Diagnosis and prognostic significance of anomalous origin of coronary artery from the opposite sinus of Valsalva assess by dual-source coronary computed tomography angiography

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ABSTRACT

Background: Clinically recognized coronary anomalies in adults are infrequent and characteristically establish on autopsy. The clinical importance coronary arteries consist of those with anomalous origin of the coronary artery from the opposite sinus of Valsalva (ACAOS) with an inter-arterial course (IAC). We have endeavored to attribute variable risk based on morphological appearances of the ACAOS by dual-source coronary computed tomography angiography (DSCTA).
Material and methods: ACAOS patients who undergoing DSCTA over a 5-year period were identified and assess morphologic characteristics. Medical records were reviewed for major adverse cardiovascular events (MACEs).
Results: A total of 1126 patients who undergoing DSCTA were evaluated. Twenty-four patients with ACAOS with IAC were recognized with a prevalence of 2.1% of study population. Twenty patients had anomalous origin of right coronary artery from left sinus of Valsalva (RCA-LSV) and 4 patients had anomalous origin of left coronary from right sinus of Valsalva (LCA-RSV). A significant increased prevalence of MACEs in were observed in intramural, slit-like and high inter-arterial course morphology group. Median follow-up time was 13 months (IQR 3–18 months). During follow-up 2 died, 4 had PCI, 13 had myocardial infarction and 7 had surgical treatment.
Conclusions: Intramural, slit-like and high type inter-arterial course morphology of ACAOS with IAC are high risk features for MACEs which can be identified by DSCTA.

1. Introduction

Anomalous coronary arteries correspond to a varied group of congenital disorders which affect between 0.3 and 5.6 % of the unselected general population undergoing cardiac catheterization [1–5]. They are increasingly identified because of the rising utilization of advanced non-invasive cardiovascular imaging techniques particularly coronary computed tomography angiography (CCTA). Congenital coronary abnormalities are the second leading cause of sudden cardiac death in the young surpassed only by hypertrophic cardiomyopathy (HCM) [3]. Those with the highest risk include individuals with an anomalous coronary artery originating from the opposite sinus of Valsalva (ACAOS) with inter-arterial course (IAC) [6–8]. The development of new dual-source computed tomography (DSCT) is capable of enhanced temporal resolution up to 83 ms [9,10]. It is promising and robust to perform high-quality CCTA without β-blocker premedication, even in patients with high heart rates permits for the precise and noninvasive depiction of ACAOS and has been shown to be superior to conventional coronary angiography [9,10]. Nonetheless, few studies on clinically significant for ACAOS have been achieved by using CCTA [11,12]. The purpose of the present study was to determine the prevalence, morphology of ACAOS and correlated clinical consequence with reverence to major adverse cardiovascular events (MACEs) of referred patients for dual-source coronary computed tomography angiography (DSCTA).
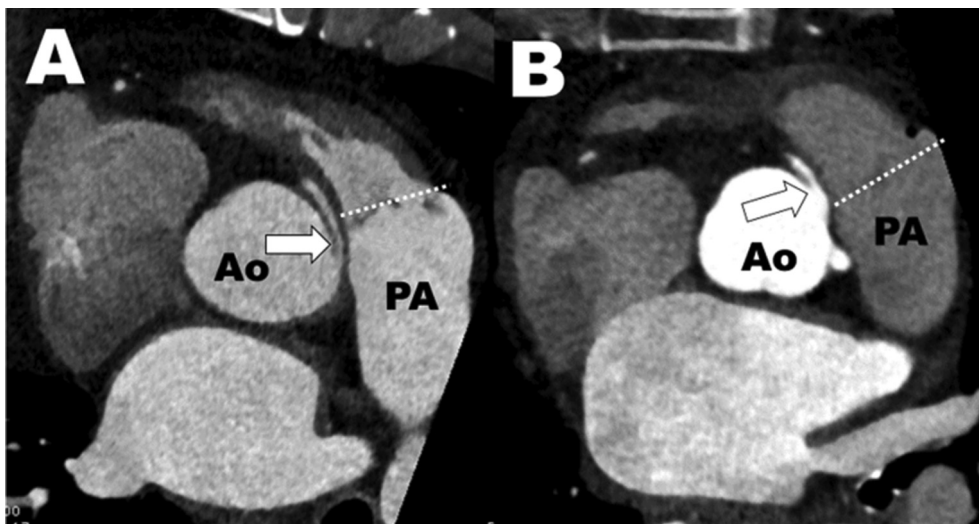
2. Material and methods

