Původní sdělení | Original research article

Comparison of EuroSCORE II, STS Score, and ACEF II Score as Predictors of Mortality in CABG Patients at Tertiary Referral Hospital in East Indonesia

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SOUHRN

Kontext: Součástí přípravy na operaci je stanovení optimálního chirurgického postupu a léčby pacienta. Ve snaze pomoci při hodnocení faktorů souvisejících s výsledkem operace byly vypracovány různé modely stratifikace rizika jako EuroSCORE II, skóre STS a skóre ACEF II. Tyto skórovací systémy se dnes používají při stratifikaci rizika pacientů podstupujících aortokoronární bypass (coronary artery bypass graft, CABG). Dosud však není jasné, který z těchto modelů je vhodnější pro pacienty v Indonésii. Cílem této studie bylo porovnat systémy EuroSCORE II, skóre STS a skóre ACEF II u indonéských pacientů po CABG.
Metody: V období od ledna 2021 do března 2023 byla provedena průřezová studie s použitím sekundárních údajů ze zdravotnických záznamů všech pacientů podstupujících CABG. Byly vytvořeny křivky operační charakteristiky přijímače (receiver operating characteristic, ROC) a následně vypočtena plocha pod těmito křivkami (area under the ROC curve, AUC) pro výpočet diskriminační síly každého modelu.
Výsledky: Do studie bylo zařazeno celkem 131 pacientů. Mortalita celé skupiny činila 5 % (sedm jedinců). Predikovaná mortalita podle modelu EuroSCORE II byla 1,58 ± 2,08, při použití skóre STS to bylo 1,14 ± 1,58, a podle skóre ACEF II činila hodnota 1,60 ± 0,97. Diskriminační síla operační mortality podle plochy pod křivkou při použití systémů EuroSCORE II, skóre STS a skóre ACEF II činila 0,94 (95% CI 0,86–0,99; $p < 0,0001$), resp. 0,93 (95% CI 0,81–0,99; $p < 0,0001$) a 0,76 (95% CI 0,55–0,97; $p < 0,05$).
Závěr: Z výsledků vyplývá, že systémy EuroSCORE II, skóre STS a skóre ACEF II mají uspokojivou diskriminační sílu. Nicméně všechny uvedené modely stratifikace rizika mají své slabiny a limitace použití a je nutno je používat uvážlivě.

Keywords:
ACEF II score
CABG
EuroSCORE II
Risk Stratification Model
STS score

ABSTRACT

Background: Identifying the optimal surgical approach and therapy for a patient is an important step in the preoperative preparation process. Risk stratification models such as EuroSCORE II, STS score, and ACEF II score were created to assist in evaluating factors associated with surgical outcomes. This scoring models are now utilized to risk stratify patients having coronary artery bypass graft (CABG) surgery. However, it has not been determined which model is better for Indonesian patients. The purpose of this study was to compare EuroSCORE II, STS score, and ACEF II score in CABG patients from Indonesia.
Methods: A cross-sectional study was conducted from January 2021 to March 2023 by utilizing secondary data collected from medical records of all patients undergoing CABG. Receiver operating characteristic (ROC) curves were created, and the area under the ROC curve (AUC) was calculated to measure the discriminative power of each score.
Results: A total of 131 patients were included in the study. The overall observed mortality on the entire group was 7 (5%). The EuroSCORE II-predicted mortality was 1.58 ± 2.08, the STS score-predicted mortality was 1.14 ± 1.58, and the ACEF II score-predicted mortality was 1.60 ± 0.97. The discriminative ability for operative mortality by area under the curve for EuroSCORE II, STS Score, and ACEF II score was 0.94 (95% CI 0.86–0.99; $p < 0.0001$), 0.93 (95% CI 0.81–0.99; $p < 0.0001$), and 0.76 (95% CI 0.55–0.97; $p < 0.05$), respectively.
Conclusion: This result suggests that EuroSCORE II, STS score, and ACEF II score have satisfactory discriminatory power. However, all three risk stratification models have their own strengths and limitation in their application and should be used wisely.

