

## "All in" or "Rien ne va plus"? First simultaneous catheter-based trivalvular treatment combined with atrial septal closure in a human



Marek Kowalski<sup>1</sup>, Frank Ritter<sup>1</sup>, Michael Billion<sup>2</sup>, Steffen Hofmann<sup>2</sup>, Norbert Franz<sup>1</sup>, Gerold Mönig<sup>1</sup>

<sup>1</sup>Department of Cardiology, Schüchtermann-Klinik, Bad Rothenfelde, Germany

<sup>2</sup>Department of Cardiac Surgery, Schüchtermann-Klinik, Bad Rothenfelde, Germany

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Transcatheter mitral valve edge-to-edge repair using the MitraClip system (Abbott Vascular, USA) and transcatheter aortic valve implantation (TAVI) are well established in high-risk or inoperable patients with severe mitral regurgitation and severe aortic stenosis [1, 2]. Furthermore, successful transcatheter tricuspid valve edge-to-edge repair using the MitraClip system has recently been described for high-risk patients with tricuspid regurgitation [3]. This valvular dysfunction is mainly caused by right ventricular dilatation driven by volume or pressure overload secondary to heart failure, mitral disease and/or aortic valvular disease [4]. Thus, most of these patients suffer from multivalvular disease. However, simultaneous transapical TAVI and transfemoral clipping of the mitral as well as tricuspid valve with MitraClip completed by occlusion of an atrial septal defect has not been described so far. We report hereby this first-in-human intervention in a high-risk patient.

An 81-year-old male patient with a history of biventricular heart decompensation suffered from severe dyspnea on admission (New York Heart Association functional class III), lower leg edema, pleural effusions and stage III chronic kidney disease. Echocardiography revealed severe aortic stenosis (aortic valve area = 0.7 cm<sup>2</sup>) (Fig. 1). In addition, severe regurgitation of the tricuspid valve (effective regurgitation orifice area (EROA) = 0.88 cm<sup>2</sup>) and mitral valve (EROA = 0.44 cm<sup>2</sup>) with tethered leaflets was found (Fig. 2). Left and right ventricular function were reduced (ejection fraction of 50% and 35%, respectively). Elevated systolic pulmonary artery pressure could be documented (65 mm Hg). As a result of heart team discussion the patient was declared as surgically inoperable and qualified for transapical transcatheter aortic valve implantation – not suitable for a transvascular approach – followed by transfemoral edge-to-edge repair of mitral and tricuspid valves using the MitraClip system within one simultaneous procedure.

All interventions were performed on July, 4<sup>th</sup>, 2017 under general anaesthesia using two- and three-dimensional transesophageal echocardiography (TEE) (iE 33, Philips

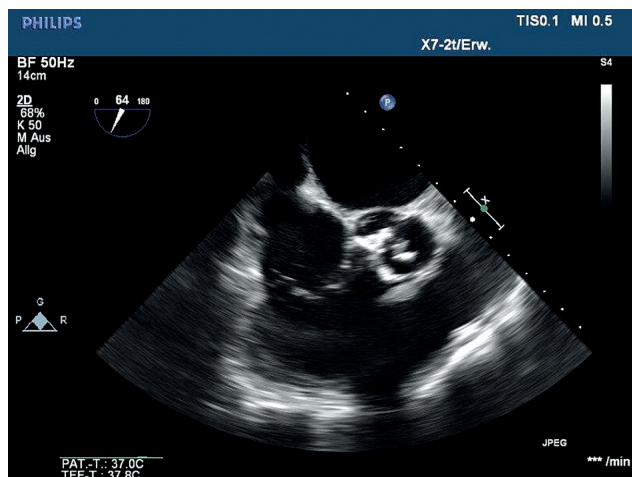
Healthcare, Netherlands) and fluoroscopy guidance (Axiom Artis Zeefloor AXH 1604, Siemens, Germany). Unfractionated heparin was administered aiming at an activated clotting time (ACT) of 250–300 s throughout the procedure.