2.1. Patient population

We performed a retrospective study included 1126 patients who underwent DSCTA between February 2012 and February

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Fig. 1. CCTA images in patients with high (A) and low type (B). High type reveal that the anomalous RCA ostium (A: arrow) from the left sinus of Valsalva is located between the aorta (Ao) and the pulmonary artery (PA) above the pulmonary valve (A: dashed line). Low type (B) demonstrate that the anomalous RCA ostium (B: arrow) from the left sinus of Valsalva is located between the aorta and the RVOT below the pulmonary valve (B: dashed line).
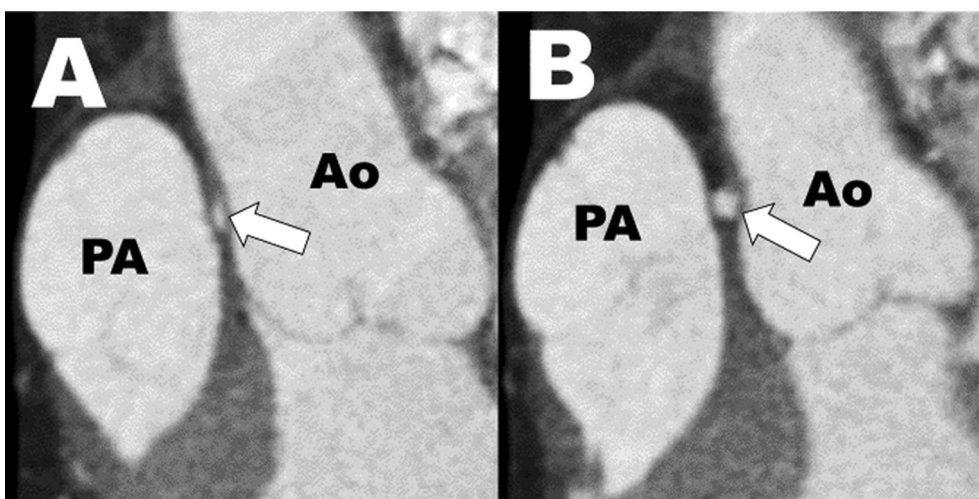
Fig. 2. CCTA images in patients with slit-like ostium (A) and normal ostium (B). Anomalous coronary artery with "slit-like" narrowing (less than 50% reduction in minimum diameter in the absence of coronary artery disease) was diagnosis as slit-like ostium (A: arrow) compare with normal proximal vessel morphology (B: arrow).

2017. The present study was approved by the Ethics Committee of the Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand. We establish 24 patients with anomalous coronary artery originating from the opposite sinus of Valsalva (ACAOS) with inter-arterial course (IAC). Relevant clinical history and follow-up data for major adverse cardiac events (MACEs) were collected for each patient by reviewing electronic medical records. MACEs was defined as cardiovascular death, myocardial infarction in the distribution of the ACAOS, revascularization in the distribution of ACAOS either percutaneous coronary intervention (PCI) or surgical treatment.

2.2. Dual-source coronary computed tomography angiography (DSCTA) scanning protocol

Coronary CTA examinations were performed on a dual- source CT scanner (Definition FLASH, Siemens Healthcare, Forchheim, Germany). The system is equipped with two X-ray tubes and two corresponding detectors mounted on a single gantry with an angu-

lar offset of 90°. The DSCTA used automatic tube current modulation in x, y, and z directions. The scanner technology permits a prospectively ECG-triggered high-pitch spiral acquisition (FLASH Spiral Cardio, Siemens Healthcare, Forchheim, Germany). The DSCTA scan parameters were as follows: two X-ray sources, detector collimation 32 × 0.6 mm with double sampling by rapid alteration of the focal spot in the longitudinal direction (Z-flying focal spot), rotation time 330 ms, tube voltage 120 kV [13]. Image acquisition was achieved during inspiratory breath-hold. Patients were scanned in the supine position.

