

RESEARCH ARTICLE

Cardiologic scoring system as predictors of mortality in geriatric COVID-19 patients

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Abstract

Objective: To develop a cardiologic scoring system to predict mortality among geriatric coronavirus disease-2019 patients.

Method: The retrospective cohort study was conducted after approval from the ethics review committee of the Dr Soetomo General Academic Hospital, Surabaya, Indonesia, and comprised data from March 1, 2020, to April 30, 2021, of geriatric patients of either gender confirmed for coronavirus disease-2019 from several referral hospitals in East Java, Indonesia. Data on comorbidities, electrocardiograph, and chest X-ray findings was examined to develop a comprehensive scoring system. Data was analysed using SPSS 26.

Results: Of the 3,893 cases reviewed, data of 322(8.27%) patients was analysed; 191(59.3%) males and 131(40.7%) females. The overall mean age was 66±4.1 years (range: 60-75 years). Of them, 267(82.9%) subjects were alive upon hospital discharge, while 55(17.1%) died during hospitalisation. Of the 24 variables analysed, 5(21%) were found to be significant: cardiomegaly, sinus tachycardia, ST-segment abnormalities, pathological T-wave inversions, and axis deviation ($p < 0.05$). Receiver operating characteristic curve analysis showed an area under the curve 0.86, cut-off point ≤ 4 with sensitivity 89% and specificity 69%.

Conclusion: The scoring system was found to have the potential to predict mortality in geriatric coronavirus disease-2019 patients based on cardiac findings during hospital admission.

Key Words: Cardiovascular, COVID-19, Electrocardiography, Arrhythmia, Cardiomegaly, Tachycardia.

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Introduction

On March 2, 2020, Indonesia saw its first 2 cases of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus¹. About 2 weeks later, the World Health Organisation (WHO) declared the virus a pandemic². There were over 6.4 million cases in Indonesia, and an approximate 9.4% of it were reported in East Java³.

The WHO defines those aged 60-75 years as geriatric individuals⁴. A study concluded that even though the geriatric population only made up about 16% of the entire coronavirus disease-2019 (COVID-19) population, 80% of total deaths come from this specific age group⁵. Data from the Indonesian Big Data Task Force showed that even though patients aged 31-45 years were the most common age group admitted to hospital for COVID-19, those in the geriatric age group experienced the highest mortality rate. The total geriatric COVID-19 cases accounted for approximately 11.2% of the total COVID-19

cases in Indonesia⁶.

COVID-19 was not the sole reason for mortality, as comorbidities also played a key role. Hence, there was a need for additional focus and attention to patients suffering mainly from cardiac-related comorbidities. A study stated that people suffering from cardiovascular diseases (CVDs) and other cardiovascular problems were twice as likely to contract severe forms of COVID-19 compared to the general population⁷. A study stated that of total COVID-19 cases with comorbidities in Indonesia, hypertension (HTN) had the highest proportion at 52.1%, followed by diabetes mellitus (DM) 33.6% and CVDs 20.9%⁸.

The current study was planned to develop a cardiologic scoring system to predict mortality among geriatric COVID-19 patients.

Materials and Methods

The retrospective cohort study was conducted after approval from the ethics review committee of the Dr Soetomo General Academic Hospital, Surabaya, Indonesia, and comprised data from March 1, 2020, to April 30, 2021, of geriatric patients of either gender confirmed for COVID-19 from several referral hospitals in

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East Java, Indonesia. Informed consent had been obtained from all the patients, and data was retrieved from September 25 to December 5, 2022, from East Java's COVID-19 registry. Data included for detailed analyses related to hospital-admitted geriatric COVID-19 patients of either gender aged 60-75 years for whom complete and readable medical records of electrocardiogram (ECG) and chest X-ray (CXR) were available. Patients with incomplete medical records were excluded. Clinical characteristics, including age, gender, clinical condition, ECG and CXR were noted.

The assessment of the patient's medical record, including the interpretation of ECG and CXR, was done by medical students and doctors who had received prior experience in analysing both ECG and CXR and under the supervision of experienced cardiologists. The characteristics of ECG and CXR used were sinus tachycardia, ST abnormalities, pathological T inversions, axis deviation, atrial fibrillation, right bundle branch block (RBBB), left bundle branch block (LBBB), QT-wave prolongation and cardiomegaly.

