International Journal of Scientific Research in Science and Technology
Available online at : www.ijsrst.com
Print ISSN: 2395-6011 | Online ISSN: 2395-602X
doi : https://doi.org/10.32628/IJSRST52411196

Validation of Patient Intrinsic Factors on Pre-Delay Coronary CT Scan Angiography (Coronary CTA) Bolus Tracking

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ARTICLEINFO

Article History:

Accepted: 20 Feb 2024
Published: 05 March 2024

Publication Issue :
Volume 11, Issue 2
March-April-2024
Page Number :
49-58

ABSTRACT

Background: There is a variation in the pre-delay scan time on the Caronaria CTA tracking bolus examination, which give a constitution against the acquisition time and the contrast.

Purpose: This study aims to determine the influence's intrinsic factors on the pre-delay scan time.

Method: Analytical research with a retrospective approach's cross-sectional design measures independent variables: aortic diameter, systolic blood pressure, age, heart rate (HR), urea, creatinine, and body mass index (BMI). The dependent variables: the time pre-delay scan is performed simultaneously; its properties are momentary and observed under current conditions. Each object was observed three times, then the data normality and influence relationships between variables were analyzed with the bivariate and multivariate analysis approaches. Data was surveyed in June–August 2023 at a Hospital in Jakarta.

Results: Bivariate analysis showed a significant relationship between aortic diameter and pre-delay scan time with a value r = 0,577, having a positive pattern, as well as having a dependency 33.3% with p = 0,000 significance. While a very strong relationship is indicated by systolic blood pressure with r = 0.534 value and positive patterns, has a dependence of 30.4% with p = 0.000 significance value. Other instrumental factors: creatinine and BMI have a moderate relationship with r = 0.308 and r = 0.338 and are positive with a determination coefficient of 0.095 and 0.115. Urea, age, and heart rate have r = 0.174, 0.200, and 0.116. The determination coefficient values are under 0.04.

Conclusion: The intrinsic factors: aortic diameter, systolic pressure, creatinine, urea, age, and heart rate have influenced positive CTA scan delays although different determination coefficients.

Keywords: CTA Coronarya, bolus tracking, pre-delay scan time, aortic diameter, systolic blood pressure.

I. INTRODUCTION

The CT scan, or computed tomography scan, is a diagnostic aid that examines human organs utilizing X-rays obtained by tomography methods and modern computing technologies. The goal of a CT Scan examination is to use ionizing radiation to detect abnormalities in human organs without the need for surgery. ionizing radiation, without the need for surgery, in order to provide more precise diagnostic findings. improved diagnostic outcomes (Hutami *et al.*, 2021). One of the examinations is to conduct a heart blood vessel examination or cardiovascular.

Cardiovascular disease is one of the leading global causes of premature death, with many high-income and capable countries showing a trend of rising life expectancy and early death over the course of 60 years. Starting in the 1970s, the world has been trying to reduce the number of deaths from major vascular diseases such as ischemic heart disease and stroke. On the other hand, excessive tobacco consumption and poor blood pressure, high lipid levels and a progressive western diet and lifestyle significantly increase the risk of cardiovascular disease (Lopez and Adair, 2019). Ischemic heart disease is the highest cause of death in some high-income countries and has a tendency at higher rates, so it is necessary to deal with it in two ways: limiting the rise of hypertension in developing countries and suppressing the growth of obesity globally (Nowbar *et al.*, 2019).

