Correlation between Blood Pressure and Severity of Atherosclerosis in The Left Main Coronary Artery with CT Coronary Angiography Examination

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ABSTRACT

Background: Cardiovascular disease, especially hypertension, is the main cause of death in both developed and developing countries. Hypertensioncan lead to atherosclerosis, which is the most common cause of ischemic and coronary heart disease. Some countries have used Computed Tomography Coronary Angiography (CTCA), which is a noninvasive test, to observe the anatomy of coronary artery. Nevertheless, invasive angiography isstill the gold standard for coronary artery visualization. Atherosclerotic plaques cancause left main coronary artery stenosis.

Purpose: The purpose of this research is to analyze the correlation between blood pressure and severity of the atherosclerosis in the left main coronary artery. With CTCA examination, the presence of plaque, severity of stenosis and type of plaques were assessed.

Methods: The study design was analytic observational with cross sectional design. Data was drawn from medical records. The sample included a total of 29 patients which were suspected of having coronary heart disease and examined with CTCA who meet inclusion and exclusion criteria in Dr. Kariadi Hospital, Semarang, Indonesia.

Result: The correlation between systolic blood pressure and left main coronary artery stenosis was obtained by Spearman's rho r = 0.0429, *p-value* of with of 0.020 (2-tailed). The correlation between diastolic blood pressure and left main coronary artery stenosis was obtained by Spearman's rho r = 0.354 with *p-value* of 0.060(2 -tailed). Some types of plaques were found in left main coronary artery, and systolic blood pressure are significantly different analysed using Anova (analysis of variance) which probability was significant with p value 0.041.

Conclusion: There was a significant correlation between systolic blood pressure and left main coronary artery stenosis. Therewas no correlation between diastolic blood pressure and left main coronary artery stenosis. Furthermore, there was a significant difference between systolic blood pressure and the type of plaques in the left main coronary artery.

Keywords: blood pressure; left main coronary artery disease;ct coronary angiography

INTISARI

Latar Belakang: Penyakit kardiovaskular, terutama hipertensi, merupakan penyebab kematian utama baik di negara maju maupun berkembang. Hipertensi menyebabkan atherosklerosis yang merupakan penyebab penyakit jantung iskemik dan krooner. Beberapa negara menggunakan *Computed Tomography Coronary Angiography* (CTCA), yang merupakan uji non invasif, untuk menilai anatomi arteri koroner. Namun, angiografi invasif masih menjadi baku emas untuk visualisasi arteri koroner. Plak atherosklerosis dapat menyebabkan stenosis pada arteri koroner utama kiri.

Tujuan: Tujuan penelitian ini adalah untuk menganalisis korelasi antara tekanan darah dan keparahan atherosklerosis pada arteri koroner utama kiri. Dengan pemeriksaan CTCA, adanya plak, keparahan stenosis dan tipe plak dinilai.

Metode: Disain penelitian adalah analisis observasional dengan disain potong lintang. Data

diambil dari rekam medis. Sampel meliputi 29 pasien yang dicurigai memmpunyai penyakit jantung koroner dan dilakukan pemeriksaan CTCA yang memenuhi kriteria inklusi dan eksklusi di Rumah Sakit Dr Kariadi, Semarang, Indonesia.

Hasil: Korelasi antara tekanan darah sistolik dan stenosis arteri koroner utama kiri diperoleh dari Spearman's rho r = 0.0429, nilai p 0.020 (2-arah). Korelasi antara tekanan darah diastolik dan stenosis arteri koroner utama kiri diperoleh dari Spearman's rho r = 0.354, nilai p 0.060 (2-arah). Beberapa tipe plak ditemukan pada arteri koroner utama, dan terdapat perbedaan signifikan pada tekanan darah sistolik. Analisis dengan tes Anova menunjukkan hasil perbedaan yang signifikan dengan nilai p 0.041.

Kesimpulan: Terdapat korelasi signifikan antara tekanan darah sistolik dengan stenosis arteri koroner utama kiri. Tidak terdapat korelasi antara tekanan darah diastolik dan stenosis arteri koroner kiri. Terdapat perbedaan signifikan tekanan darah sistolik berdasarkan tipe plak pada arteri koroner utama kiri.