For the transapical TAVI the left ventricular apex was surgically exposed (anterolateral minithoracotomy) and the apical suture was prepared. The apex was then punctured and a guidewire was placed in the left ventricular cavity and advanced through the aortic valve into the ascending aorta. Using the guidewire, a 5 Fr Impulse Femoral Right 4 Angiographic Catheter (Boston Scientific, USA) was introduced via the ventricular cavity in the descending aorta. Next a guide wire was placed (Amplatzer Super Stiff, Boston Scientific, USA) through the apex into the descending aorta. After that the 18 Fr sheath was introduced (Certitude, Edwards, USA) followed by the crimped valve (Sapien 3 TA 26 mm Aortic Bioprosthesis, Edwards, USA) and the device was positioned in the aortic valve annulus. The valve was implanted under aortic angiographic control and rapid pacing. The apex was closed after removing the introducer system. The procedure resulted in correct positioning of the aortic bioprosthesis with minimal aortic regurgitation (Fig. 3). Echocardiography showed a mean gradient of 5 mm Hg and an aortic valve area of 3.1 cm<sup>2</sup>.

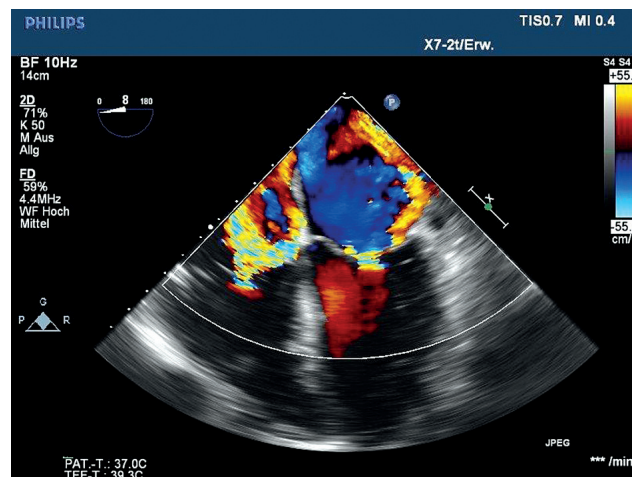
Then the mitral valve edge-to-edge repair using the MitraClip system was performed. After puncture of the right femoral vein and reaching the left atrium via transseptal puncture the steerable guiding catheter was placed into the left atrium and the clip delivery system (CDS) was introduced into the guiding catheter. The next step of the maneuver consisted of advancing the MitraClip device into the left atrium, opening both arms, navigation and advancing the system into the left ventricle. By retracting the MitraClip device both leaflets of the mitral valve were grasped and closed to coapt. Doing so, an effective reduction of mitral regurgitation could be achieved and the clip was deployed. The clip delivery system was evacuated.

**Address for correspondence:** Marek Kowalski MD, PhD, Department of Cardiology, Schüchtermann-Klinik, Ulmenallee 5-11, 49214 Bad Rothenfelde, Germany, phone: +49 542464130023, e-mail: MKowalski@schuechtermann-klinik.de

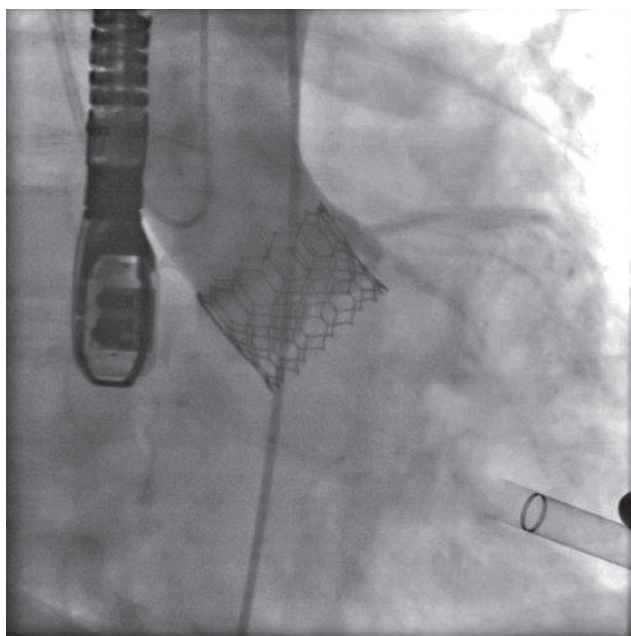
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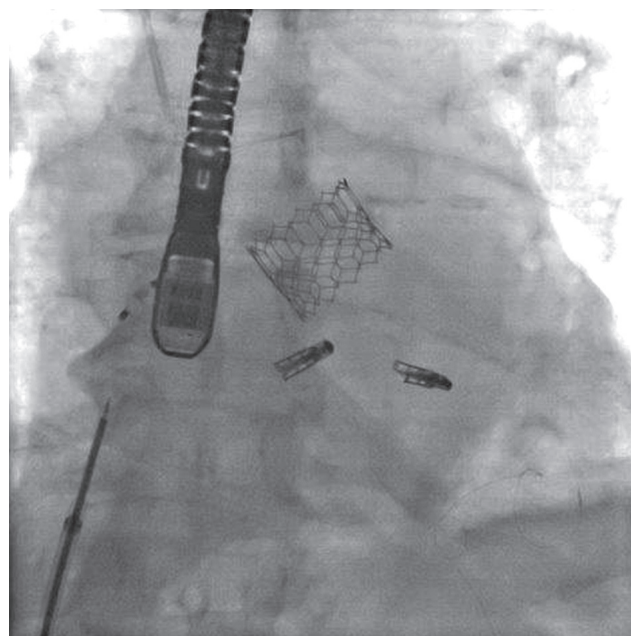
**Fig. 1.** Two-dimensional transesophageal echocardiography (mid-esophageal 64°, short axis view): aortic stenosis prior to TAVI