A cardiac CT scan is a non-invasive imaging of the heart's organs that has become a routine for cardiologists. CT scan capabilities are possible for a fairly accurate and quick study to look at the coronary artery walls, to see if there is a possibility of atheroma, even stenosis, while heart scan using CT scans can look at heart morphology in general like thrombus in the intra-heart (Pasteur-Rousseau and Sebag, 2020). The first thing to do is evaluate the presence of chest pain in normal patients, which is in line with the ESC 2019 recommendation, where CT scanning is highly recommended in patients with low to moderate levels of chronic coronary syndrome (Neumann *et al.*, 2020). The process of coronary CTA examination has some very important things like when it comes to contrast, when is the right time in contrast, how long is the contrast time, what's the right amount of volume in contrast and when it's right time to take a picture CT Scan acquisition (Halliburton *et al.*, 2006). The development of the CT Scan feature is very helpful in solving the problem, namely using the bolus tracking feature on a device that has the ability to detect, analyze threshold values reached during contrast delivery and execute commands for the CT scan device to take a picture / acquisition (El Merhi *et al.*, 2020).

Bolus tracking technique is one of the contrast media injection methods used in CTA Coronary. After the contrast media is injected into the blood vessels, a technique called "bolus tracking" is employed in computed tomography imaging to show real-time monitoring (direct appearance) of media contrast display in one intended scan area (Utami *et al.*, 2022). The use of bolus tracking in each Caronaria CTA examination is often found to vary in the long value of the pre-delay scan threshold attained in each

individual, the length of the time that the preset scan is achieved in this threath will give a constitution of the total acquisition time which is very closely related to the total amount of contrast and copies to be provided during the acquisition is ongoing see also Adibi and Scahbazi (2014).

The overall amount of contrast in the media to be injected is significantly impacted by how long the threshold is reached, which is obviously quite troublesome if the initial estimate of the volume of contrast is inaccurate. There are two typical factors that contribute to the errors in estimating the contrast volume of the medium: too much or too little contrast medium to be injected; if there are too many, the superior vena cava still has a lot of media contrast, which will cause a streak artifact in the first area of scanning (Lipson, 2006; Goldstein *et al.*, 2015). If there are too few, the injection of contrast media continues while the acquisition is ongoing. If it is too little, the potential value of the degree of depth (positivity) in the end (distal) part of the distal coronary artery coronaria decreasing artery, so greatly affecting the overall coronarian visualization. But, if it is too much, it greatly interferes with the tracker process, which is the process of acquisition repeated and accompanied by analysis gradually until the threath value is reached and gives information to the system to carry out the acquisitions of CTA Coronaria (Martens *et al.*, 2020). The execution has frequently struggled to ascertain the length of the scan delay time on the Coronaria CTA test at this time.

Tang, et. al. (2011) has conducted research into factors that influence the delay time and density of coronary arteries during coronar angiography with DSCT. Factors related to sex, age, height, weight, transversal cardiac diameters, transverse thoracic diameter (TTD), heart rate (HR), body surface area and cardiotorax ratio were studied. Coronary artery density also varies with HR and body weight, but studies related to aortic diameter and blood pressure have not been found (Tang *et al.*, 2011; Shinbane *et al.*, 2016).

Research on the determination of pre-delay scan on CTA Corona Bolus Tracking according to factors: Aortic diameter, systolic blood pressure, age, HR, urea, creatinine, and BMI becomes an argument felt important in providing answers to the problems that occurred. This research is based on field observations where there are frequent differences in the time of delay to reach certain thresholds. The evaluation is carried out through a simple application to facilitate the setting of pre-delay scan time correction that is parallel and can provide correction of the amount of media contrast and copy to be given.

II. MATERIAL AND METHOD

This research is a quantitative analytical study with cross-sectional design through independent and dependent variable measurement (pre-delay scan time) carried out simultaneously and its properties are momentary and observed under current conditions, and each object is observed once with ethical clearance no. 1362/EA/KEPK/2023 issued by the Poltekkes Kemenkes Semarang. The target results are expected to be able to describe the time pre-delay scan reaches the threshold on coronary CTA linked to aortic diameter, age systolic blood pressure, HR, urea, creatinine, and BMI.