Sinus tachycardia was defined as an elevated heart rhythm determined when a rate was >100 beats per minute. ST abnormalities included both ST elevation when abnormally high above the isoelectric line, and ST depression which was determined by measuring the vertical distance between the patient's trace and the isoelectric line at a location 2-3mm from the QRS (Q, R, S wave) complex. T-waves represented the repolarisation of the ventricles. Negative T-wave in lead aVR (augmented vector right) was normal, while lead V1 could have positive, negative or biphasic T-wave. In addition, isolated negative T-waves could be found in lead III, aVL (augmented vector left) or aVF (augmented vector foot). Left axis deviation was reflected by a positive QRS complex in lead I, and negative in leads aVF and II. The degrees of deviation was determined by a 12-lead ECG when the electrical conduction of the heart was >105 degrees. ECG in atrial fibrillation demonstrated irregular ventricular rate along with the absence of P-waves. RBBB showed the wide QRS complex with a terminal R-wave in lead V1 and slurred S-wave in lead V6 (Precordial Lead VI). The hallmark of LBBB was the presence of a QRS prolongation, deep and broad S-wave in V1/V2 (Precordial Lead I and II), and broad clumsy R-wave in V5/V6 (Precordial Lead V and VI). QT prolongation related to the QT interval in either lead II or V5-V6. The QTc (corrected QT interval) was considered prolonged at >440ms in men, >460ms in women. In CXR, cardiomegaly was noted when the heart was >50% bigger than the average size of the chest cavity on the posterior-anterior (PA) projection.

Data was analysed using SPSS 26. Chi-square test was used for univariate analysis to assess the relationship of each variable with mortality. Variables with $p < 0.25$ were subjected to multivariate analysis and logistic regression with backward stepwise to find the model used to predict mortality. In contrast, variables with $p \geq 0.25$ were eliminated, as they were deemed non-significant. The odds ratio (OR) and 95% confidence interval (CI) were calculated using univariate and multivariate logistic regression models, while possible confounders were also taken into account. In multivariate analysis, $p < 0.05$ was considered significant. P-value in the analysis represents the probability of null hypothesis. For the goodness-of-fit, Hosmer-Lemeshow test was performed to test the logistic model for model applicability. The explained variation percentage was expressed as the Nagelkerke's R-square. Each significant variable was observed, and the scores were calculated using the scoring model. Subjects included in counting the probability of death were chosen using a simple random sampling method to randomly select a subset of the population generated by a random calculation formula [=rand ()] using Microsoft Excel 2019. From the model obtained through logistic regression analysis, the percentage of mortality was calculated based on the overall total score. Receiver operating characteristic (ROC) curves were used to determine specificity, sensitivity and cut-off point of the scoring model to predict mortality. ROC curve is also used to assess diagnostic performance and overall accuracy of the assay. Any missing data found in an observed case was removed entirely to avoid statistical bias and incorrect results.

Results

Of the 3,893 cases reviewed, data of 322(8.27%) patients was analysed; 191(59.3%) males and 131(40.7%) females. The overall mean age was 66 ± 4.1 years (range: 60-75 years). Of them, 267(82.9%) subjects were alive upon

Table-1: Univariate analysis of clinical condition, ECG and CXR findings.

	Clinical outcome in geriatric COVID-19 patients (n = 322)		p-Value
	Alive n (%), 267 (82.9)	Dead n (%), 55 (17.1)	
Male, n (%)	162 (60.7)	29 (52.7)	0.43
Age, median (IQR)	65 (62 – 68)	65 (63 – 70)	0.30
Clinical condition characteristics			
Hypertension	89 (27.6)	20 (6.2)	0.67
Diabetes mellitus	85 (26.4)	23 (7.1)	0.26
Pulmonary disease	35 (10.9)	8 (2.5)	0.78
Cardiovascular disease	9 (2.8)	5 (1.6)	0.06
Chronic kidney disease	3 (0.9)	3 (0.9)	0.03
Malignancy	4 (1.2)	1 (0.3)	0.86

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ECG and CXR characteristics and univariate analysis

Cardiomegaly	75 (23.2)	27 (8.4)	0.02
Sinus tachycardia	50 (15.5)	33 (10.2)	<0.01
ST abnormalities	61 (18.9)	27 (8.4)	<0.01
T inversions pathological	28 (8.7)	14 (4.3)	<0.01
Axis deviation	29 (9.0)	16 (5.0)	<0.01
Atrial fibrillation	10 (3.1)	1 (0.3)	0.47
Ventricular fibrillation	0 (0)	1 (0.3)	0.03
RBBB	16 (5.0)	6 (1.9)	0.29
LBBB	2 (0.6)	0 (0)	0.52
QT prolongation	16 (5.0)	3 (0.9)	0.88

ECG: Electrocardiograph, CXR: Chest X-ray, RBBB: Right bundle branch block, LBBB: Left bundle branch block, IQR: Interquartile range.

hospital discharge, while 55(17.1%) died during hospitalisation.