2.3. Dual-source coronary computed tomography angiography (DSCTA) image analysis

All acquired DSCTA images were transferred to a dedicated 3D-postprocessing workstation and the image analysis was accomplished by an experience cardiovascular radiologist by using the maximum intensity projections (MIPs), curved multiplanar reformations (cMPRs), and volume rendering technique (VRT). The
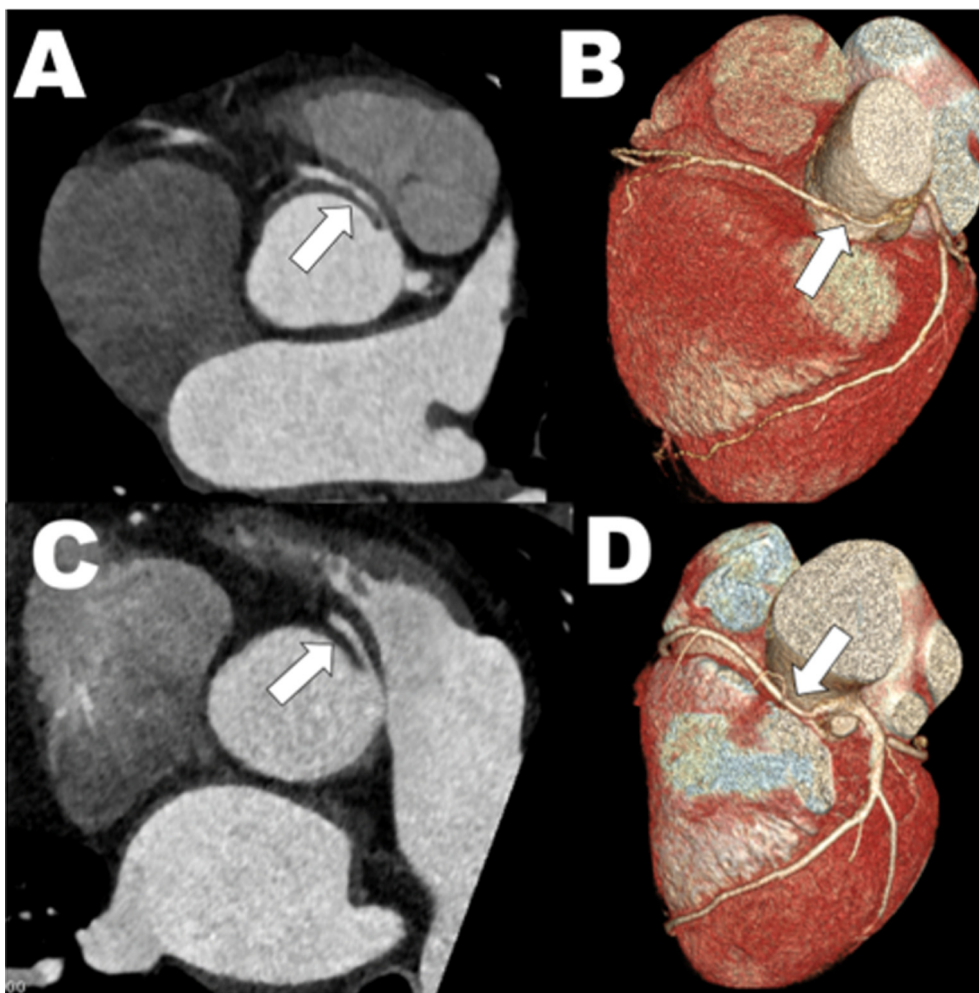
Fig. 3. CCTA images in patients with intramural course (A and B) and non-intramural course (C and D). Intramural course reveal that the anomalous RCA from the left sinus of Valsalva which direct visualization of the vessel within the aortic wall and the absence of adjacent epicardial fat (A and B: arrows). Non-intramural course demonstrates that the anomalous RCA from the left sinus of Valsalva not incorporated into the aortic wall. (C and D: arrows).

Table 1
Base line characteristics of the patients according to intramural course.

Clinical data	Intramural course (n = 6)	Non-intramural course (n = 18)	Control (n = 50)	p-value
Age	51.3 ± 14.9	53.8 ± 15.1	52.1 ± 14.2	0.73
Male gender	3 (50)	10 (55.6)	25 (50)	0.82
Hypertension	2 (33.3)	9 (50)	25 (50)	0.49
Dyslipidemia	4 (66.7)	10 (55.6)	30 (60)	0.64
Diabetes mellitus	2 (33.3)	3 (16.7)	13 (26)	0.39
Current smoker	1 (16.7)	1 (5.6)	5 (10)	0.41
Symptoms				
Chest pain	4 (66.7)	5 (27.8)	13 (26)	0.09
Syncope	1 (16.7)	4 (22.2)	10 (20)	0.78
Palpitation	1 (16.7)	9 (50)	15 (30)	0.16
MACEs				
Cardiovascular death	1 (16.7)	0 (0)	0(0)	0.08
PCI	0 (0)	4 (22.2)	0 (0)	0.22
Myocardial infarction	4 (66.7)	2 (11.1)	0 (0)	0.008
Surgical treatment	5 (83.3)	2 (11.1)	0 (0)	0.001

Values are n (%) or mean ± standard deviation.
MACEs: Major adverse cardiovascular events.