INTRODUCTION

Cardiovascular disease is the main cause of death in both developed and developing countries. By 2020 it is estimated that there will be 25 million deaths each year from cardiovascular disease, almost half caused by coronary heart disease. Coronary heart disease is a cardiovascular disease that has high morbidity and mortality.[1,2,3]

The risk factors for cardiovascular disease are smoking, hypertension, diabetes, obesity, and dyslipidemia.[2] According to WHO, nearly one billion people has hypertension, two thirds of them were found in developing countries and as one of the leading cause of death in the world, the number was expected to increase. By 2025 it is estimated that 1.56 billion people will suffer from hypertension. Hypertension is the most cause of coronary heart disease, patients with hypertension will also lead to complications such as diabetes mellitus. [1,2,3]

Atherosclerosis is the leading cause for ischemic heart disease and coronary heart disease. If there is more atherosclerotic plaque were found, the greater possibility of obstruction found. Blood pressure is closely related with atherosclerotic plaque formation in coronary artery. In a study by Tae Soeng, patients with stage 2 hypertension may have coronary heart disease by 9,4% and may develop atherosclerotic plaque by 40%.

Even in patients with normal blood pressure, atherosclerotic plaque could be found in around 16,5% and have the possibility of getting coronary heart disease by 2,2%. Hypertension is also related with the type of atherosclerotic plaque. In study by Tae Seong, patients with stage 2 hypertension were found to have about 13,6% with non calcified plaques, 21,7% with mixed plaques, and 12,8% with calcified plaques.[1,5,6,7]

Several countries have used Computed Tomography Coronary Angiography (CTCA) which is a non-invasive method to assess coronary artery anatomy, despite the invasive angiography is still the gold standard for coronary artery visualization. Computed Tomography Coronary Angiography (CTCA) is a high resolution imaging for coronary arteries and has a high accuracy to see the presence of atherosclerotic plaques that cause coronary artery stenosis. According to Schuijf's study, the sensitivity and specificity of Computed Tomography Coronary angiography (CTCA) in detecting coronary artery stenosis are about 93% and 96%.[8,9,10]

Left main coronary artery disease is stenosisof the left main coronary artery that is caused by atherosclerotic plaque. Left main coronary artery is the most elastic coronary artery that supplies about 75-85% blood to left ventricle. In patient with left dominant artery, it

could supply up to 100% blood to epicardial. According to study by Shao Liang, stenosis most commonly occurred in mid region or in the branches (52.8%) and could be fatal. Significant stenosis on the left main coronary artery may lead stenosis at least in one or more coronary arteries. If stenosis occured in left main coronary artery, left ventricle dysfunction could happen and lead to arrythmia, which put the patients to high risk of mortality.[11,12,13]

According to a study by Gamal et al., in 40 patients suspected with coronary heart disease, 26 patients had coronary artery stenosis with 58.4% in left main coronary artery and its branches and 30% in right coronary artery. If there were about 70% stenosis on the left main coronary artery, patient's three years survival rate would be just 41%.[14,15,16,17,18]

Based on this background, the authors aim to examine the correlation between blood pressure and the left main coronary artery atherosclerosis severity level with Computed Tomography coronary angiography (CTCA) examination in Dr. Kariadi Public Hospital, Semarang, Indonesia. The authors consider the risk of high blood pressure with the type of atherosclerotic plaque on the left main coronary artery and with the degree of stenosis on the left main coronary artery.

METHODS

This research is an analytical observational research with cross-sectional design. Target population were patients suspected with coronary heart disease who undergo CT Coronary Angiography examination. Sampled population were patients suspected with coronary heart disease who undergo CT Coronary Angiography in Radiology Department of Dr. Kariadi Public Hospital in Semarang, Indonesia.

