

May dual-source computed tomography angiography replace invasive coronary angiography in the evaluation of patients referred for valvular disease surgery?

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Abstract

Background: Coronary computed tomography (CT) angiography is currently the only alternative to invasive angiography in the evaluation of coronary anatomy. In patients referred for valvular or thoracic aortic disease surgery, invasive coronary angiography remains the gold standard required by cardiac surgeons during the preoperative evaluation. According to the current European Society of Cardiology guidelines, evaluation of coronary anatomy is recommended in all patients above 40 years of age, with a history of coronary artery disease (CAD), in postmenopausal women, patients with left ventricular systolic dysfunction, with suspected ischaemic aetiology of mitral regurgitation, and in patients with one or more risk factors for CAD. The possibility to perform coronary CT angiography to exclude CAD before planned non-coronary cardiac surgery was first allowed in the 2010 Report of the American College of Cardiology Foundation Task Force on Expert Consensus.

Aim: To evaluate the usefulness of dual-source CT for the evaluation of coronary anatomy in patients before planned cardiac valvular surgery.

Methods: We studied 98 consecutive patients with a haemodynamically significant valvular heart disease and guideline-based indications for coronary angiography to exclude CAD before planned valvular surgery. Exclusion criteria included cardiac arrhythmia (atrial fibrillation, frequent ventricular and supraventricular premature beats), estimated glomerular filtration rate < 60 mL/min/1.73 m², allergy to iodine contrast agents, and lack of patient consent. Mean patient age was 58.8 (range 30–78) years. Coronary artery calcium score (CACS) was first determined in all patients. Coronary CT angiography was not performed if CACS was > 1000. In the remaining patients, complete CT evaluation was performed with the administration of a contrast agent. Conventional invasive coronary angiography was subsequently performed in patients with at least one > 50% stenosis, artifacts due to calcifications, or motion artifacts.

Results: In 79 (80.6%) patients, CT angiography excluded the presence of a significant coronary artery stenosis without the need for invasive angiography. Conventional coronary angiography was required in 19 (19.4%) patients, including 13 (13.3%) patients with a > 50% stenosis in CT angiography, 2 (2%) patients with calcification artifacts, 1 (1%) patient with motion artifacts, 2 (2%) patients with CACS > 1000 in whom CT angiography was not performed, and 1 (1%) patient with allergic symptoms during administration of a test dose of the contrast agent. Ultimately, significant CAD was diagnosed in 9 (9.2%) patients in whom coronary artery bypass surgery was also performed. In addition, vascular anomalies were diagnosed with cardiac CT angiography in 5 (5.1%) patients. In 14 patients, CT angiography was also used for previously planned evaluation of a coexisting aortic aneurysm.

Conclusions: Coronary CT angiography may be useful to exclude significant CAD in patients referred for valvular disease surgery.

Key words: valvular heart disease, coronary artery disease, computed tomography

Kardiol Pol 2012; 70, 9: 877–882

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Received: 23.10.2011 Accepted: 01.03.2012

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INTRODUCTION

Valvular heart disease, with their varied symptomatology, may hinder or even preclude evaluation of ischaemic heart disease based exclusively on clinical symptoms or noninvasive testing (electrocardiogram [ECG], stress echocardiography). Thus, coronary angiography is routinely performed in most patients referred for valvular or thoracic aortic disease surgery. This study remains the gold standard required by cardiac surgeons during the preoperative evaluation. According to the current European Society of Cardiology guidelines, evaluation of coronary anatomy is recommended in all patients above 40 years of age, with a history of coronary artery disease (CAD), in postmenopausal women, patients with left ventricular systolic dysfunction, with suspected ischaemic aetiology of mitral regurgitation, and in patients with one or more risk factors for CAD [1]. Coronary computed tomography (CT) angiography is currently the only alternative to invasive angiography in the evaluation of coronary anatomy. The possibility to perform coronary CT angiography to exclude CAD before planned non-coronary cardiac surgery was first allowed in the 2010 Report of the American College of Cardiology Foundation Task Force on Expert Consensus [2]. With rapid development of this diagnostic method, its wide availability and low invasiveness, combined with the ability of concomitant evaluation of other cardiac structures, large vessels including the thoracic aorta, and calcifications within the aorta, aortic valve and mitral apparatus, clinicians began to appreciate usefulness of this study before planned surgical procedures, including cardiac valve surgery.