The samples used are coronary CTA data at the radiological service division of RSPP Jakarta in June – August 2023. The sampling technique used is purposive samplings referring to Henning et al., (2023). The CTA Scan Protocol refers to several adaptations and developments in accordance with the research objectives on (Kartika et al., 2019; Pham *et al.*, 2019). The data was interpreted and analyzed by examining the relationship between aortic diameter, systolic pressure, age, HR, urea, creatinine, and BMI to the time delay threshold of 150 HU. Then using the statistical methods of aorta diameter and systemic pressure, the age of HR, ureum, creatinin, BMI and time delays were processed with the help of the SPSS application: The analysis of multiple regression (Juliandi and Manurung, 2014) (Ghozali, 2018). and Regression analysis techniques (Janir, 2012) (Efendi *et al.*, 2020).

III. RESULTS AND DISCUSSION

RESULTS

The results of the normality tests for 78 samples are described in Table 1. These findings shed light on the properties of the data's distribution that are being studied. The study makes it easier to comprehend how well the sample adheres to the normalcy assumptions.

Tabel 1. Research variable descriptive analysis

No	Variable	Mean	Median	Min – Max	Standard Deviation	Kolmogorov Smirnov Testing	Description
1	Systole Blood Pressure (mgHg)	137.30	134.00	100 – 193	22.03	0.061	Normal Distribution
2	Aortic Diameter (mm)	33.58	33.68	25.67 - 42.53	4.25	0.042	Normal Distribution
3	Ureum (mg/dL)	24.89	24.00	12.00 – 51.00	7.28	0.000	Unnormal Distribution
4	Creatinine (mg/dL)	0.97	1.00	0.50 – 1.80	0.26	0.054	Normal Distribution
5	BMI	26.40	25.73	16.42 - 36.59	4.02	0.200	Normal Distribution
6	Delay Time (second)	19.66	19.47	14.04 – 24.37	2.39	0.200	Normal Distribution
7	Age (years)	50.37	49.00	31 – 77	12.96	0.043	Normal Distribution
8	Heart Rate (bpm)	72.80	70.00	53 – 172	16.11	0.000	Unnormal Distribution

Table 1 shows that systolic blood pressure, aortic diameter, creatinine, BMI, delay time and age have normal distributed data patterns. This data test refers to the Kolmogorv-Smirnov test aimed at comparing the data distribution (which will be tested for normality) with the standard normal distribution (C.R Kothari, 2004). This suggests that the data meets normal-distributed assumptions and can be used for further statistical analysis and used as an amplifier in the narrative arguments of the data-data explanation later. A normal distributed data if the data significance is below 0.05, but if the significance above 0.05, then there is no significant difference from the data comparison (Stolp *et al.*, 1984).

On the other hand, the data patterns for ureum and heat rate do not follow normality assumptions and lack a normal distribution. Unknown effects of urea and heat crack limited effects of time delay CT Scan, urea levels in the body potentially affect contrast clearance used in CT-Scan and patient body heat levels can cause increased physiological stress that potentially affects patient movements during the scan process (Flohr *et al.*, 2007). It appears that the obtained data is not normally distributed implicitly will affect the conclusions to be drawn.

Tabel 2. Correlation and regression analysis linear variable parameter intrinsic factor versus scan delay time variable

Variabel	R	R^2	Persamaan garis	p-value

Systole Blood Pressure	0,551	0,304	TIME SCAN DELAY = 11,423 + 0,060 Systole Blood Pressure	0,000
Aortic Diameter	0,577	0,333	TIME SCAN DELAY = 8,736 + 0,325 Aortic Diameter	0,000
Ureum	0,174	0,03	NA	0.132
Creatinine (mg/dL)	0,308	0,095	TIME SCAN DELAY = 16,872 + 2,873 Creatinine	0,007
BMI	0,338	0,115	TIME SCAN DELAY = 14,324 + 0,202 BMI	0,003
Ages	0,200	0,04	NA	0,083
Heart Rate	0,116	0,013	NA	0,318

The correlation between systolic blood pressure, aortic diameter, creatinine levels and BMI with the delay scan time of the CTA examination Coroner showed a strong relationship (r > 0.3) and positive poles means that the increasing blood pressure is systolic, the diameter of the aorta, the levels of creatinin and the BMI are increasing the time of delay of the scan. Although there is no literature showing that systolic blood pressure affects the results of CTA scans. However, high or low blood pressure can affect the risk of complications during or after CTA procedures, especially if contrast is used (Mamourian and Litt, 2013).