ACAOS with IAC were classified into anomalous origin of right coronary artery (RCA) from the left sinus of Valsalva and (RCA-LSV) and anomalous origin of left coronary artery (LCA) from right sinus of Valsalva (LCA-RSV). The morphology of each anomalous coronary artery was classified as high inter-arterial course with anomalous ostium located between the aorta and the pulmonary artery and above the level of the pulmonary valve (high type) (Fig. 1), slit-like ostium (Fig. 2) and intramural course (Fig. 3).

Table 2
Base line characteristics of the patients according to slit-like ostium.

Clinical data	Slit-like ostium (n = 18)	Normal ostium (n = 6)	Control (n = 50)	p-value
Age	51.0 ± 16.7	52.9 ± 13.2	52.1 ± 14.2	0.81
Male gender	10 (55.6)	3 (50)	25 (50)	0.82
Hypertension	8 (44.4)	2 (33.3)	25 (50)	0.64
Dyslipidemia	9 (50)	4 (66.6)	30 (60)	0.48
Diabetes mellitus	4 (22.2)	1 (16.7)	13 (26)	0.78
Current smoker	1 (5.6)	1 (16.7)	5 (10)	0.41
Symptoms				
Chest pain	8 (44.4)	1 (16.7)	13 (26)	0.23
Syncope	5 (27.8)	4 (66.6)	10 (20)	0.09
Palpitation	5 (27.8)	1 (16.7)	15 (30)	0.59
MACEs				
Cardiovascular death	2 (11.1)	0 (0)	0(0)	0.4
PCI	3 (16.7)	1 (16.7)	0 (0)	0.55
Myocardial infarction	12 (66.7)	1 (16.7)	0 (0)	0.037
Surgical treatment	7 (38.9)	0 (0)	0 (0)	0.04

Values are n (%) or mean ± standard deviation.
MACEs: Major adverse cardiovascular events.

Table 3
Base line characteristics of the patients according to high type.

Clinical data	High type (n = 8)	Low type (n = 16)	Control (n = 50)	p-value
Age	51.1 ± 15.2	54.2 ± 14.8	52.1 ± 14.2	0.63
Male gender	6 (75)	10 (62.5)	25 (50)	0.55
Hypertension	3 (37.5)	9 (56.3)	25 (50)	0.72
Dyslipidemia	5 (62.5)	11 (68.8)	30 (60)	0.76
Diabetes mellitus	2 (25)	4 (25)	13 (26)	1.0
Current smoker	1 (12.5)	2 (12.5)	5 (10)	1.0
Symptoms				
Chest pain	5 (62.5)	5 (31.3)	13 (26)	0.15
Syncope	2 (25)	5 (31.3)	10 (20)	0.75
Palpitation	1 (12.5)	6 (37.5)	15 (30)	0.21
MACEs				
Cardiovascular death	2 (25)	0 (0)	0(0)	0.04
PCI	1 (12.5)	2 (12.5)	0 (0)	1.0
Myocardial infarction	6 (75)	4 (25)	0 (0)	0.02
Surgical treatment	4 (50)	1 (6.3)	0 (0)	0.01