In univariate analysis (Table 1), no significant relationship

Table-2: Logistic regression with the scoring model from modified B value.

Step 7	B	Wald	Sig	Exp (B)	95% CI for Exp (B)		Scoring Model
					Lower	Upper	
Cardiomegaly	- 0.86	5.65	0.02	0.42	0.21	0.86	2
Sinus tachycardia	- 2.38	36.26	<0.01	0.09	0.04	0.20	5
ST abnormalities	- 1.50	15.51	<0.01	0.22	0.11	0.47	3
T inversions pathological	- 1.56	11.29	<0.01	0.21	0.08	0.52	3
Axis deviation	- 1.15	7.18	<0.01	0.32	0.14	0.73	2
Constant	3.59	24.26	<0.01	36.11			

CI: Confidence interval.

of the clinical outcome was found with HTN, pulmonary disease, CVD and malignancy (p>0.25).

Atrial fibrillation, RBBB, LBBB and QT prolongation were also excluded (p>0.25), while cardiomegaly, sinus tachycardia, ST abnormalities, pathological T inversions, axis deviation and ventricular fibrillation (p<0.25) were subjected to logistic regression.

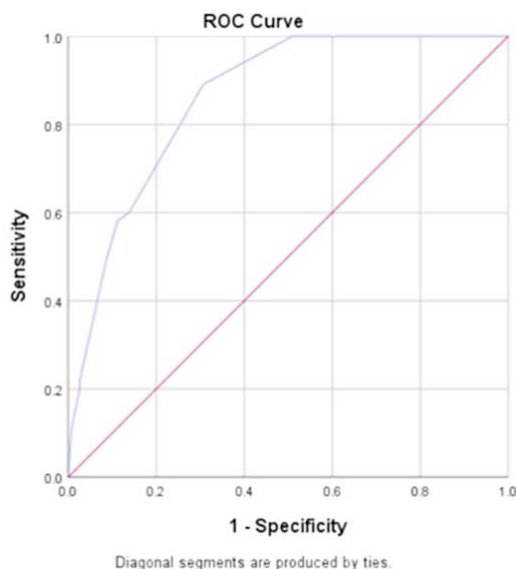
All the variables in multivariate analysis were assessed for collinearity and interaction. Of the 24 variables analysed, 5(21%) were found to be significant: cardiomegaly (OR=0.42; p=0.02), sinus tachycardia (OR=0.09; p<0.01), ST abnormalities (OR=0.22; p<0.01), pathological T inversions (OR=0.21; p<0.01) and axis deviation (OR=0.22; p<0.01). Moreover, based on the B value of each variable, a logistic model was formed:

$$Y = - (3.6 - 0.86 [\text{cardiomegaly}] - 2.38 [\text{sinus tachycardia}] - 1.5 [\text{st abnormalities}] - 1.56 [\text{pathological T inversions pathological}] - 1.15 [\text{axis deviation}]).$$

A value of 1 was given when the variable was present, and 0 when absent. Therefore, the complete formula to predict the clinical outcome, specifically mortality, was:

$$p(x) = 1 / (1 + e^{-(3.6 - 0.86 [\text{cardiomegaly}] - 2.38 [\text{sinus tachycardia}] - 1.49 [\text{ST abnormalities}] - 1.56 [\text{pathological T inversions}] - 1.15 [\text{axis deviation}])}).$$

To simplify the prediction, the formula was



Total score	Probability of death
0 – 3 points	2.63%
5 – 8 points	32.95%
≥ 9 points	53.33%

Figure-1: The area under the curve (AUC) of the total score as part of receiver operating characteristic (ROC) curve analysis.

modified into a scoring model (Table 2).

The goodness-of-fit was established ($p=0.05$) R-square coefficient 0.37, showing a moderate relationship.

A lower mortality rate of $<5\%$ was seen, with total score 0-3 points, which was considered low risk in the model, while a higher mortality rate of $>50\%$ was observed with a total score of ≥ 9 points, which fell in the high-risk category in the scoring model.

The ROC curve illustrated the AUC with a score of 0.86, showing that the developed scoring model was strong in predicting an outcome. The overall cut-off value was ≤ 4 , sensitivity was 89%, specificity was 69%, the positive predictive value (PPV) was 68.93% and the negative predictive value (NPV) was 89.02% (Figure 1). The model has also been validated.