Although, creatinine has the highest linear time regression equation pre-delay scan CTA namely, TIME SCAN DELAY =16,872 +2,873 Creatinine levels. However, the determination coefficient value of 0.095 indicates that the delay time of coronary CTA scan has a dependence of only 9.5% on creatinine levels. This creatin determination will be clearly visible if the patient in the sample has renal impairment.

On the relationship of the variables ureum, age and heart rate with delay time scan CTA Coroner examination showed no relationship or weakness where the value of determination coefficient is less than 0,04. Results of simple linear regression statistical test obtained no significant influence between age and heart rate with delays scan time (value p=0,083 > 0,05). A positive of p= 0.083 indicates the directional influence of age and heart rate on the delay time of the scan although it is not significant (Ghozali, 2018).

Screening intrinsic factor relationship with pre-delay time CTA

The variable age is based on the candidate variable entering with a p value less than 0.25, systolic blood pressure, aortic diameter, urea level, creatinine level, and BMI. In the screening this intrinsic influence on the pre-delay time is determined through multivariate analysis where the valid variable is a variable with *p-value* < 0.05. If in the multivariate model is found variable whose *p-value* is > 0.05, then the variable should be removed in the model. Variable output is done not simultaneously, but gradually one by one, starting from the largest *p-value* (Stolp *et al.*, 1984).

Tabel 3. Multivariate modeling intrinsic factor influence on CTA pre-delay time

Model	Model 1					Model 2					Model 3				
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta			B	Std. Error	Beta			B	Std. Error	Beta		
(Constant)	3,978	1,98		2,009	0,048	4,621	1,812		2,55	0,013	4,061	1,98		2,051	0,044
TEKANAN_DARAH_SYSTOLE	0,044	0,011	0,405	3,836	0	0,046	0,011	0,425	4,147	0	0,045	0,011	0,415	3,947	0
DIAMETER_AORTA	0,263	0,062	0,467	4,232	0	0,277	0,06	0,491	4,621	0	0,273	0,062	0,484	4,428	0
UMUR	-0,052	0,021	-0,282	-2,513	0,014	-0,058	0,019	-0,312	-2,969	0,004	-0,053	0,021	-0,289	-2,58	0,012
UREUM	0,053	0,031	0,162	1,741	0,086	0,055	0,03	0,168	1,815	0,074	0,066	0,028	0,199	2,312	0,024
CREATININ	0,923	0,867	0,099	1,065	0,29	0,967	0,863	0,104	1,121	0,266					
INDEKS_MASA_TUBUH	0,045	0,055	0,076	0,817	0,417						0,049	0,055	0,082	0,884	0,38

In table 3, we obtained a significant value on the body time index variable of 0.417 > 0.05 and then the BMI variable was removed from the model. If the BMI variable is removed then there is a change in the value of Beta = (4.621 – 3.978)/ 3.978 x 100%) = 16.16%. If the change in Beta value exceeds 10% then the variable BMI is retained in the model again. So what is excreted is creatinine (*p-value* = 0,290). The low beta value of creatinin is supposed to have no influence on the pre-delay time of the CTA (Ahmad Hariri Sokhibi *et al.*, 2023).

The change in the value of beta = (4.061 – 3,978)/ 3,978 x 100%) = 2,09%, then the creatinin variable is removed from the Model. From the results of the analysis it turns out there is no more *p-value* > 0,05 thus the process of searching for the variable entering the model has been completed with the model equation Line of linear regression:

Time pre-delay scan = 4.061 + 0.045 systolic blood pressure + 0.273 aortic diameter – 0.053 Age + 0.049 urea + 0.066 BMI.