The aim of this study was to evaluate the usefulness of dual-source CT for the evaluation of coronary anatomy in patients before planned cardiac valvular surgery.

METHODS

Study group

This was a retrospective single-centre study performed in the Institute of Cardiology in Warsaw. We studied consecutive patients with a haemodynamically significant valvular heart disease and guideline-based indications for coronary angiography to exclude CAD before planned valvular surgery. Exclusion criteria included cardiac arrhythmia (atrial fibrillation, frequent ventricular and supraventricular premature beats), estimated glomerular filtration rate < 60 mL/min/1.73 m², allergy to iodine contrast agents, and lack of patient consent. We analysed 98 consecutive patients, including 54.1% of men, in whom coronary CT angiography was performed since January 2010 to April 2011. Table 1 shows rates of specific valvular heart disease in the study population. Mean patient age was 58.8 (range 30–78) years.

Coronary CT angiography

Coronary CT angiography was performed using a dual-source Somatom Definition scanner (Siemens, Germany). Each

Table 1. Rates of specific valvular heart disease in the study population

Valvular heart disease	Prevalence
Aortic stenosis	34.7%
Aortic regurgitation	19.4%
Combined aortic valve disease*	20.4%
Mitral regurgitation	5.1%
Mitral stenosis	2%
Combined mitral valve disease*	8.2%
Tricuspid regurgitation	2%
Combined multi-valve disease*	8.2%

*Combined valve disease = coexisting valvular stenosis and regurgitation

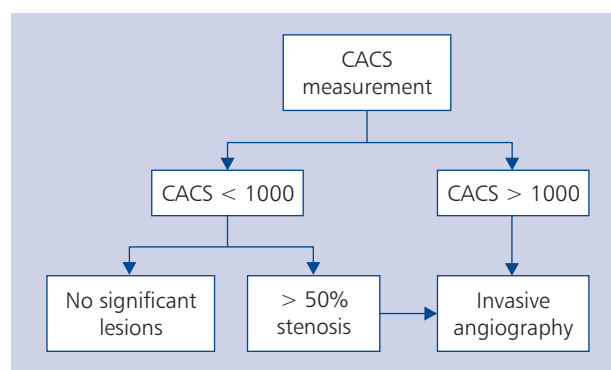


Figure 1. Study design; CACS — coronary artery calcium score

study began with determination of the coronary artery calcium score (CACS) (Fig. 1). Calcifications were defined as areas with a density of > 130 Hounsfield units and volume of at least 1 mm³. Calcifications were measured using the Agatston score. Coronary CT angiography was not performed if CACS was > 1000. A volume of 60–80 mL of the angiography contrast agent was administered at a rate of 5–7 mL/s. To induce maximal coronary vasodilatation, patients were given 0.8 mg of nitroglycerin, except for patients with severe aortic stenosis in whom the dose was reduced to 0.4 mg or not administered at all. If resting heart rate was above 65 bpm or extrasystoles were present, metoprolol was administered intravenously in sequential doses of 2.5 mg (up to 15 mg). Verapamil was given in patients with contraindications to beta-blockers (e.g., advanced asthma).

The acquisition protocol was retrospectively gated with ECG. CT tube voltage was 100 kV in patients with a body mass of < 80 kg and 120 kV in the remaining patients. Tube current ranged from 370 to 450 mAs and was set automatically according to a protocol to reduce radiation dose (Care4Dose, Siemens). Pitch ranged from 0.2 to 0.5 depending on the heart rate during acquisition. Scanning range was typi-

cally planned based on the anatomic data acquired during evaluation of CACS. Structures from the aortic root to the diaphragm level were scanned, with possible extension of the scanning range to include the whole aortic arch if evaluation of the aorta was planned. Data were reconstructed in 0.6 mm thick layers with 0.4 mm collimation. Best quality phase data were selected for further analysis. Reconstructions with a small and large field of view were created to analyse coronary arteries and extracardiac structures, respectively (the latter for the analysis of incidental pathology). Radiation dose was 4.6 to 16.2 mSv, depending on the acquisition parameters and the scanning range.

