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Research paper

Diagnostic evaluation and treatment strategy in patients with suspected prosthetic heart valve dysfunction: The incremental value of MDCT

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ABSTRACT

Background: In patients with suspected prosthetic heart valve (PHV) dysfunction, routine evaluation echocardiography and fluoroscopy may provide unsatisfactory results for identifying the cause of dysfunction. This study assessed the value of MDCT as a routine, complementary imaging modality in suspected PHV-dysfunction for diagnosing the cause of PHV dysfunction and proposing a treatment strategy.

Methods: Patients with suspected PHV dysfunction were prospectively recruited. All patients underwent routine diagnostic work-up (TTE, TEE ± fluoroscopy) and additional MDCT imaging. An expert panel reviewed all cases and assessed the diagnosis and treatment strategy, first based on routine evaluation only, second with additional MDCT information.

Results: Forty-two patients were included with suspected PHV obstruction (n = 30) and PHV regurgitation (n = 12). The addition of MDCT showed incremental value to routine evaluation in 26/30 (87%) cases for detecting the specific cause of PHV obstruction and in 7/12 (58%) regurgitation cases for assessment of complications and surgical planning. The addition of MDCT resulted in treatment strategy change in 8/30 (27%) patients with suspected obstruction and 3/12 (25%) patients with regurgitation.

Conclusion: In addition to echocardiography and fluoroscopy, MDCT may identify the cause of PHV dysfunction and alter the treatment strategy.

Abbreviations: LVOT, left ventricular outflow tract; MDCT, multidetector-row computed tomography; PHV, prosthetic heart valve; SVD, structural valve deterioration; TEE, transesophageal echocardiography; TPG, transprosthetic pressure gradient; TTE, transthoracic echocardiography.

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1. Introduction

Following implantation of prosthetic heart valves (PHV), lifelong follow-up is required in order to detect possible dysfunction.[1,2] PHV dysfunction is a serious and potentially life-threatening condition that requires careful evaluation. Obstruction of the prosthesis with abnormally high gradients may be caused by tissue masses (thrombus, pannus) an, angulated PHV position or obstruction of the left ventricular outflow tract (LVOT). Abnormal regurgitation may be due to structural valve deterioration, interference of leaflet motion, valve dehiscence or prosthetic endocarditis. The accurate diagnosis of the underlying mechanism is mandatory for proper decision-making. However, identifying the cause of dysfunction using routine echocardiography and fluoroscopy can be challenging even for experienced clinicians.[3–5] PHV-related reverberations, acoustic shadowing and limited viewing angles may hinder thorough evaluation of clinically relevant valve-related regions.[6,7] Over the last years, the addition of ECG-gated MDCT imaging has been suggested in patients with suspected PHV dysfunction.[8–11] Although its role assessing flow to quantify regurgitation and stenosis of PHV remains limited, MDCT can provide complementary information on anatomy and underlying pathology due to its three-dimensional nature and high spatial resolution.[12] In the routine diagnostic work-up of patients with suspected prosthetic valve endocarditis, MDCT has shown value to detecting complications of prosthetic valve endocarditis and provide information relevant for surgical planning.[13] In suspected dysfunction other than endocarditis, the value of routine MDCT on top of the standard imaging care has not been evaluated systematically. We performed a cross-sectional study in patients with suspected PHV dysfunction to evaluate the incremental value of retrospectively ECG-gated MDCT as routine additional imaging modality in a daily clinical practice setting with respect to diagnosing the cause of PHV dysfunction as well as its impact on treatment strategy.

