Comparison of Calcified Plaque Volume in Coronary Arteries using Filtered Back Projection and Intelli IP Advanced at CT-scan 128 Slice

Naufal Arya Pratama[1], Lailatul Muqmiroh[1], Amillia Kartika Sari[1,*], Widiana Ferriastuti[2], Falentina Syivasari[3], Muhaimin[1], Sidarta Prassetyo[4], Cong Tien Nguyen[5], Phan Anh Phuong[5], Vu Dang Luu[5]

[1]*Radiologic Imaging Technology Program*
Faculty of Vocational Studies, Airlangga University
Surabaya, Indonesia
E-mailc: naufal030698@gmail.com, lailatul.muqmiroh@vokasi.unair.ac.id, amilia.kartika.sari@vokasi.unair.ac.id, muhaimin@vokasi.unair.ac.id

[2]*Department of Radiology*
Faculty of Medicine, Airlangga University
Surabaya, Indonesia
E-mail: widiana-f@fk.unair.ac.id

[3]*Department of Radiology, Mitra Keluarga Hospital*
Surabaya, Indonesia
E-mail: valsyivasari@gmail.com

[4]*Faculty of Vocational Studies, Airlangga University*
Surabaya, Indonesia
E-mail: sidarta@vokasi.unair.ac.id

[5]*Department of Radiology, Bach Mai Hospital*
Hanoi, Vietnam
E-mails: nctien1983@gmail.com, anhphuongxq@gmail.com, vudangluu@hmu.edu.vn

[*]*Corresponding author*

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Abstract: *Calcified plaque has a major effect on increasing plaque volume which can increase the risk of Coronary Artery Disease (CAD). The use of Filtered Back Projection (FBP) on CT-scans still has flaws in terms of image quality that can result in errors in the calculation of plaque volume. Intelli IP Advanced is hitachi CT-scan's Iterative Reconstruction (IR) type and can improve image quality compared to FBP. The purpose of this study is to find out the comparison of calcified plaque volume in coronary arteries using FBP and Intelli IP Advanced. This study used 38 samples of coronary artery blood vessels that had calcified plaque and reconstructed using the reconstruction of FBP and Intelli IP Advanced algorithms (Levels 1-3). Plaque calculation is done automatically using aquarius intuition edition application on CT-scan Hitachi SCENARIA 128 Slice. The results in this study found significant differences ($p < 0.05$) in calcified plaque volume results with the use of FBP and Intelli IP Advanced algorithm reconstruction (Levels 1-3). However, significant differences are found only in algorithm reconstruction pairs (Intelli IP Advanced Level 1 and Level 3) that have a $p < 0.05$. The conclusion is that IR affects the volume value of calcified plaque.*

Keywords: *Calcified plaque, Filtered back projection, Intelli IP Advanced.*

Introduction

Coronary Heart Disease (CHD) has been considered as a deadly disease in Indonesia. The Sample Registration System (SRS) survey in 2014 in Indonesia showed that CHD was the highest cause of death at all ages after stroke, which was 12.9% [4]. Coronary heart disease, also called Coronary Artery Disease (CAD) is a disease of the coronary arteries where the narrowing of the coronary arteries due to the process of atherosclerosis occurs [7]. The fact that there are a great number of deaths due to CHD requires serious treatment, ranging from prevention to efforts to cure CHD. One of ways to determine the presence of abnormalities in the heart is a Coronary Computed Tomography (CCTA) examination. CCTA is an examination to evaluate CAD because it is capable of assessing stenosis and atherosclerotic plaque [9]. The amount of plaque volume is a strong predictor in assessing cardiovascular conditions [12]. A study conducted by Weber et al. [12] stated that overall the increase in plaque volume was driven by an increase in the volume of calcified plaque. This indicates that calcified plaque has a major effect on increasing plaque volume which can increase the risk of CAD.

Most studies on CCTA were reconstructed using Filtered Back Projection (FBP). FBP is one of the most common methods used in image reconstruction applied to CT-scans [1]. However, FBP still has a lack of resolution and an increase in image noise [6]. The use of Iterative Reconstruction (IR) is one of the solutions as it has emerged as a new technique in CT cardiac examination for dose reduction and image quality improvement [6]. Each IR in the CT-scan modality has a different name. The latest IR that has been developed by CT Hitachi is Intelli IP Advanced. Intelli IP Advanced is an improvement of Intelli IP Normal which has been implemented in Hitachi's SCENARIA CT-scan [2]. Intelli IP Advanced has one to seven levels. The higher the level used, the higher the noise reduction that can be done but it can cause blurry images [8].