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Background

Coronary artery bypass graft, known as CABG, is a surgical procedure used to recover blood flow in heart that has a blocked artery, thus restoring cardiac vascularization. This open-heart surgery procedure involves grafting a part of a blood vessel to bypass obstructions in coronary arteries and improve the flow of blood to the heart.[1] In the context of cardiac surgery, in-hospital mortality or mortality due to the procedure serves as a key indication of healthcare quality.[2] Failure to achieve the ideal level of heart function during cardiac surgery often results in mortality, leading to early health complications and adverse long-term effects. It is essential to take consideration of the risk factors related to patients undergoing surgery carefully in order to improve healthcare services.

Determining the best surgical strategy and therapy for patient is an important step in the preparation process prior to surgery.[3] Risk stratification models have been developed to help in assessing risk factors that are correlated with surgical outcomes. These risk stratification models assist in predicting surgical outcomes and enhancing patient care quality. Another reason for the utilization of risk stratification models is the process of decision-making. Risk stratification model can play a crucial role in aiding physicians and hospitals in managing patients with high-risk profiles. Furthermore, risk stratification models are essential for enhancing surgical success rates, conducting quality analyses, and accomplishing significant outcomes.[3]

Risk stratification model such as STS score (Society of Thoracic Surgeons), EuroSCORE (European System for Cardiac Operative Risk Evaluation) and ACEF (Age, Creatinine, and Ejection Fraction) can be used to assess the degree of risk involved in cardiac surgical procedures. EuroSCORE is among the risk stratification models utilized to evaluate the quality of cardiac surgery. EuroSCORE I wass established in 1999 and was once considered as a gold standard in risk stratification models.[3,4] EuroSCORE II represents an update and improvement of EuroSCORE I, aimed at preserving and optimizing its utility in predicting cardiac surgeries. This development and update were a response of the previous EuroSCORE's tendency to overestimate risk and outcomes.[5,6] STS score stands out as one of the most frequently utilized risk stratification models. The essentials data for its development are derived from the Society of Thoracic Surgeons National Cardiac Database (STS NCD), which was established in 1989 and represents the largest clinical database of its kind.[3,7] ACEF (Age, Creatinine, and Ejection Fraction) is one of the risk stratification models in cardiac surgery that has been developed in recent years. It involves the patient's age, serum creatinine and ejection fraction to calculate the risk and outcome.[8,9] ACEF II incorporates five risk factors in determining the patient's risk level, with the formula being age (in years) / ejection fraction (%). Additional points are assigned for specific conditions such as serum creatinine >2 mg/dl (2 points), emergency status of the surgery (3 points), and anemia (hematocrit/HCT <36%, 0.2 points for each HCT point below 36%).[10] Furthermore, the ACEF score can also be utilized to predict risk in patients undergoing percutaneous coronary interventions, in addition to elective cardiac surgeries.[8,11]

Many surgeons and medical institutions tend to use this risk stratification model for risk assessment since there has not been a risk stratification model designed specifically utilizing local patient data. However, it's crucial to remember that the patient data used to construct these risk assessment model came from patients in Europe and America. Considering the fact that these models weren't initially designed for Indonesia patients in mind, there are still concerns about how effectively it may predict the risk for these individuals.

To this day, limited information is available regarding risk stratification models in Indonesian patients. In research carried out in Indonesia, only EuroSCORE II has shown good validity.[12] But another study suggests that EuroSCORE II was unsuitable for risk prediction of in-hospital mortality.[13,14] Furthermore, there is a shortage of data related to ACEF score and limited research on ACEF II score in Indonesia. However, limited data is available on STS score and ACEF II score. The lack of comparable evaluations of the discriminatory and calibration capacities of these risk stratification models is another area of concern. Hence, this study aims to assess the performance of STS score, EuroSCORE II, and ACEF II score in Indonesian patients undergoing CABG surgery.

Methods

All patients undergoing CABG procedures between January 2021 and February 2023 were included in this study. Data was collected in the Department of Thoracic, Cardiac and Vascular Surgery database and was analyzed retrospectively. The inclusion criteria were patients undergoing coronary artery bypass graft above the age of 18 years. This study also enrolled patients undergoing CABG with other procedures like CABG with mitral valve repair (MVR) or CABG with aorta valve repair (AVR). All patients undergoing CABG were included whether they had an elective, urgent, emergency, or other circumstances and condition on the patients as long as the risk probability can be calculated by the risk stratification models. Mortality in this study is defined as in-hospital mortality. Exclusion criteria of this study were lack of perioperative data that hinder the calculation of the risk stratification model and the analyses of the study.