Values are n (%) or mean ± standard deviation.
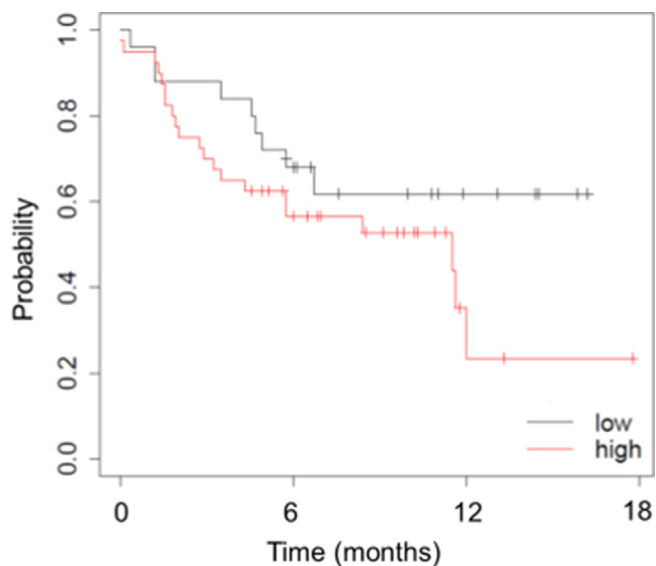MACEs: Major adverse cardiovascular events.
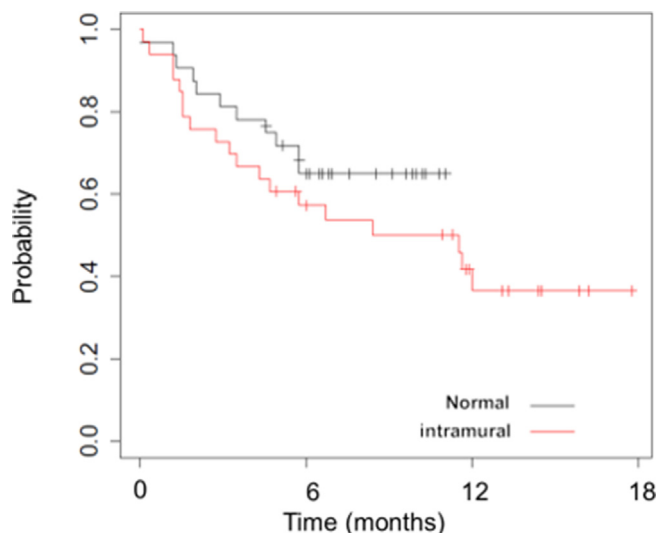
Fig. 4. Kaplan-Meier curve for major adverse cardiac events (MACEs). Cumulative event rates of MACEs up to 18 months for the intramural course group (red line) and normal group (grey line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
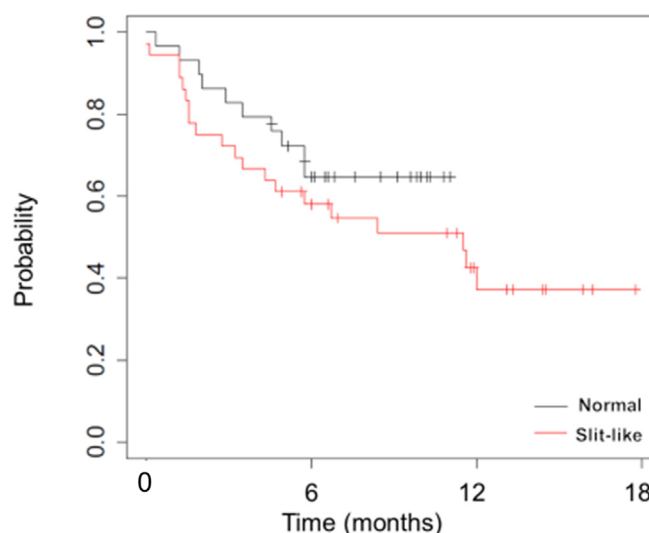
Fig. 5. Kaplan-Meier curve for major adverse cardiac events (MACEs). Cumulative event rates of MACEs up to 18 months for the slit-like ostium group (red line) and normal group (grey line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 6. Kaplan-Meier curve for major adverse cardiac events (MACEs). Cumulative event rates of MACEs up to 18 months for the high inter-arterial course group (red line) and low group (grey line). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Statistics

Data analysis was performed using SSPS 19.0 for Windows (SPSS, Chicago, Illinois, USA). Data are presented as mean ± SD or median (IQR). Ordinal data were compared using the $\chi 2$ Contingency tables, the Fisher exact tests or Mann–Whitney U. The independent Student t test was used to define the differences in base line characteristics, symptoms and MACEs between the intramural course and non-intramural course, slit-like ostium and normal ostium and high type and low type morphology groups. Hazard ratio and Kaplan-Meier curve analysis for cumulative event rates of MACEs for the intramural course, slit-like ostium and high type groups were assessed. For all statistical tests, two-tailed testing with a probability value of <0.05 was considered statistically significant.