2. Methods

2.1. Patients

Patients with suspected PHV dysfunction were prospectively recruited from the outpatient clinic or upon hospital admission in two academic centers (University Medical Center Utrecht and Academic Medical Center, Amsterdam) over a period of three years starting May 2010. The inclusion criteria were: (1) signs of abnormal obstruction including >20 mmHg increase of the aortic peak transprosthetic pressure gradient (TPG), an elevated mean mitral TPG (>10 mmHg) with normal heart rate, or restricted leaflet motion on fluoroscopy; (2) signs of abnormal (peri)prosthetic regurgitation (non-endocarditis); (3) abnormalities with a high clinical suspicion of of PHV dysfunction (e.g. stroke, dyspnea). Patients aged <18 years, patients with known contrast allergy or pregnant women were not included. Patients without routine transthoracic (TTE) and transesophageal (TEE) echocardiography imaging were excluded. The institutional review board approved this study and all patients provided written informed consent [IRB 10-008]. Patient characteristics were collected including age, gender, medical history, physical and laboratory examination and surgical records.

2.2. Routine imaging

All patients underwent both TTE and TEE either in the primary hospital or, after referral, in one of the academic centers Dependent on the suspected cause of PHV dysfunction, echocardiography included evaluation of the mean and peak gradients, effective orifice area, velocity time integrals, prosthetic leaflet motion, presence of (obstructive) masses and presence of prosthetic or periprosthetic regurgitation. Additional fluoroscopy was performed in mechanical valves upon the clinicians' request for evaluation of leaflet motion restriction and/or rocking motion of the valve.

2.3. MDCT

Patients with an impaired renal function received intravenous sodium chloride to reduce the risk of contrast-induced nephropathy. Beta-blockers were administered after approval by the cardiologist in selected patients to reduce heart rates during MDCT. A 256-slice or 64-slice MDCT (iCT and Brilliance 64, Philips Healthcare, Best, The Netherlands) was used. Our image acquisition protocol has been described previously.[13] In brief, patients underwent a prospectively ECG-triggered acquisition of the PHV region. Second, iodinated contrast was administered and a retrospectively ECG-gated acquisition was performed: tube voltage 120 kV, tube current-time product 600 or 700 mAs, collimation 128 or 64 $\times$ 0.625 mm and, 270 or 330 ms gantry rotation time and pitch 0.16 or 0.18. Effective radiation exposure (mSv) was esitmated from the dose-length product using a conversion factor of 0.0145 mSv/mGy*cm.[14] Images were reconstructed in 10% increments throughout the cardiac cycle with 0.9mm slice thickness and 0.45 mm slice distance. Multiplanar reformatted images reconstructed in plane and perpendicular to the PHV and valve leaflets were used for evaluation.[15] Mechanical leaflet angles were measured in systole and diastole and cine mode was used to dynamically evaluate leaflet excursions. All images were assessed for PVH-related pathology such as periprosthetic regurgitation, abscesses, thrombus and/or pannus and LVOT obstruction.

2.4. Diagnosis and treatment strategy

Routinely, clinical decisions regarding complex valve pathology are made in multidisciplinary cardiac teams. After patients were evaluated according to clinical routine, an expert panel retrospectively evaluated all cases for study purposes to assess the cause of PHV dysfunction and propose a treatment strategy (1) after initial evaluation with echocardiography and fluoroscopy and (2) with additional MDCT information (Fig. 1 and Appendix 1). The panel included three cardiologists and three cardiothoracic surgeons with clinical experience in PHV patient care. Two experts evaluated each patient independently according to standardized scoring forms; a third expert reviewed conflicting judgments for a final decision. The primary outcomes were whether MDCT: (A) has incremental value *in addition to* routine clinical imaging and (B) changes the treatment strategy. MDCT was considered to have incremental value if it allowed to identify the cause of dysfunction or to propose a treatment strategy. All cases were systematically assessed for a wide range of pathology: pannus, thrombus, LVOT obstruction (subvalvular membrane, ventricular septal hypertrophy, mitral prosthesis), patient prosthesis mismatch, tilted PHV implantation, structural valve deterioration (SVD), aneurysms, prosthetic and periprosthetic regurgitation. Therapeutic strategies included watchful waiting, additional imaging (e.g., magnetic resonance), intravenous heparin, fibrinolysis, antibiotics, percutaneous valve repair, emergency and elective surgery.

2.5. Data analysis

Data analysis was performed using SPSS version 20.0 for Windows. Categorical data are presented as numbers and