Materials and methods

Sample preparation

The population taken was data from all CT cardiac patients at Hitachi 128 Slice CT scanner at Bach Mai Hospital Vietnam from November 2019 to January 2020. This study used 38 samples which were the number of coronary arteries with calcified plaque. The samples taken were data from patients with heart rate less than 85 bpm and with plaque calcification which had been proven by calculating calcium score (Fig. 1).

Fig. 1 Cardiac rendering volume and
automated plaque calcification measurement

Automated plaque calcification measurements

This study used a Hitachi SCENARIA 128 Slice CT Scanner. The Aquarius Intuition Edition ver.4.4.12.185.3539 application on the Hitachi 128 Slice CT Scanner workstation was used to

measure the volume of plaque in coronary arteries. The reconstruction in this study used thickness 0.625 mm, Recon index 0.5 mm, Filter 71 heart standard, and Recon phase range of 40-60% for each image reconstruction (FBP and Intelli IP Advanced Levels 1-3). Automatic measurements were carried out by making tracking on coronary arteries on the rendering of the heart volume display, and, then, it would automatically display the results of plaque volume based on the level of the Hounsfield Unit (HU) value.

Statistical analysis

The data analysis used was the Shapiro-Wilk method to test the normality and the Repeated Measurements Analysis of Variance (Repeated Measurements ANOVA) method was used for significance test if the data was normally distributed. However, if the data was not normally distributed, the Friedman method, continued with the Wilcoxon test, was used. The data was processed by using SPSS version 20 software. Based on these statistical results, it can be concluded if there is a significant difference in volume or not from plaque calcification in FBP and Intelli IP Advanced.

Results

Based on the results of the average volume of calcified plaque on each algorithm, the overall average volume of calcified plaque was obtained (Fig. 2). The mean value of calcified plaque volume for each reconstruction algorithm was 15.8 ± 39.8 mm^3 at FBP, 16.57 ± 38.32 mm^3 at Intelli IP Advanced (Level 1), 16.11 ± 40.84 mm^3 at Intelli IP Advanced (Level 2), 15.19 ± 37.78 mm^3 on Intelli IP Advanced (Level 3).

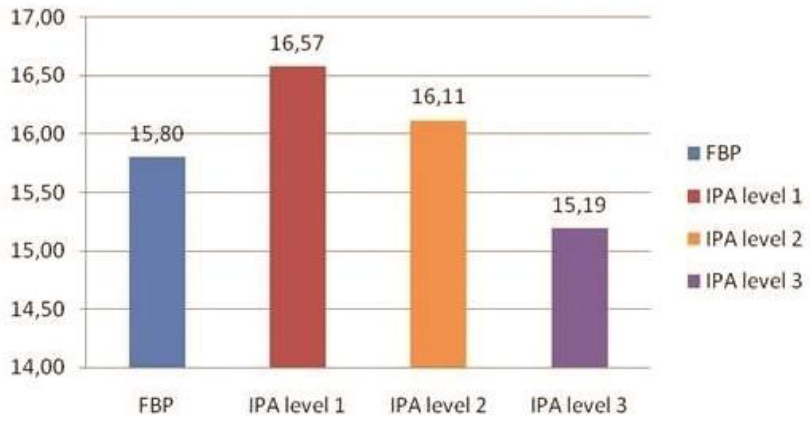

Fig. 2 Average value of calcified plaque volume in each reconstruction algorithm

Normality test

Based on the results of the normality test using the Shapiro-Wilk method, the significance value of the calcified plaque volume data using FBP and Intelli IP Advanced (Levels 1-3) were p-value < 0.05 (0.000; 0.000; 0.000; 0.000), respectively. Based on these results, it could be inferred that the data were not normally distributed and would be continued with the significance test using the Friedman method that was then followed by the Wilcoxon method.

Significance test

Based on the results of significance test with Friedman method, the significance value was 0.026, and, therefore, the $p < 0.05$. If the $p < 0.05$, there were significant differences in the results of calcified plaque volume with the use of reconstruction algorithms and Intelli IP FBP Advanced (Levels 1-3). Then, the results of the significance value of each pair of reconstruction algorithms were obtained from the results of the significance test using the

Wilcoxon method. The reconstruction algorithm pairs (Intelli IP Advanced Level 1-FBP, Intelli IP Advanced Level 2 - FBP, Intelli IP Advanced Level 3 - FBP, Intelli IP Advanced Level 2 - Level 1, Intelli IP Advanced Level 3 - Level 2) had a significant value $p > 0.05$. Therefore, there was no significant difference in calcified plaque volume between the FBP and Intelli IP Advanced reconstruction pairs. Meanwhile, a pair of reconstruction algorithms of Intelli IP Advanced Level 3 and Level 1 had a significance value $p < 0.05$ (0.005). Thus, there was a significant difference of the volume of calcified plaque in the pair of the reconstruction algorithms (Intelli IP Advanced Level 3 and Level 1).