Conventional invasive coronary angiography was subsequently performed in patients with at least one > 50% stenosis, artifacts due to calcifications, or motion artifacts. The studies were evaluated by both radiologists and cardiologists experienced in both invasive and noninvasive evaluation of coronary arteries.

RESULTS

In 79 (80.6%) patients, CT angiography excluded the presence of a significant coronary artery stenosis without the need for invasive angiography. Conventional coronary angiography was required in 19 (19.4%) patients, including 13 (13.3%) patients with a > 50% stenosis in CT angiography, 2 (2%) patients with calcification artifacts, 1 (1%) patient with motion artifacts, 2 (2%) patients with CACS > 1000 in whom CT angiography was not performed, and 1 (1%) patient with allergic symptoms during administration of a test dose of the contrast agent. Ultimately, significant CAD was diagnosed in 9 (9.2%) patients in whom coronary artery bypass surgery was also performed (Figs. 2A–C, 3A–C). In addition, cardiac CT angiography revealed vascular anomalies in 5 (5.1%) patients, such as a rotated origin of the left coronary artery, anomalous branches of the left anterior descending artery, origin of the circumflex artery from the right coronary artery or the left anterior descending artery, and left anterior descending artery and right coronary artery fistulas draining to the left atrial appendage (Fig. 4). In 14 patients, CT angiography was also used for previously planned evaluation of the size of a coexisting aortic aneurysm (Fig. 5). Following the diagnostic evaluation, aortic valve replacement or repair was performed in 69 patients, mitral valve replacement or repair in 25 patients, and combined surgery involving 2 or 3 valves in 4 patients. Concomitant surgery involving ascending aortic aneurysm was performed in 8 patients, including 4 patients in whom the final decision to proceed with surgery was made after evaluation of the aneurysm using CT.

Repeated evaluation of the coronary arteries using invasive angiography mostly involved lesions in the left anterior descending artery and the right coronary artery, present in 73% and 26% of the evaluated patients, respectively. Mean CACS in patients who underwent CT angiography was 59 Agatston

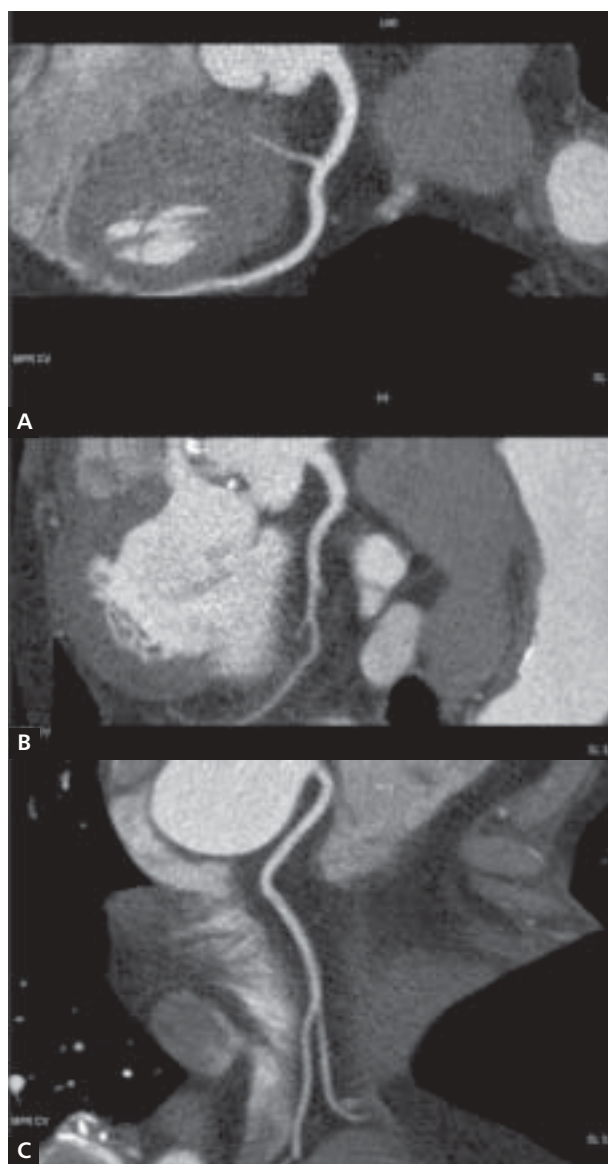


Figure 2. Normal coronary arteries in computed tomography angiography; **A.** Left anterior descending artery; **B.** Left circumflex artery; **C.** Right coronary artery

units. Among 79 (80%) patients in whom CT angiography yielded a negative result, CACS was zero in 34 (54%) of patients.