Discussion

The main finding of the current study was that 5 cardiologic characteristics (cardiomegaly, sinus tachycardia, ST abnormalities, pathological T inversions, axis deviation and ventricular fibrillation) had the potential to be developed into a scoring model as a mortality predictor in geriatric COVID-19 patients.

The overall mortality of geriatric COVID-19 patients in the current study was 17.1%, which was consistent with an study that reported 26.34% mortality among geriatric COVID-19 patients, with mean age 75.08 \pm 7.39 years⁹. Another study stated a significantly higher mortality (54.3%)¹⁰. This difference might be because the study included geriatric patients aged age 60 years and above. Interestingly, a study showed COVID-19 mortality in elderly patients to be 11%¹¹.

The current study presented five cardiologic characteristics that would impart a higher risk of mortality in geriatric COVID-19 patients. The first parameter was cardiomegaly, which has been shown in a previous study to have involvement in severe COVID-19 cases, although a greater proportion of these cases were not in need of mechanical ventilation during hospital admission¹². Another study demonstrated the higher risk for complications in COVID-19 patients presenting with cardiomegaly, which was marked by significant increase in C-reactive protein (CRP), blood urea, nitrogen and creatinine levels compared to patients without cardiomegaly¹³.

The second parameter was ST abnormalities, which was further classified into ST elevation and depression.

According to previous studies, ST elevation was commonly found in COVID-19 patients requiring intensive treatment¹⁴. Likewise, ST depression was often observed in severe systemic inflammation cases and patients in critical state^{15,16}.

The third parameter was pathological T inversions. Pathological T-wave findings in ECG were associated with higher risk of mortality, mechanical ventilation demand, and values of cardiac biomarkers in comparison to patients with normal ECG, as described in a previous study¹⁷. Similar findings were suggested in another study, which additionally mentioned pathological T-wave as a common finding in COVID-19 patients¹⁸.

The fourth parameter was axis deviation, which has been rarely discussed as a predictor of mortality in COVID-19 patients. Nonetheless, a study showed a higher proportion of non-survivors in patients with axis deviation, which was attributable to depolarisation disorder¹⁹.

The last parameter was sinus tachycardia, which has been widely discussed and associated with increased mortality in COVID-19 patients²⁰. A cohort study showed that sinus tachycardia had a significant relationship, marked by increased CRP, abnormal CXR findings and prolonged hospitalisation²¹.

The scoring model developed in the current study demonstrated a reliable method which can be used as a predictor of mortality in geriatric COVID-19 patients based on cardiologic findings, with 89% sensitivity and 69% specificity.

The current had limitations that included the narrow subject characteristics that were included in the model, and variability with pre-existing studies. Arguably, these limitations may be due to the variability of the subjects' other clinical conditions that were not considered in the current study. Therefore, further studies are required that may considering the subjects' clinical condition in its entirety to develop a more consistent and reliable scoring model.

Conclusion

Cardiologic characteristics, such as cardiomegaly, ST abnormalities, pathological T inversions, axis deviation and sinus tachycardia, may be used as a scoring model to predict mortality among geriatric COVID-19 patients.