Discussion

The results of the measurement of the average volume of calcified plaque in this study were 15.8 ± 39.8 mm^3 on FBP, 16.57 ± 38.32 mm^3 on Intelli IP Advanced (Level 1), 16.11 ± 40.84 mm^3 on Intelli IP Advanced (Level 2), 15.19 ± 37.78 mm^3 on Intelli IP Advanced (Level 3). These results indicate that Intelli IP Advanced (Level 1) has the highest mean of the volume value of calcified plaque between FBP and Intelli IP Advanced (Level 2) and (Level 3). This is different from the research conducted by Károlyi et al. [3] which states that FBP higher calcified plaque volume value than IR. This could happen because the IR method can produce images with low noise and high spatial resolution [10]. Reconstruction of the IR algorithms for each CT-scan has a different effect [5], and the level of spatial resolution generated in each IR model is different.

Based on the normality test using the Shapiro-Wilk method, the data in this study were not normally distributed ($p < 0.05$). Therefore, it was continued by conducting the significance test using the Friedman method and the result showed $p < 0.05$, which means that there is a significant difference in this study. To find out which pairs of reconstruction algorithms have significant differences in the value of the volume of calcified plaque, a further significance test was performed using the Wilcoxon method.

The results of the significance test using the Wilcoxon method obtained $p < 0.05$ which was only found in the Intelli IP Advanced (Level 1) and Intelli IP Advanced (Level 3) pairs. Therefore, a significant difference in the value of the volume of calcified plaque was only found in Intelli IP Advanced (Level 1) and Intelli IP Advanced (Level 3) (Fig. 3). Meanwhile, there was no significant difference in the value of the volume of calcified plaque found in the other pairs of reconstruction algorithms.

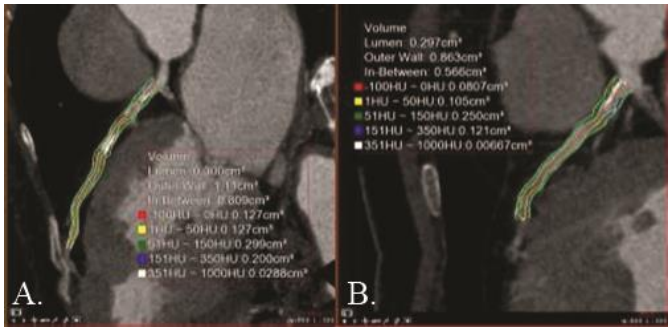

Fig. 3 Results of measurement of calcified plaque volume on:
A) FBP; and B) Intelli IP Advanced (Level 3).

Analysis of calcified plaque volume by using FBP

The use of FBP is a reconstruction algorithm that is quite good in seeing details of small objects such as coronary arteries even though it has shortcomings in terms of noise. However,

the use of FBP can sometimes lead to blooming artifact in calcified plaque. The blooming artifact can cause an error in calculating the volume of calcified plaque in the automatic method because the blooming artifact causes the size of the calcified plaque to appear larger than its original size, especially in calculating the volume of calcified plaque using the automatic method based on the obtained HU value.

Analysis of calcified plaque volume using Intelli IP Advanced

Spatial resolution can affect the calculation of calcified plaque volume by automated methods. Intelli IP Advanced has a lower level of spatial resolution at each level [2]. Intelli IP Advanced (Level 1) has the highest level of spatial resolution followed by (Level 2) and (Level 3). High spatial resolution is very good in CCTA examination because it aims to see small objects. However, a low level of spatial resolution will cause blooming artifact, make the calcified plaque size look larger and cause the calcified plaque volume value to be larger than the original [11].

Comparative analysis of calcified plaque volume using FBP and Intelli IP Advanced

The average volume on Intelli IP Advanced (Level 1) has the highest value than any other reconstruction algorithms. There is no significant difference in volume values, except for Intelli IP Advanced (Level 1) and (Level 3). This can happen because Intelli IP Advanced has different levels of spatial resolution and noise reduction capabilities at each level [2]. The different levels of spatial resolution will have an impact on the calculation of the volume of calcified plaque because the IR method can affect the blooming artifact that can manipulate the actual number and size of calcified plaque. The IR method should be used with caution in the calculation of calcified plaque in the coronary arteries [5]. The IR capability of each brand of CT-scanner is different so that the results of the volume of calcified plaque produced are also different.

Conclusion

Based on the results of the use of FBP and Intelli IP Advanced in calculating the volume of calcified plaque in the coronary arteries, different values were obtained, but after the statistical tests, there was no significant difference in values between the two.

The limitations of this study include the fact that this study did not measure the plaque in each artery one by one and used an automatic method that calculated everything entirely so that it affected the volume value obtained. There was no consensus on the use of Intelli IP Advanced for cardiac CT and the use of Intelli IP Advanced should be tailored to the scanning area.