DISCUSSION

In 2010, the use of cardiac CT angiography to exclude significant CAD in patients referred for cardiac valvular surgery was considered for the first time in the Report of the American College of Cardiology Foundation Task Force on Expert Consensus. At the same time, debate continues between cardiologists and cardiac surgeons, with latter arguing that in most or even all patients, invasive coronary angiography should be performed to evaluate coronary anatomy. As a result, conventional coronary angiography is still being performed in most

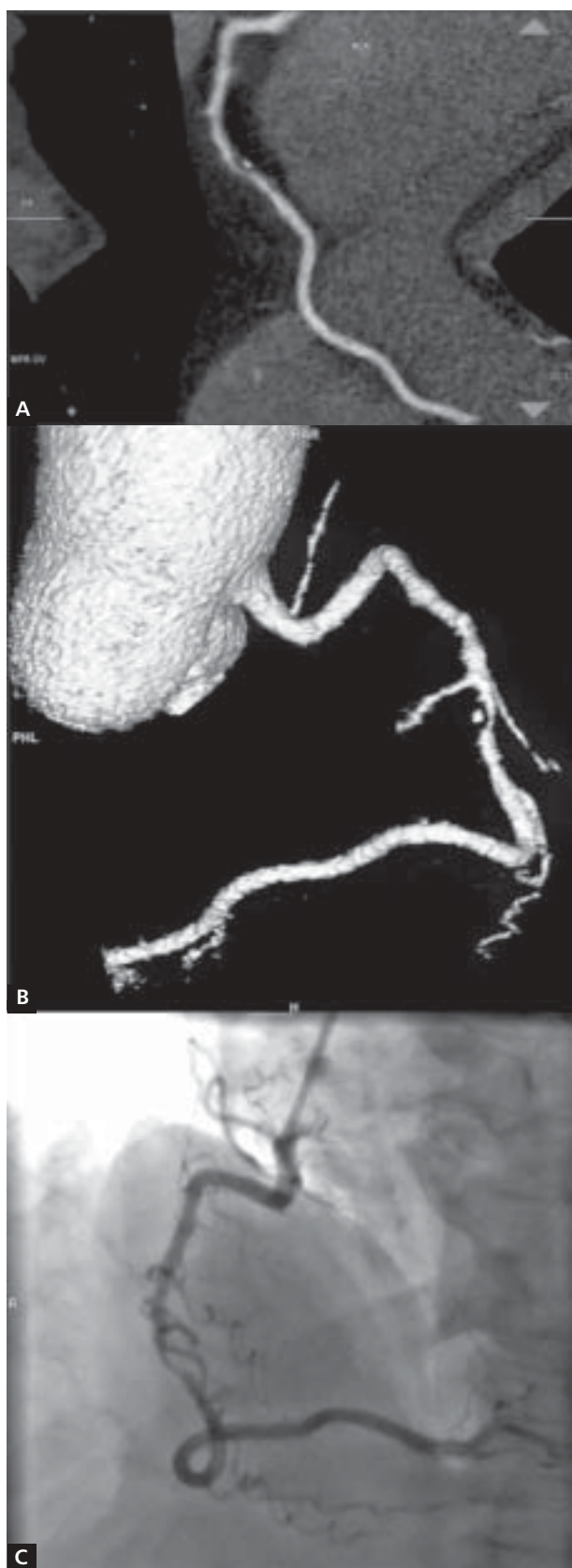


Figure 3. A significant stenosis of the right coronary artery; **A, B.** Computed tomography angiography; **C.** Invasive coronary angiography



Figure 4. Vascular anomaly — origin of the left circumflex artery from the right coronary artery



Figure 5. Ascending aortic aneurysm in computed tomography angiography

patients, even including those in whom ischaemic heart disease is not expected. It is thus of interest how common CAD is among patients referred for valvular heart surgery. Multiple literature data are inconsistent in this regard. As reported by Orłowska-Baranowska and Rawczyńska-Englert [3] in a paper published in 1998, coronary angiography showed significant CAD in only 173 (13%) among 1292 patients referred for valvular heart surgery in 1982–1990.