4. Results

Of the 1126 DSCTA studies were recruits in the present study, 24 patients with ACAOS with IAC were identified with the mean age of 51.8 ± 14.1 years. The baseline characteristics of the control group and patient according to intramural course, slit-like ostium and high type was shown in Tables 1–3, respectively. There was no statistically significant in the prevalence of traditional risk factors for coronary artery disease and presenting symptoms. In the patient with intramural course, cardiovascular death occurred in one patient. The intramural course group revealed higher incidence of myocardial infarction and surgical treatment compared with non-intramural course group significantly (p = 0.008 and 0.001, respectively) with hazard ratio = 1.52 for cumulative event rates of MACEs (Fig. 4). In the patient with slit-like ostium, cardiovascular death occurred in two patients. The slit-like ostium group showed higher incidence of myocardial infarction and had surgical treatment compared with normal ostium group significantly (p = 0.037 and 0.04, respectively) with hazard ratio = 1.51 for cumulative event rates of MACEs (Fig. 5). In the patient with high type demonstrated higher incidence of cardiovascular death, myocardial infarction and had underwent surgical treatment compared with low type group significantly (p = 0.04, 0.02 and 0.01,

respectively) with hazard ratio = 1.77 for cumulative event rates of MACEs (Fig. 6). Median follow-up time was 13 months (Interquartile range (IQR: 3–18 months). During follow-up 2 died, 4 had PCI, 13 had myocardial infarction and 7 had surgical treatment.

5. Discussion

The present study has shown the prevalence of ACAOS with IAC and correlate morphologic findings with clinical data and major adverse cardiovascular events (MACEs) by DSCTA in a tertiary care academic medical center over a 5-year period. LCA-RSV was less common (0.35%) than was RCA-LSV (1.78%) in the present study. Twenty-four patients with ACAOS with IAC were recognized with a prevalence of 2.1% of study population which is similar to previous study who reported a prevalence of 1.7% [11]. The present study demonstrated the possible to recognize high risk features of ACAOS with IAC by DSCTA. Interestingly, significant increased prevalence of MACEs was observed in intramural, slit-like and high inter-arterial course morphology group which created attention in the use of CCTA to risk stratify patients and guide management. To our knowledge, this is the first study in Thailand to define the diagnostic value and prognostic significance evaluate by DSCTA in the ACAOS with IAC patients.

CCTA offers comprehensive description of ACAOS morphology with high temporal and spatial resolution. In comparison with CCTA, invasive coronary angiography has traditionally been the diagnostic imaging test to identify coronary anomalies [2]. Nevertheless, because of the two-dimensional projection, clarification of the exact relationship with nearby anatomical configurations and the conception of a complex three-dimensional vessel path might be problematic and misreading is stated up to 50% of cases [16,17]. Therefore, guidelines arrange for a Class I recommendation for CCTA for imaging of ACAOS [10].

The present study demonstrated that cardiovascular death was associated with DSCTA identified high type. The proposed mechanism is compression of the coronary artery between the aorta and the pulmonary artery predominantly during exercise causing augmented aortic wall dispensability effects compression of ACAOS [12,14,15].

Myocardial infarction and surgical treatment were associated with DSCTA identified intramural course, slit-like ostium and high type group. Supportive the significance of the CCTA to describe ACAOS with IAC morphology in the present study. Accordingly, the present study results sustenance that CCTA propose the capability to non-invasively characterize high risk feature of ACAOS with IAC which previously not generally recognize the clinical importance.

The present study has several limitations that may artificially have raised the incidence of the ACAOS reported. One limitation was the retrospective design of the study which was susceptible to selection and subject to confounding. Furthermore, the present study may not represent the true prevalence in a more general population since the highly selected study population and the small sample size for the reason that the cases were collected from a tertiary care academic institution.

6. Conclusion

High risk features for major adverse cardiovascular events (MACEs) identified by dual-source coronary computed tomography angiography (DSCTA) are intramural, slit-like and high type inter-arterial course morphology of anomalous origin of the coronary artery from the opposite sinus of Valsalva (AOCA) with an inter-

arterial course (IAC). DSCTA possibly will consequently contribute to discriminate patients at jeopardy of adverse events.

7. Funding and competing interests

None.

8. Contributions

NC involved in study design, data collection, review imaging and medical records, statistical analysis, data interpretation, drafted the manuscript. PM involved in drafted the manuscript. All authors read and approved the final manuscript.

9. Ethical declaration

9.1. Ethics approval and consent to participate

This study was reviewed and proved by the local Ethics Committee of Khon Kaen University, Thailand and was registered under reference number HE611388. All methods were performed in accordance with the relevant guidelines and regulations. The local Ethics Committee of Khon Kaen University also approved our investigation with a waiver of informed consent due to retrospective study design.

9.2. Consent for publication

Not applicable.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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