The sample of the study were patients suspected with coronary heart disease who undergo CT Coronary Angiography examination

performed by MSCT scan 64 slices of Somatom Sensation Siemensin Radiology Department of Dr. Kariadi Hospital Semarang in the study period. Examination was performed in patients with heart-byte / heart rate less than 65 beats per minute or less than 70 beats per minute. This study protocol decreased patient's heart rate before the scanning if it was more than 70 beats per minute. For inpatients, intravenous infusion sets had been installed from the room with Venocath / Abbocath size 18 G in cubital vein. We monitored the patient by measuring the pulse tension. Media contrast as much as 80-100 ml was injected from the injector machine, with 5 ml per second flow rate of injection and pressure of 325 psi.[19]

Inclusion criteria were patients with suspected coronary heart disease, which age > 18 years old.Blood pressure was checked and recorded on a complete medical record.CT coronary angiography examination was performed and there was a file of examination result.

Exclusion criteria were patients with incomplete medical records, patients with incomplete CT coronary angiography examination, patients with Ca Score > 400 / total occlusion in the coronary artery because it will cause artifacts so the assessment is not optimal, patients that had been done Percutaneus Coronary intervention (PCI) previously, patients that had been done Coronary Artery By Pass Graft (CABG) therapy, patients with vascular anomalies such as aortic aneurysm or aortic dissection, patients with congenital heart disease, patients with secondary hypertension and patients with bleeding, malignancy and HIV infection.

The sampling method was done by consecutive sampling method.The minimal sample size (n) was calculated using the sample formula for the correlation test. The value of Zalpha = 1.96 and Z beta = 0.842. The standarddeviation (SD) of % left main coronary

artery stenosi was set in 9.57. The value of (Xa-Xo) was 5.0. The formulae was:

$$n = \frac{(Z\text{-alfa} + Z\text{-beta})* SD\ 2}{(Xa - Xo)}$$

$$= \frac{(1.96 + 0.846)*S\ 2}{(5.0)}$$

$$= 28.8$$

Based on the calculation of the sample size above, a subjects necessary for this study were at least 29 patients needes as research subjects.

Patients who match the study criteria will be used as research subjects. We conducted patient data search of the patients with alleged coronary heart disease which had performed CT coronary angiography examination. The data of confirmed CD file of CT coronary angiography examination and the patient history in medical record to collect blood pressure, blood glucose, lipid profile and smoking history data. Blood pressure was obtained from the secondary data i.e. average blood pressure recorded in the medical record before the patient was performed CT coronary angiography. In this study, blood pressure data did not consider the consumption of antihypertensive drugs, this is one of the weakness in this study.

Then, we assessed the type of atherosclerotic plaque and the degree of left main coronary artery stenosis. These variables were correlated and data analysis was performed.

Before being analyzed the data completeness were checked to avoid the existence of incomplete data or data errors. The datawere then performed the cleaning, coding and tabulation equipped with the middle values and its variant. Subsequently, the data was entered into the computer software to be analyzed. To prove the hypothesis, author used statistical test using correlation test (statistical test used is Spearman statistical test because one of the variable is ordinal scale). Statistical tests were performed at α = 5%.

RESULTS

The total number of research subjects matching the study criterias were 29 people, which were consisted of 22 men (75.9%) and 7 women (24.1%). Age distribution of study subjects of ≤ 40 years was as many as 3 people (10.3%), age 41 - 50 years as many as 10 people (34.5%), age 51-60 years as many as 9 people (31%), age 61-70 years as many as 5 people (17.2%) and age 71 - 80 years as many as 2 people (6.91%). The subjects' blood pressure distribution was divided into 4 (normal 1 person (3.4%), pre-hypertension 4 people (13.8%), stage 1 hypertension 10 people (10%), and stage 2 hypertension 14 people (48.3%).

Distribution of blood glucose status in research subjects were divided into two: 8 people (27.6%) with diabetes mellitus, and 21 people (72.4%) without diabetes mellitus. Distribution of smoking history in the research subjects divided into two: with smoking history of 18 people (62.1%) and no smoking history of 11 people (37.9%). The distribution of lipid profile of research subjects was divided into two: hyperlipidemia 24 people (82.8%) and not hyperlipidemia 5 people (17.2%).