The outcome of this study was the comparison of risk stratification model between EuroSCORE II, STS score, and ACEF II score in predicting mortality in patients undergoing CABG procedures. This was assessed by calculating their discriminatory power in predicting mortality and calibration of the models. Another outcome of the study is assessed with the correlation between this three risk stratification models and evaluated with the predicted probability for operative mortality.

The calibration of the models was assessed using the Hosmer–Lemeshow test. Essentially, it measures the model's capacity to predict survival across different levels of patient risk.[15] The discriminatory ability was assessed by calculating the receiver operating characteristic (ROC) curve. From this, the area under the curve (AUC) can be

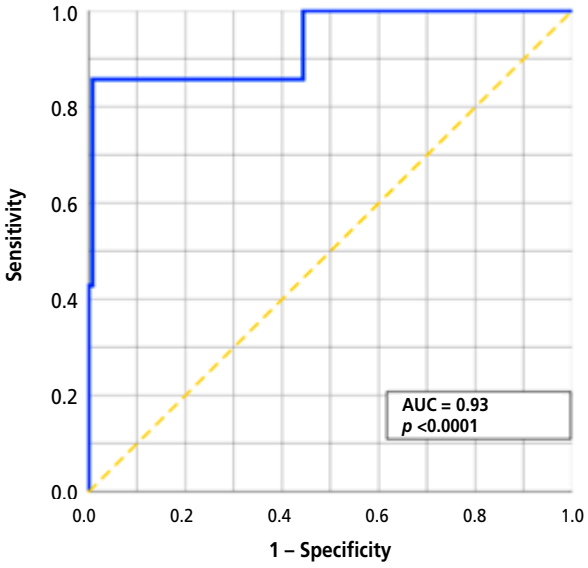

Fig. 1 – ROC curve of STS score.

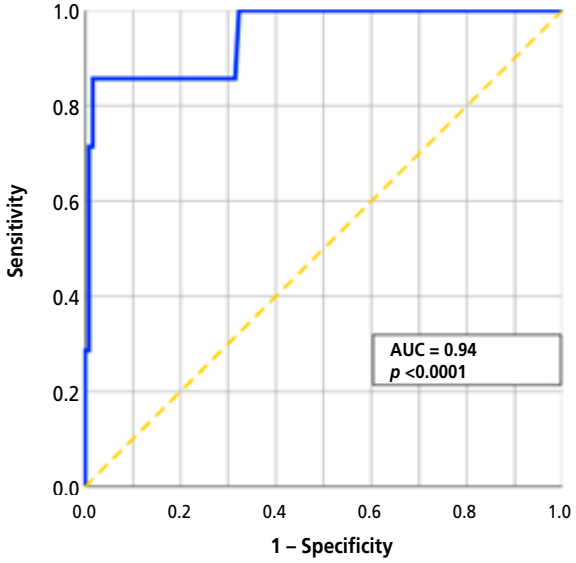

Fig. 2 – ROC curve of EuroSCORE II.

found for each model. AUC is defined as the measure of how often a patient who survives is predicted using the models to have a greater likelihood of survival compared to a patient who passes away during their hospital stay.[5,15] The discriminatory ability of STS score, EuroSCORE II, and ACEF II score were compared using these analyses. The correlation between the risk stratification models was assessed using Spearman correlations. A positive correlation between them indicates the agreement of the models. The higher the score, the higher the agreement between the models. This study also conducted univariate logistic regression analyses to evaluate the predicted probability for operative mortality.

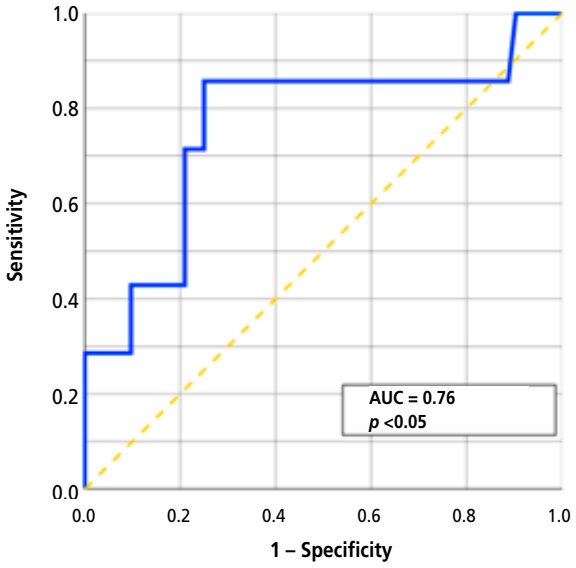

Fig. 3 – ROC curve of ACEF II score.