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References

- Gorbiano MI. BREAKING: Jokowi announces Indonesia's first two confirmed COVID-19 cases. News release. The Jakarta Post Media Centre. [Online] 2020 [Cited 2021 September 04]. Available from URL: <https://www.thejakartapost.com/news/2020/03/02/breaking-jokowi-announces-indonesias-first-two-confirmed-covid-19-cases.html>
- Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. *Acta Biomed* 2020;91:157-60. doi: 10.23750/abm.v91i1.9397
- East Java Provincial Government. Vaccine Data. [Online] 2021 [Cited 2021 September 04]. Available from URL: <https://infocovid19.jatimprov.go.id/vaksinasi>
- World Health Organisation (WHO). Ageing and Health. News release. The WHO Media Centre. [Online] 2021 [Cited 2021 September 04]. Available from URL: <https://www.who.int/news-room/fact-sheets/detail/ageing-and-health>
- Freed M, Cubanski J, Neuman T, Kates J, Michaud J. What Share of People Who Have Died of COVID-19 Are 65 and Older – and How Does It Vary By State? [Online] 2020 [Cited 2021 September 04]. Available from URL: <https://www.kff.org/coronavirus-covid-19/issue-brief/what-share-of-people-who-have-died-of-covid-19-are-65-and-older-and-how-does-it-vary-by-state/>
- Vera, Suprana YGE. Clinical Profile of COVID-19 Older Patients Hospitalized in Immanuel Teaching Hospital Bandung. *J Penyakit Dalam Indones* 2022;9:89-93. DOI: 10.7454/jpdi.v9i2.743
- Lee Lewis DK. COVID-19 and the heart: What have we learned? [Online] 2021 [Cited 2021 September 04]. Available from URL: <https://www.health.harvard.edu/blog/covid-19-and-the-heart-what-have-we-learned-2021010621603>
- Karyono DR, Wicaksana AL. Current prevalence, characteristics, and comorbidities of patients with COVID-19 in Indonesia. *J Community Empowerment Health* 2020;3:77-84. Doi: 10.22146/jcoemph.57325
- Ulugerger Avci G, Bektan Kanat B, Suzan V, Can G, Korkmazer B, Karaali R, et al. Clinical outcomes of geriatric patients with COVID-19: review of one-year data. *Aging Clin Exp Res* 2022;34:465-74. doi: 10.1007/s40520-021-02047-y
- Elsorady KE, Aziz NN, Daniel SH. Predictors of In-Hospital Mortality in Geriatric Patients with COVID-19. *J Geriatr Med Gerontol* 2021;7:e118. doi.org/10.23937/2469-5858/1510118
- Bakhshwin D, Alotaibi M, Ali AS, Althomali A, Alsuwat A, Alhamyani A, et al. Mortality Predictors Among COVID-19 Elderly in Taif, Saudi Arabia. *Infect Drug Resist* 2022;15:3213-2. doi: 10.2147/IDR.S364279
- Kanayama A, Tsuchihashi Y, Otomi Y, Enomoto H, Arima Y, Takahashi T, et al. Association of severe COVID-19 outcomes with radiological scoring and cardiomegaly: findings from the COVID-19 inpatients database, Japan. *Jpn J Radiol* 2022;40:1138-47. doi: 10.1007/s11604-022-01300-2
- Shankayi Z, Bahrami F, Mohammadzadeh T, Anvar AG, Amini H, Asadi MM, et al. Cardiomegaly found in hospitalized patients with novel coronavirus disease (COVID-19). *New Microbes New Infect* 2022;46:100974. doi: 10.1016/j.nmni.2022.100974.
- Barman HA, Atici A, Alici G, Sit O, Tugrul S, Gungor B, et al. The effect of the severity COVID-19 infection on electrocardiography. *Am J Emerg Med* 2021;46:317-22. doi: 10.1016/j.ajem.2020.10.005
- Antwi-Amoabeng D, Beutler BD, Singh S, Taha M, Ghuman J, Hanfy A, et al. Association between electrocardiographic features and mortality in COVID-19 patients. *Ann Noninvasive Electrocardiol* 2021;26:e12833. doi: 10.1111/anec.12833
- Liaqat A, Ali-Khan RS, Asad M, Rafique Z. Evaluation of myocardial injury patterns and ST changes among critical and non-critical patients with coronavirus-19 disease. *Sci Rep* 2021;11:4828. doi: 10.1038/s41598-021-84467-4
- Rosén J, Noreland M, Stattin K, Lipcsey M, Frithiof R, Malinovsky A, et al. ECG pathology and its association with death in critically ill COVID-19 patients, a cohort study. *PLoS One* 2021;16:e0261315. doi: 10.1371/journal.pone.0261315
- Romero J, Alviz I, Parides M, Diaz JC, Briceno D, Gabr M, et al. T-wave inversion as a manifestation of COVID-19 infection: a case series. *J Interv Card Electrophysiol* 2020;59:485-93. doi: 10.1007/s10840-020-00896-7.
- Yang D, Li J, Gao P, Chen T, Cheng Z, Cheng K, et al. The prognostic significance of electrocardiography findings in patients with coronavirus disease 2019: A retrospective study. *Clin Cardiol* 2021;44:963-70. doi: 10.1002/clc.23628
- Cho JH, Namazi A, Shelton R, Ramireddy A, Ehdaie A, Shehata M, et al. Cardiac arrhythmias in hospitalized patients with COVID-19: A prospective observational study in the western United States. *PLoS One* 2020;15:e0244533. doi: 10.1371/journal.pone.0244533
- Hsieh JYC, Kan JYL, Mattar SAM, Qin Y. The clinical implications of sinus tachycardia in mild COVID-19 infection: A retrospective cohort study. *SAGE Open Med* 2021;9:20503121211054973. doi: 10.1177/20503121211054973