Distribution of stenosis degree found in left main coronary artery were divided into three: 12 people (41.4%) with normal left main coronary artery, 10 people (34.5%) with non significant stenosis, and 7 people (24.5%) with significant stenosis. Distribution of plaque on the left main coronary artery was divided into four: none in 17 people (58.8%), soft plaques in 3 people (10.3%), calcified in 6 people (20.7%), and mixed plaque in 3 people (10.3%).

The correlation between systolic blood pressure andpercentage of left main coronary artery stenosis was obtained by Spearman's rho

anlysis. The r value was 0.0429 with significancy (2-tailed) by 0.020. It was concluded there was a significant correlation between systolic blood pressure with left main coronary artery stenosis (figure 1).
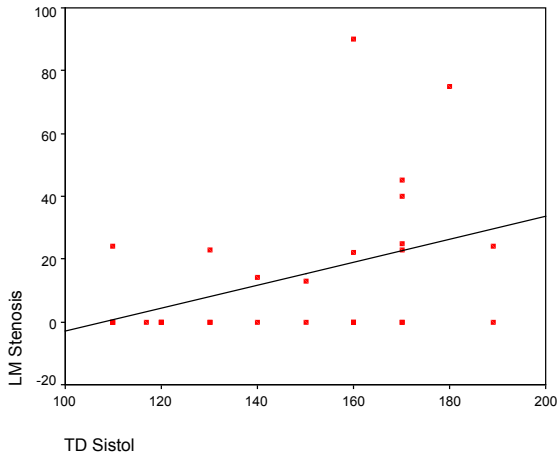

Figure 1. The correlation between systolic blood pressure (TD Sistol) in mmHg and % left main coronary artery stenosis (LM Stenosis)

Correlation between diastolic blood pressure with percentage left main coronary artery stenosis was obtained by Spearman's rho r value of 0.354 with Sig. (2 -tailed) of 0.060, which was concluded there was no significant correlation between diastolic blood pressure with left main coronary artery stenosis (figure 2).
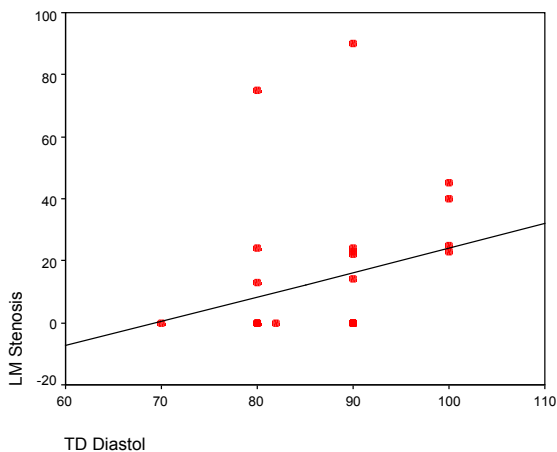

Figure 2. The correlation between diastolic blood pressure (TD Diastol) in mmHg and % left main coronary artery stenosis (LM Stenosis)

Because there were several types of plaque in the left main coronary artery which correlated with systolic blood pressure, hypothetical test were performed using variance analysis or analysis of variance (ANOVA). The result showed the significance probability value was obtained of 0.041. It was concluded that there was significant difference between systolic blood pressure and type of plaques in left main coronary artery (figure 3).
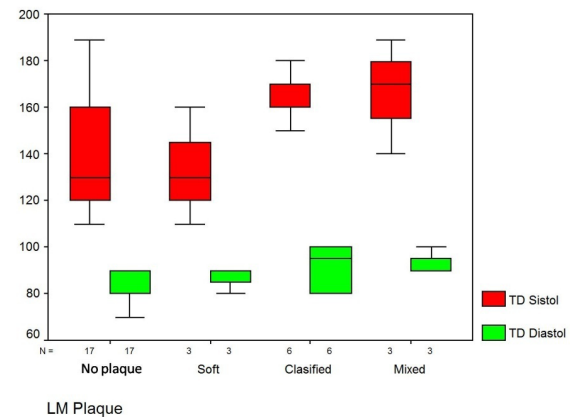