A major advantage of coronary CT angiography is its low invasiveness. Conventional coronary angiography, regardless of the site of vascular access, is associated with low but not negligible risk of significant complications which may be up to several percent depending on many factors, including the clinical condition of the patient [4]. This risk is higher, e.g., with left main CAD. Every opportunity to reduce risk associated with diagnostic procedures should favour coronary CT angiography over conventional invasive angiography. Complications related to invasive testing often result in delayed surgery, which may be of particular importance in patients referred for urgent or semi-urgent valvular surgery.

Regardless of the ability to evaluate coronary arteries, CT also allows accurate delineation of local anatomy, which is of particular importance when planning cardiac surgery, including valvular disease surgery. Coronary CT angiography may also evaluate internal mammary arteries, possible vascular anomalies, and intramuscular coronary arteries. In patients with ascending aortic aneurysm, this method avoids difficulties and risk of invasive coronary angiography, while allowing verification of the size of the aneurysm. In our study, coronary CT angiography was performed in 2 patients in whom it was not possible to cannulate the right or left coronary artery. In addition, this method allows evaluation of the remaining cardiac structures, aortic calcifications, aortic valve, and mitral apparatus, including planimetric evaluation of the valve area. Another group are high-risk patients in whom noninvasive preoperative evaluation of coronary arteries should be considered due to their clinical condition (e.g., infective endocarditis with vegetations on the aortic valve). One such case was noted in our study group. This diagnostic method may also be considered in high-risk patients with multiple concomitant diseases who are candidates for transcatheter aortic valve implantation [5].

Rapid development of coronary CT angiography resulted in increasing diagnostic value of this method. Introduction of 64-row CT scanners was a breakthrough followed by publication of more than 50 reports that compared imaging of coronary arteries using both modalities. In these reports, sensitivity and specificity of detecting significant coronary stenoses on a per-patient basis was 91–99% and 74–96%, respectively [6–8]. Meijboom et al. [9] evaluated clinical usefulness of 64-slice coronary CT angiography to exclude significant (> 50%) coronary artery stenoses in 360 patients aged 50–70 years with CAD. Sensitivity and specificity for detecting patients with at least one significant stenosis were 99% and 64%, respectively. Positive predictive value was 86%, and negative predictive value was 97%. Coronary CT angiography was also evaluated as a tool to exclude CAD in patients referred for valvular disease surgery. In a study by Rodríguez-Palomares et al. [10], 106 patients with significant valvular heart disease underwent conventional invasive angiography and CT angiography, and results of these two diagnostic mo-

dalities were compared with each other. Sensitivity and specificity for detecting significant coronary stenoses using CT angiography were 95% and 94%, respectively. In a study by Cornily et al. [11] among 199 patients with aortic stenosis or regurgitation in whom CT angiography was performed to evaluate coronary anatomy, 106 patients were found to have no significant lesions and subsequently underwent aortic valve surgery based on the CT angiography result only, without performing invasive angiography.

Finally, it must be noted that decisions regarding preoperative evaluation of coronary arteries, including the choice of diagnostic modality, in patients with significant valvular disease should always be made after considering all indications and contraindications for such testing, and should take into account the probability of CAD. Advanced valvular heart disease itself may be accompanied by conditions that make coronary CT angiography contraindicated (e.g., in patients with mitral stenosis and chronic atrial fibrillation). Careful patient selection is thus necessary to include only those in whom a diagnostic result of CT angiography may be expected, rendering invasive angiography unnecessary.

CONCLUSIONS

Coronary CT angiography is currently the only alternative to invasive angiography in the evaluation of coronary anatomy. This imaging method is useful as a tool to exclude ischaemic heart disease in patients before planned valvular surgery. It also allows concomitant evaluation of other cardiac structures, large vessels including the thoracic aorta, and calcifications within the aorta, aortic valve and mitral apparatus.

Conflict of interest: none declared

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Czy angiografia serca za pomocą dwuźródłowej tomografii komputerowej może zastąpić koronarografię u chorych kwalifikowanych do operacji wady zastawkowej?