The most dominant variable affecting the scan delay time is the aorta diameter variable, with a value Beta = 0.273.

Tabel 4. Linear regression analysis influence of intrinsic factors on CTA pre-delay time

Coefficients[a]												
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	4.061	1.980		2.051	.044	.112	8.011					
Systole Blood Pressure	.045	.011	.415	3.947	.000	.022	.068	.551	.427	.329	.629	1.589
Aortic Diameter	.273	.062	.484	4.428	.000	.150	.396	.577	.468	.369	.582	1.718
Ages	-.053	.021	-.289	-2.580	.012	-.095	-.012	.200	-.295	-.215	.555	1.800
Ureum	.066	.028	.199	2.312	.024	.009	.122	.174	.266	.193	.936	1.068
BMI	.049	.055	.082	.884	.380	-.061	.159	.338	.105	.074	.811	1.233

DISCUSSION

The impact of aortic diameter on the length of the pre-delay scan time - CTA coronary examination

The results of the statistical analysis related to the relationship between the diameter of the aorta and the time delay scan CTA coronary examination also obtained a very strong relationship with the value of r=0.577 with having a positive pattern so that has meaning increasing the Aortic diameter then

increasing also the delay time of the scan. This is in line with previous research that concluded that the larger the transversal cardiac diameter, the longer the delay in scanning the coronary CTA (Tang *et al.*, 2011).

The *effect of systolic blood pressure on the duration of pre-delay scan time - coronary CTA examination*

The results of the analysis of systolic blood pressure against the time delay scan in coronary CTA have a very strong relationship with the value of r = 0.534 with having a positive pattern so that has a meaning the greater the systolic pressure will affect the increased delay time scan obtained. It was also found that the time delay scan results in coronary CTAs had a dependency of 30.4% on this systolic blood pressure. From the data that the statistical analysis of the trial on linear regression also obtained a significant relationship between the systolic pressure and the delay time scan with a magnitude of significance of p=0.000. From the data we obtained regarding the relationship between systolic blood pressure and the time delay scan on coronary CTA this is a new data and no comparison related to previous research (Flohr, Schoepf and Ohnesorge, 2007).

The influence of aortic diameter and systolic blood pressure on the length of pre-delay scan time - CTA coronaria examination

From the results of the analysis obtained how the diameter of the aorta and systolic blood pressure jointly influence the length of the pre-delay scan time on the CTA Coronaria examination, seen the variable of the Aorta diameter becomes a very dominant variable influencing the time of this pre-detail scan with the value Beta = 0.273, followed by the systolic pressure variable with a value of Beta = 0.045, further resulted also the equation of the double linear regression line of the relationship between the aortic diameter and the systolic blood press together influences the lengthen of the time before delay can on the Coronarian CTA examination i.e:

Pre-delay scan time = 4.061 + 0.045 Sistolic blood pressure + 0.273 Aortic diameter.

The Influence of other instrumental factors (heart rate, age, creatinine levels, urea levels, body mass index) on the length of pre-delay scan time - CTA coronary examination

Creatinin and BMI have values of r=0.308 and r=0.338 respectively, the creatinine determination coefficients of 0.095 and 0.115 respectively. It concluded that the creatinine and BMI variables had a moderate and positive relationship to the length of the delay scan in the coronary CTA examination. This indicates that the values of creatinin and the BMI had a positive and moderate relationship with the delays of the scan. Related to BMI this study is not consistent with the research carried out by Tang*et al.*, (2011) that there is no relationship between the time delayed scan and the time.