Figure 3. The boxplotof mean systolic blood pressure (TD Sistol) and diastolic blood pressure (TD Diastol) in mmHg based on type of left main coronary artery plaques

As continuation from analysis of variance hypothetical test, a multiple comparison test were performed because there was significant difference between systolic blood pressure and type of plaque in left main coronary artery. To see which group were different, significance value was set as < 0.05. From multiple comparisons result, it was concluded that there were differences between mean systolic blood pressure with no plaque and calcified plaque, with significance value of 0.018. There were no differences between no plaque and soft plaque, no plaque and mixed plaque, soft plaque and calcified plaque, and soft plaque and mixed plaque because of the significance value of > 0.05 (figure 3).

From the correlation test between diastolic blood pressure and plaque type in left main coronary artery using Chi Square test, it was

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Table 1. Characteristics of subjects

Variable	n (%)	Mean ± SD	Median (min – max)
Gender			
Male	22 (75.9)		
Female	7 (24.1)		
Age, years		53.79±10.49	53 (32 – 78)
≤ 40	3 (10.3)		
41 – 50	10 (34.5)		
51 – 60	9 (31.0)		
61 - 70	5 (17.2)		
71 - 80	2 (6.9)		
Diabetes Mellitus			
Yes	8 (27.6)		
No	21 (72.4)		
Lipid profile			
Yes	24 (82.8)		
No	5 (17.2)		
Smoking history			
Yes	18 (62.1)		
No	11 (37.9)		
Systolic Blood Pressure		147.07 ± 25.48	150 (110 – 189)
Diastolic Blood Pressure		87.66 ± 7.33	90 (70 – 100)
Normal	1 (3.4)		
Pre-hypertension	4 (13.8)		
Stage 1 hypertension	10 (34.5)		
Stage 2 hypertension	14 (48.3)		
Plaque			
None	17 (58.8)		
Non-calcified plaque	3 (10.3)		
Mixed plaque	3 (10.3)		
Calcified plaque	6 (20.7)		
Stenosis			
Normal	12 (41.4)		
Non Significant Stenosis	10 (34.5)		
Significant Stenosis	7 (24.1)		

obtained the significance value of 0.212, which indicated there was no significant correlation between diastolic blood pressure and plaque type in left main coronary artery (figure 3).

DISCUSSION

In this study, significant stenosis in left main coronary artery (> 50%) occurred in patients with average systolic and diastolic blood pressure of 170/85 mmHg (stage 2 hypertension). In Tae Seong's study, patients with stage 2 hypertension have coronary heart disease (obstructive CAD/significant stenosis). The difference between this study and previous study was that this study focused only on left main coronary artery, whereas in previous study, all segments of coronary artery were taken into account.[18]

In this study correlation between systolic blood pressure and stenosis of left main coronary artery were concluded from Spearman's value rho r of 0.429 with sig. (2-tailed) of 0.020 which means there were significant correlation between systolic blood pressure with stenosis of left main coronary artery. Correlation between diastolic blood pressure and left main coronary artery were concluded from Spearman's value rho r of 0,354 with sig. (2-tailed) of 0.060 which means there were no correlation between diastolic blood pressure with stenosis of left main coronary artery. According to Borghi's study, there was also significant correlation between systolic blood pressure (p = 0.003) with myocardial infarction, on the other hand, there was no significant correlation between diastolic blood pressure with myocardial infarction.[7]

The difference between this study and Borghi's study is that this study focused only on stenosis of left main coronary artery, whereas previous study look at the correlation between blood pressure and risk of myocardial infarction like acute coronary syndrome, but still has the same result which is systolic blood pressure has big impact to stenosis occurence in left main coronary artery which leads to myocardial infarction.[7]

Because there were several types of plaque in left main coronary artery, hypothetical test was performed using variance analysis or ANOVA and obtained significance probability value of 0.041, which means there were significant difference between systolic blood pressure and plaque type in left main coronary artery.