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Streszczenie

Wstęp: Angiografia serca za pomocą tomografii komputerowej (angiografia serca TK) to obecnie jedyna alternatywa dla koronarografii w ocenie naczyń wieńcowych. W przypadku pacjentów kwalifikowanych do operacji zastawek serca czy aorty piersiowej koronarografia pozostaje metodą referencyjną i jest wymagana przez kardiochirurgów jako element oceny przedoperacyjnej. Postępowanie takie jest zgodne z obowiązującymi wytycznymi Europejskiego Towarzystwa Kardiologicznego, które zaleca wykonanie oceny tętnic wieńcowych u: wszystkich chorych > 40. rż., z chorobą wieńcową (CAD) w wywiadzie, u kobiet w wieku pomenopauzalnym, u pacjentów z dysfunkcją skurczową lewej komory, z podejrzeniem niedokrwiennej podłoża niedomykalności zastawki mitralnej oraz u osób z ≥ 1 czynnikiem ryzyka CAD. Możliwość wykonania angiografii serca TK w celu wykluczenia CAD u chorych przed planowaną operacją pozawieńcową po raz pierwszy dopuszczają zalecenia Grupy Roboczej Amerykańskiego Towarzystwa Kardiologicznego z 2010 r.

Cel: Celem pracy była ocena przydatności dwuźródłowej TK w badaniu tętnic wieńcowych u pacjentów przed planowanymi operacjami zastawkowymi.

Metody: Do analizy włączono kolejnych 98 chorych z istotną hemodynamicznie wadą zastawkową, którzy zgodnie z zaleceniami mieli wskazania do wykonania koronarografii w celu wykluczenia CAD przed operacjami zastawkowymi. Kryteria wyłączenia obejmowały: zaburzenia rytmu serca (migotanie przedsionków, liczne dodatkowe pobudzenia komorowe i nadkomorowe), eGFR < 60 ml/min/1,73 m², uczulenie na jodowe środki kontrastowe oraz brak zgody chorego na wykonanie badania. Średnia wieku chorych wynosiła 58,8 roku (30–78 lat). U każdego pacjenta oznaczano wskaźnik zwapnień (CACS) tętnic wieńcowych. Wartość CACS > 1000 powodowała odstępianie od angiografii serca TK. U pozostałych chorych wykonywano pełne badanie z podaniem środka kontrastowego. U chorych z co najmniej jednym zwężeniem > 50%, z artefaktami spowodowanymi zwapnieniami, z artefaktami ruchowymi wykonywano koronarografię.

Wyniki: U 79 osób (80,6% wszystkich analizowanych) angiografia serca TK pozwoliła na wykluczenie istotnych zmian w naczyniach wieńcowych, bez konieczności wykonywania koronarografii. U 19 (19,4%) osób wystąpiła konieczność przeprowadzenia badania koronarograficznego. Przyczyną tego były: u 13 (13,3%) osób stwierdzone w angiografii serca TK zwężenia naczyń > 50%, u 2 (2%) osób artefakty spowodowane zwapnieniami, u 1 (1%) osoby artefakty ruchowe, u 2 (2%) osób wysoki CACS (> 1000), z powodu którego odstąpiono od wykonania angiografii serca TK, u 1 (1%) osoby pojawienie się objawów uczulenia w trakcie podawania testowej dawki kontrastu w angiografii. Ostatecznie u 9 (9,2%) chorych rozpoznano istotne zmiany w naczyniach wieńcowych i pacjenci ci dodatkowo zostali poddani zabiegowi pomostowania aortalno-wieńcowego. Ponadto u 5 (5,1%) chorych angiografia serca TK pozwoliła na rozpoznanie anomalii naczyniowych. W 14 przypadkach za pomocą TK przeprowadzono zaplanowaną wcześniej, jednoczasową ocenę tętniaka aorty.

Wnioski: Angiografia serca TK może być badaniem przydatnym w wykluczeniu CAD u pacjentów poddawanych operacjom zastawkowym.

Słowa kluczowe: wady zastawkowe, choroba wieńcowa, tomografia komputerowa

Kardiol Pol 2012; 70, 9: 877–882

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Praca wpłynęła: 23.10.2011 r. Zaakceptowana do druku: 01.03.2012 r.

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