Results

There were 131 patients undergoing CABG procedures during the study period. Those consisted of 16 (12%) women. In this study, there were 58 (44%) patients with diabetes and 77 (59%) with hypertension comorbidity. According to the urgency of operation, elective surgery was the highest type of surgery. Patient characteristics and detailed demographics are described in **Table 1**.

The overall mortality in the entire group was 7 (5%). Risk stratification model using EuroSCORE II found a predicted mortality of 1.58 ± 2.08, STS score-predicted mortality was 1.14 ± 1.58, and ACEF II score-predicted mortality was 1.60 ± 0.97. Hosmer–Lemeshow test for STS has a *p*-value of 0.230. For EuroSCORE II and ACEF II score, the Hosmer–Lemeshow test showed a *p*-value with $p = 0.731$ and $p = 0.80$, respectively. These results indicated good model fit for all risk stratification models ($p > 0.05$). The discriminative ability for operative mortality of the STS score was 0.93 (95% CI 0.81–0.99; $p < 0.0001$]). The discriminative ability of the EuroSCORE II, as measured by the AUC, was 0.94 (95% CI 0.86–0.99; $p < 0.0001$). On the other hand, discriminative ability for ACEF II score showed the value 0.76 (95% CI 0.55–0.97; $p < 0.05$). These analyses indicate that all three risk scores have good discriminative ability, but EuroSCORE II and STS score is more superior than ACEF II score. There is a very subtle difference in the discriminative power between EuroSCORE II and STS score.

The correlation analyses showed that all three risk stratification models were well correlated with each other. The STS score was highly correlated with EuroSCORE II ($r = 0.75$, $p < 0.0001$). ACEF score II was moderately correlated with EuroSCORE II ($r = 0.56$, $p < 0.0001$) and the STS score ($r = 0.52$, $p < 0.0001$). These results indicate that three risk stratification models are in agreement between each other.

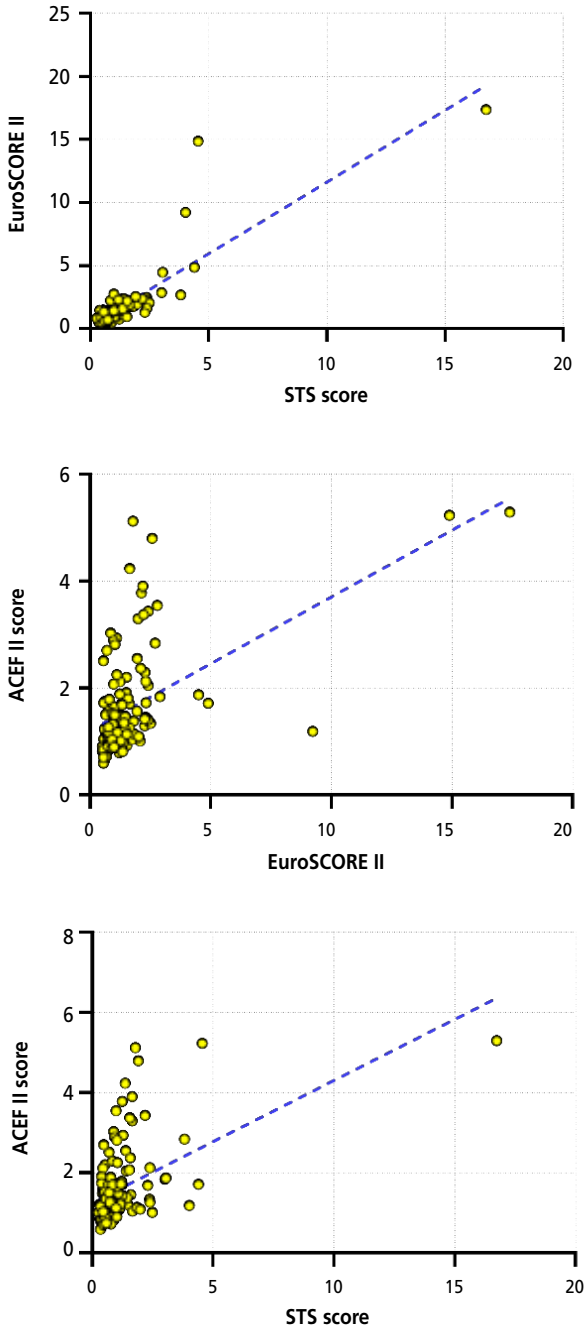

Fig. 4 – Scatterplots demonstrating the correlation between STS score, EuroSCORE II, and ACEF II score.

