1.74(1.16–2.59)	1.3(0.83–2.02)	0.251

Note:*statistically significant at p <0,05 with 95% Confidence Interval.
Abbreviations: AHR; adjusted hazard ratio; CHR, crude hazard ratio; CI, confidence interval; CKD, chronic kidney disease, GCS, Glasgow coma scale.

At the end of the follow-up, about 114 (27%) at (95% CI: 22.97–31.47) of the patients developed cardiac arrest. In this study's findings, the incidence density rate of cardiac arrest was 19.6 per 1000 person-days of observation. This finding was lower than the study conducted in the United Kingdom,[22] with 25 per 1000 person days observations. The disparity might be due to the difference in the sample size that was conducted on only 56 patients, whereas the current study was conducted on the 422 ICU patients. Also, the current study revealed that the incidence rate was relatively higher than the previous study in Brazil,[13] which reported 7.5 per 1000 persons observation. This might be due to variations in study population, study duration, quality care, and sample size, which the previous study did on 1000 ICU patients. However, scientific evidence on the occurrence of cardiac arrest in intensive care unit is limited, particularly in developing countries like Ethiopia.

Patients having chronic kidney disease were found to be at a higher hazard of developing cardiac arrest than their counterparts (AHR=3.0; 95% CI: 1.98–4.73). Other studies conducted in California,[23] North Carolina,[14] Washington University in St. Louis,[6] and both the USA and Canada[24] supported this finding. The current finding also is comparable with previous reports[10,11] that revealed chronic renal disease was associated with cardiac arrest and mortality. A possible justification could be that possible immediate complications such as hyperkalemia could alter the resting potential for my ocytes and lead to fast sodium channel inactivation. It blocks the conduction of myocardial action potential, in that way inducing cardiac arrest.[25] Furthermore, as renal function impaired levels of toxins and pro-inflammatory cytokines induced plaque or by direct effects on the myocardium and electrical conduction systems. This is supported by previous studies.[26–28]

The study result also showed that endotracheal intubation was a significant predictor of cardiac arrest among patients in the intensive care unit. The hazard of cardiac arrest was about three times higher among intubated patients compared to those who did not intubate. This finding is comparable with previously reported studies.[12,29,30] One possible reason might be the severity of the disease and the complicated nature of endotracheal intubation during the procedure. Thus, the absence of pre-oxygenation, difficult intubations, hemodynamic instability, and the use of neuromuscular blockade agents like succinylcholine might be the

reason for cardiac arrest among intubated ICU patients. This is also supported by different literature.[31–33] However, there needs to be further investigation to clear the risk factors of cardiac arrest among intubated ICU patients.

Furthermore, having delirium as a complication during the follow-up period was reported as a significant predictor of developing cardiac arrest among ICU patients. This finding was conformable with a previous study conducted in the USA,[21,34] which that reported excited delirium was a risk factor for sudden cardiac arrest among individuals who required restraints. Even though, we could not find previously reported data regarding association between delirium and cardiac arrest among patients who were admitted to the ICU. Further study will be needed on the delirium-related effects on cardiovascular outcomes among patients in the ICU.

The hazard of developing Cardiac Arrest among patients who had hypoxia (oxygen saturation <90%) at admission to the ICU was 1.6 times higher compared to their counterparts (AHR=1.6; 95% CI: 1.03–2.46). This study finding was in line with previous studies.[31,35–37] Finally, the hazard of cardiac arrest among patients who were admitted to ICU with Cardiovascular diseases was 2 times (AHR=2.0; 95% CI: 1.27–2.85) higher than those who were admitted with other reasons for ICU admission. This finding was supported by a previous report.[38] However, we could find previous reports that revealed an association between cardiovascular disease and the incidence of cardiac arrest. There needs to be further study to magnify the association between cardiac arrest and cardiovascular disease.

Finally, several risk scores reported to predict mortality in severe patients that play a crucial role in clinical decision-making and patient management by categorising the patients into risk groups. Various risk stratification tools have been developed to assess the likelihood of adverse outcomes in individuals experiencing ST elevation myocardial infarctions.[9,39,40] Among those, intermountain risk scores have great value in intensive care unit patients. Prediction models should be created to provide more precise mortality scores.

Strengths and Limitations of the Study

To the best of our knowledge, this is the first study in Ethiopia to investigate the incidence and predictors of cardiac arrest patients who were admitted to Intensive Care Units. The purpose of this study was to address the knowledge gaps about the burden of cardiac arrest and possible risk factors that were preventable to decrease ICU mortality. Retrospective studies have several limitations, including the fact that their design makes them prone to various biases. Charts that were not intended to gather data for the study must be reviewed for retrospective studies, which means that some data will inevitably be absent. We did not include the outcome of cardiac arrest patients due to lack of recording on the patient's charts, and this study did not incorporate some important variables like the result of arterial blood gas analysis (ABGA) and mechanical ventilation parameters.

Conclusion

In this study, cardiac arrest has been identified as a significant problem and presented as a critical challenge to better outcomes for ICU patients and intensive care unit care providers. The incidence of cardiac arrest after ICU admission was 27% (95% CI: 23, 32). This study revealed that chronic kidney disease, delirium, intubation, oxygen saturation level <90%, and patients admitted to ICU for cardiovascular disease were independent predictors of the occurrence of cardiac arrest among intensive care unit patients. In conclusion, this study highlights the possible predictors of cardiac arrest in the intensive care unit. It fills a crucial knowledge gap, providing valuable insights that can contribute to the development of targeted interventions and improved outcomes in case of cardiac arrest. Finally, we recommend that clinicians pay attention to those identified as risk factors for early interventions to improve the recovery process of patients in the ICU. We also recommend that researchers conduct further studies using a large sample size, in multicenter studies, and include variables that were not incorporated in the current study.

Abbreviation

BUN, blood urea nitrogen; CI, confidence interval; GCS, Glasgow coma scale; ICU, intensive care unit; IRB, institutional review board; USA, United States of America; WCU, Wachemo University.

Data and Material Availability

The raw data is available from the corresponding authors on rational request, and the summary data are available on the main document via tayemezgebu26@gmail.com.

Ethics Approval

This study was approved by an institution of review board (IRB) of Wachemo University. The study was performed with the declaration of Helsinki. The documentation of informed consent was waived by our institutional review board of Wachemo University.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest in this work.

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