From the result of multiple comparisons, it is concluded that there were differences between mean systolic blood pressure of no plaque and calcified plaque with significance value of 0.018. There were no differences between no plaque and soft plaque, no plaque and mixed plaque, soft plaque and calcified plaque, and soft plaque and mixed plaque because of its significance value of > 0.05.

Distribution of plaque in left main coronary artery with blood pressure ie no plaque in left main at systolic / diastolic blood pressure average 139/85 mmHg, soft plaque at systolic / diastolic blood pressure average 133/87 mmHg, calcified plaque at systolic / diastolic blood pressure averaged 167/92 mmHg and mixed plaque at systolic / diastolic blood pressure averaged 166/93 mmHg. In this study we found left main coronary artery has calcified plaque and mixed plaque in patients with mean blood pressure of stage 2 hypertension as well as in Tae Seong's study that assessed all coronary artery segments, the results of patients with stage 2 hypertension were also found mixed plaques and calcified plaques. Based on the similar results from this study and research from Tae Seong, it means there is same type of plaque in the left main coronary artery as well as in other coronary artery segments in patient with stage 2 hypertension.[18]

Correlation test between diastolic blood pressure and type of plaque in left main coronary

artery using Chi Square test was obtained significance value of 0.212 showed there was no correlation between diastolic blood pressure with type of plaque in left main coronary artery. From Borghi's study result, it was also concluded that there was no correlation between diastolic blood pressure and occurence of myocardial infarction (p = 0.865) nor the occurence of atherosclerotic plaque. The difference between this study and Borghi's study is that this study focused only on stenosis of left main coronary artery, whereas Bhorgi's study look at the correlation between blood pressure and risk of myocardial infarction like acute coronary syndrome, but still has the same result which is systolic blood pressure has big impact to stenosis occurence in left main coronary artery which leads to myocardial infarction.[7]

In this study it is seen that systolic blood pressure greatly affects the formation of atherosclerotic plaque that cause stenosis in left main coronary artery. This study result is similar with other studies that mentioned the importance of systolic blood pressure as the risk factor of cardiovascular disease which leads to mortality.

The presence of significant correlation between systolic blood pressure and the formation of atherosclerotic plaque and stenosis in left main coronary artery, maybe because in this study the research subjects were mostly more than 50 years old which were 16 people (55.5%), this matches with the result of a study by Stanley, which stated that age plays important roles in affecting correlation between blood pressure and cardiovascular disease.

In patients younger than 50 years old, diastolic blood pressure strongly affect cardiovascular disease more than systolic blood pressure or pulse rate by increasing peripheral resistance and pressure. Between the age of 50 – 59 years, the three factors are equally affect the risk of cardiovascular disease. In more than 60 years old patients, systolic blood pressure plays bigger role in affecting cardiovascular disease by increasing the rigidity of main arteries. With rigid arterial structures, peripheral amplification is reduced, increasing amplitudes and velocity, affecting the left ventricle ejection, increasing aortic systolic blood pressure, increasing afterload, and increasing central arterial rigidity.[20]

This study result shows that blood pressure is related with occurance of left main coronary artery disease, but the weakness of this study is that blood pressure data was taken secondarily from patients' medical record, without considering the anti-hypertension medicine consumed by the patients, variants of the tools used as well as the officer performing the blood pressure measurement. It is suggested that for the next research blood pressure data could be taken in better an more accurate manner.

CONCLUSION

From the study of the correlation between blood pressure and severity of atherosclerosis in left main coronary artery on CTCA, it was concluded that there are significant correlation between systolic blood pressure with stenosis of left main coronary artery, there is no correlation between diastolic blood pressure with stenosis of left main coronary artery, there is significant difference between mean systolic blood pressure and plaque type in left main coronary artery, there are difference in mean systolic blood pressure between no plaque and calcified plaque and there is no correlation between mean diastolic blood pressure and type of plaque in left main coronary artery.

Our suggestion for the next study are the consideration for more samples, the consideration of factors like blood glucose level, lipid profile, age, smoking history, and body weight which are not evaluated in this study.

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