Univariate logistic regression found that age, smoking status, STS score-predicted mortality, EuroSCORE II-predicted mortality, and ACEF II score-predicted mortality have significant results. Patients with higher age tend to be more susceptible to mortality than the younger age group (OR 1.24; 95% CI 1.09–1.43; p <0.05). For each year increase in patient age, there is 1.24-times increase in the likelihood of patient mortality. Patients with current smoker status are 7-times more susceptible to mortality than patients that have never smoked (OR 7.10; 95% CI 1.09–46.27; p <0.05).

Table 1 – Patient characteristics (n = 131)	
Age (mean ± SD)	59.5 ± 8.75
Gender (female)	16 (12%)
Diabetes	58 (44%)
Hypertension	77 (59%)
Ejection fraction (%)	51.6 ± 14.0
Creatinine (mg/dL)	1.14 ± 0.41
Heart valve disease	73 (56%)
Aorta regurgitation	20 (15%)
Mitral regurgitation	62 (47%)
Tricuspid regurgitation	34 (26%)
Urgency of operation	
Elective	99 (76%)
Urgent	31 (24%)
Emergency	1 (1%)
Mortality	7 (5%)
STS mortality risk (%)	1.14 ± 1.58
EuroSCORE II mortality risk (%)	1.58 ± 2.08
ACEF II mortality risk (%)	1.60 ± 0.97

Values are mean ± SD or n (%). EuroSCORE – European System for Cardiac Operative Risk Evaluation; STS – the Society of Thoracic Surgeons.

Discussion

Mortality rate among patients undergoing CABG procedures was 5% out of 131 in this study. This figure aligns with the previous research that 8.9% patients experienced mortality from 292 patients who underwent adult cardiac surgery between January 2016 and December 2018.[16] According to the Society of Thoracic Surgeons' National Cardiac Database, there were 205,778 patients who underwent CABG between 1984 and 1993, with a mortality rate of 2.9% during that period.[17] Another study in the United States reported a 2.4% mortality rate for CABG surgery during the period 1997–2011.[18] In the UK, a study covering the years 2002–2016 revealed a mortality rate of 1.73% among patients undergoing CABG.[19] Similarly, a study in India showed a mortality rate of 1.5% for CABG surgeries conducted from 2015 to 2020.[15] In China, during the period from 2000 to 2018, there was a mortality rate of 2.21% among patients undergoing CABG surgery.[20]

Compared to other countries, mortality rate among patients undergoing CABG surgery in Indonesia is higher, surpassing countries where mortality rates fall below 3%. Several factors may contribute including lack of public awareness regarding healthcare in Indonesia. Additionally, the geographical distance from healthcare centers and the economics condition, particularly of the lower-middle class people, may contribute to this issue. Another problem in Indonesia are insufficient cardiovascular diseases services in primary healthcare and disease monitoring in

the population, and low patient compliance both in the prevention and treatment of diseases.[21]

Male gender dominates the gender demographic among those undergoing CABG procedures with 115 (88%) of the total 131 patients. Previous research also indicates a higher prevalence of males in adult cardiac surgery, with 164 (77%) male patients.[16] Studies in India reported that 86.5% of CABG surgery cases were among males.[15] Similarly, research in China revealed that males constituted the majority, accounting for 75.78% of total CABG patients.[20] This aligns with previous studies on cardiovascular diseases, indicating a higher prevalence among males.[22,23] The elevated prevalence of cardiovascular diseases in males can be attributed to their susceptibility to these diseases at a younger age. Hormonal factors in females tend to provide some protection against cardiovascular diseases before menopause, after which the risk significantly increases.[24] Other risk factors such as smoking, diabetes, and dyslipidemia contribute to the higher incidence of cardiovascular diseases in males.[23] However, it's essential to note that females are not exempt from cardiovascular diseases. Various risk factors, including age, hypertension, and cholesterol levels, pose significant challenges for women. Other factors such as endocrine disorders and pregnancy-related complications make women vulnerable to cardiovascular diseases.[23,25]