Urea, age, and heart rate have values r=0.174; r=0,200; 0.116. The determination coefficients of urea and age, respectively, are 0.03; 0.04; 0.013. The variables of urea, age, and heart rate have no influence on the delay time of the scan. In relation to the heart rate this study is not consistent with the previous study that stated that there was a relationship between the card rate of the time of delay scan and negative for the length of the delays scan (Tang *et al.*, 2011). Related to urea there is no comparison because so far no similar study has been found that investigates the relationship of urea to the time delay scan in coronary CTA (Flohr *et al.*, 2007). According to the analysis conducted in this study, the length of the pre-delay scan time on the coronary CTA examination was found to be influenced by both systolic blood pressure and aortic diameter, as follows:

Pre-delay scan time = 4.061 + 0.045 systolic blood pressure + 0.273 aortic diameter.

Pre delay scan time correction application

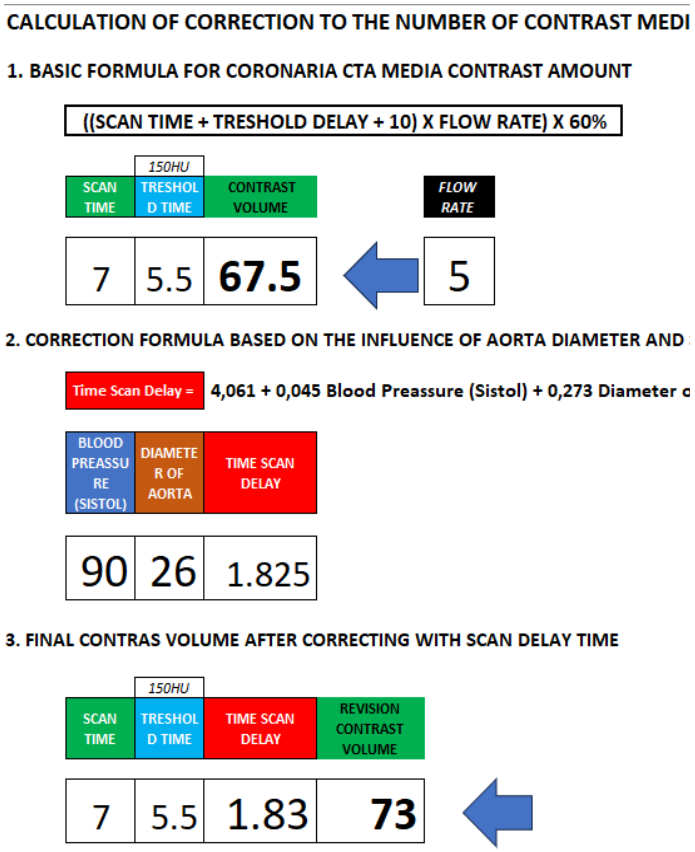

Figure 1. Display of coronary CTA media contrast correction calculation application

IV. CONCLUSION

The delay time of a coronary CTA scan is equal to the pre-delay scan time = 4.061 + 0.045 Sistolic blood pressure + 0.273 Aorta diameter. This delay is influenced by the aortic diameter and the cytolic blood pressure with a dependency value of 30.4% - 33.3% and a significance of p = 0,000. This proves the beta value = 0.0273 on the aorta diametric and is followed by the systolic blood pressure variable with a beta value of 0.045. While the intrinsic factor creatinine, BMI, urea, age, and heart rate have little influence on the pre-delay scan time of coronary CTA examination.

V. ACKNOWLEDGMENTS

The researchers thanked the Radiology team for contributing directly to the research. The author states there is no conflict of interest of any team in the conclusion of this study.

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Cite this article as :

Arief Oesmanto, Antonius Gunawan Santoso, Darmini, Ahmad Hariri, Agus Rochmat, "Validation of Patient Intrinsic Factors on Pre-Delay Coronary CT Scan Angiography (Coronary CTA) Bolus Tracking", International Journal of Scientific Research in Science and Technology (IJSRST), Online ISSN : 2395-602X, Print ISSN : 2395-6011, Volume 11 Issue 2, pp. 49-58, March-April 2024. Available at doi : https://doi.org/10.32628/IJSRST52411196
Journal URL : https://ijsrst.com/IJSRST52411196