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Naufal Arya Pratama, B.Sc.
E-mail: naufal030698@gmail.com

Naufal Arya Pratama received his B.Sc. Degree of Radiologic Imaging Technology from Faculty of Vocational Studies, Airlangga University, Indonesia in 2020. His research interest are in diagnostic imaging and image processing.

Lailatul Muqmiroh, Ph.D. Student
E-mail: lailatul.muqmiroh@vokasi.unair.ac.id

Lailatul Muqmiroh is a Lecturer at Applied Bachelor of Radiologic Imaging Technology, Faculty of Vocational Studies, Airlangga University, Indonesia. She received her B.Sc. Degree at Medical Faculty of Brawijaya University, Indonesia in 2000, and M.Sc. Degree at Medical Faculty of Airlangga University majoring Radiology in 2010. Recently, she is a Ph.D. student of Medical Faculty at Airlangga University. Her research fields are diagnostic imaging, image processing, and interventional radiology.

Amillia Kartika Sari, M.Sc.
E-mail: amillia.kartika.sari@vokasi.unair.ac.id

Amillia Kartika Sari is a Lecturer at Diploma of Radiology Imaging Technology, Faculty of Vocational Studies, Airlangga University, Indonesia. She received her M.Sc. Degree from Universitas Airlangga in 2018, and she is a Radiographer. Her interests include computed tomography, diagnostic imaging technology, radiation protection, mammography, radiology management, image processing.

Widiana Ferriastuti, Ph.D.
E-mail: widiana-f@fk.unair.ac.id

Widiana Ferriasuti is a Lecturer at the Department of Radiology, Faculty of Medicine, Airlangga University. She received her Ph.D. Degree from Airlangga University in 2021 and is a radiology consultant of neuroradiology and head and neck imaging. Her current research interests include brain-head and neck tumor, head and neck inflammation, brain-head and neck trauma, also dementia and degenerative spine.

Falentina Syivasari, M.Sc.
E-mail: valsyivasari@gmail.com

Falentina Syivasari is a Senior Radiographer and a graduate of the Radiology Department, Faculty of Medicine, Airlangga University, Surabaya, Indonesia. She obtained her M.Sc. Degree in 2022 from Strada, Indonesia. Her research fields are diagnostic imaging technology, radiology management.

Muhaimin, M.Sc. Degree
E-mail: muhaimin@vokasi.unair.ac.id

Muhaimin is a Lecturer at Diploma of Radiology Imaging Technology, Faculty of Vocational Studies, Airlangga University, Indonesia. He received his master degree from Airlangga University in 2019. His interests include magnetic resonance imaging and diagnostic imaging technology.

Sidarta Prassetyo, M.Sc.
E-mail: sidarta@vokasi.unair.ac.id

Sidarta Prassetyo is a Lecturer at Diploma of English, Faculty of Vocational Studies, Airlangga University, Indonesia. He received his B.Sc. Degree in English Literature from Airlangga University in 2006 and earned his M.Sc. Degree in Teaching English to Speakers of Other Languages (TESOL) from San Jose State University, California, USA. His interests include children's literature, materials development for language learning and teaching, and Teaching English For Specific Purposes Focusing On English For Vocational Purposes. He published several poetry books, children's books, activity books, and picture/illustration books.

Cong Tien Nguyen, M.Sc.
E-mail: nctien1983@gmail.com

Cong Tien Nguyen is a Radiologic Technologist in Bach Mai Hospital, Ha Noi, Vietnam. He has completed his study in Medical Technical in Diagnostic Imaging in Hai Duong Medical Technical Colleges, Hai Duong, Vietnam and M.Sc. Degree in Biomedical Science, Gunma University, Gunma, Japan. He has strong background at CT and MRI cardiovascular imaging.

Phan Anh Phuong, B.Sc.
E-mail: anhphuongxq@gmail.com

Phan Anh Phuong is a Teacher of Bach Mai Medical College, Hanoi, Vietnam. He has graduated B.Sc. Degree of Medical Imaging Technician from Hai Duong Medical University, Hai Duong Province, Vietnam. He is an Assistant Manager and Medical Imaging Technician at Bach Mai Radiology Center in Bach Mai Hospital, Ha Noi, Vietnam, concentrate with a focus on multiple CT scanner and MRI techniques.

Assoc. Prof. Vu Dang Luu
E-mail: **vudangluu@hmu.edu.vn**

Vu Dang Luu is an Associate Professor of Radiology in Bach Mai Hospital, Vietnam. He is a Director of Radiology Center of Bach Mai Hospital, Vietnam. His research fields are diagnostic imaging, and interventional radiology.