This study calculated discriminative ability of the risk stratification models for each patient undergoing CABG procedures. The results indicate that STS score, EuroSCORE II, and ACEF II score have discrimination abilities of 0.93, 0.94, and 0.76, respectively. In a previous study, EuroSCORE II demonstrated good discriminatory capability, with an AUC value of 0.85 on the ROC curve.[16] However, another research suggests that EuroSCORE II may be unsuitable for predicting mortality risk in Indonesia.[13,14] On the other hand, there is still limited information regarding STS score and ACEF II score in Indonesia.

STS score, EuroSCORE II, and ACEF II score demonstrate good capabilities in predicting mortality. However, several studies in the United States indicate that STS score outperforms EuroSCORE II in predicting mortality among adult cardiac surgery.[26] In contrast, European studies suggest that EuroSCORE II is superior to STS score in predicting mortality in adult cardiac surgery patients.[27–29] Another research indicates that EuroSCORE II is superior to ACEF II score.[30] Studies in Asia also show that these risk stratification models perform equally well and do not favor one scoring system over the other despite limitations in information regarding ACEF II score.[15,20,31]

Based on other factors, EuroSCORE II and ACEF II score are more versatile in their application across various types of cardiac surgery procedures compared to STS score. EuroSCORE II and ACEF score II can be applied to almost all cardiac surgery procedures, whole STS score is limited to 7 types of cardiac surgical procedures. Moreover, EuroSCORE II and ACEF II score require only 17 and 5 variables, respectively, in contrast to STS score that need 67 variables. This makes EuroSCORE II and ACEF II score faster in assessing the prediction of patient mortality. However, STS score has an ability to predict postoperative patient morbidity, such as renal failure, stroke, prolonged ventilation, deep sternal wound infection, reoperation, short length of stay, and long length of stay.

All three risk stratification models exhibit good capabilities and applicable in hospital settings. However, they have their own strengths and limitations in their application. Risk stratification models should not be used alone when predicting patient mortality. Other consideration, such as discussion among doctors and healthcare professionals, patient's condition, and patient's own decisions, also play a crucial role in predicting and performing CABG procedures. Furthermore, risk stratification models do not incorporate variables related to the skill and proficiency of the surgeon, as well as the quality of service before and after the operation. Therefore, these factors need to be considered when estimating optimal management for patients. Another consideration in performing CABG surgery is the patient's mental state and motivation. According to previous research, optimism is associated with better outcomes in the recovery process after CABG surgery.[32] Other factors, such as the economic and social conditions of the patient, also need to be taken into account.

Conclusion

ACEF II score, EuroSCORE II, and STS score predict the outcome fairly accurate in Indonesian population and should be used. Based on our study, EuroSCORE II and STS score is superior to ACEF II score. However, all three risk stratification models have their own strengths and limitation in their application. Physician, surgeon, or healthcare professional should use them wisely. Risk stratification models should also not be used alone when predicting patient mortality and consider another role such as discussion among professional, patient's condition and decisions, skill and proficiency of the surgeon, and service's quality.

Limitation

This study was conducted as a single-center study and become the important limitation. Small number of patients in this study has also become the limitation in our study. This condition may not be representative of real-life practices in the surgical association among Indonesian's professional despite the large sample size. For more accurate validation risk stratification models, it is important to involve several centers with geographical and healthcare infrastructure difference as well as the impact of economic and social variations on results.

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Conflict of interest
The authors declare that there is no known conflict for this work.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
This research has been approved by the Health Research Ethics Committee of Dr. Soetomo Hospital with number 1098/LOE/301.4.2/X/2022.

Consent for publication
Not applicable

Authors' contribution
Conceptualization YES, AM; data curation AM, YES; formal analysis YES, AM, A; investigation YES, AM, A; methodology YES, AM, A; project administration YES, AM, A; software YES, AM; supervision YES, A, HS; validation YES, AM, A, HS; visualization AM writing original draft YES, AM; writing review and editing by all author. Approval of final manuscript by all authors.

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