**Fig. 2.** Two-dimensional transesophageal echocardiography (mid-esophageal 8°, 4-chamber view, color Doppler): severe tricuspid and mitral regurgitation prior to tricuspid and mitral valve repair using MitraClip system



**Fig. 3.** X-ray (right anterior oblique (RAO) 10°, cranial 0°) final aortic angiography: aortic bioprosthesis in correct position, aortic regurgitation trace. TEE probe in transesophageal position. Pigtail catheter positioned in aortic root

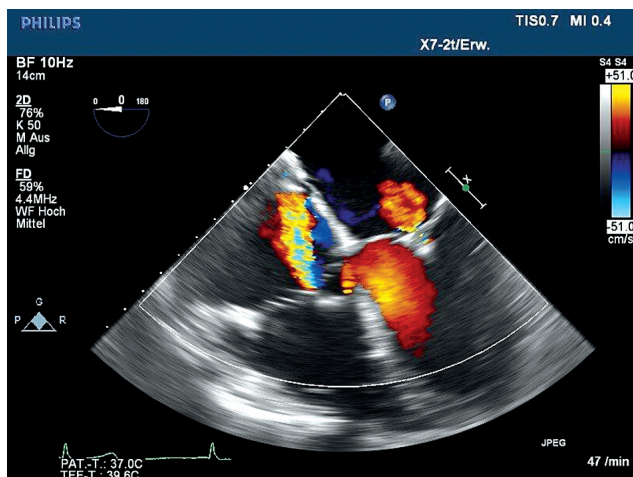


**Fig. 4.** X-ray (RAO 0°, cranial 0°) final view after TAVI, mitral/tricuspid valve repair using MitraClip system and septal occlusion (devices from right to left): MitraClip in mitral position, aortic bioprosthesis, MitraClip in tricuspid position, septal occluder. Occluder delivery system positioned in right atrium. TEE probe in transesophageal position

After retracting the steerable guiding catheter into the right atrium a new clip delivery system was introduced. Then the clip delivery system was angulated to position the CDS vertical to the tricuspid valve. The next step of the maneuver consisted in opening both arms of the MitraClip, navigation and advancing the system into the right ventricle. To ensure a correct perpendicular position, a gastric short axis view (TEE) of the tricuspid valve was most helpful. By retracting the device the anterior and septal leaflets were grasped and closed to coapt.

After a significant reduction of tricuspid regurgitation the clip was deployed. The clip delivery system was withdrawn and finally a 25 mm PFO Occluder (St. Jude Medical, USA) was successfully implanted to close the remaining atrial septal defect (ASD) with significant interatrial shunt (Fig. 4). Finally the guiding catheter was retracted into the inferior caval vein and withdrawn. The femoral puncture site was closed using a Z-suture.

Reconstruction of the two- and three-dimensional transesophageal echocardiographic dataset documented



**Fig. 5.** Two-dimensional transesophageal echocardiography (mid-esophageal 0°, 4-chamber view, color Doppler): reduction of tricuspid regurgitation (grade II) and mitral regurgitation (grade I) after mitral and tricuspid valve repair using MitraClip system

a significant improvement: there was an effective reduction of both mitral regurgitation to grade I (EROA = 0.19 cm<sup>2</sup>) and tricuspid regurgitation to grade II (EROA = 0.29 cm<sup>2</sup>) (Fig. 5). There was only minimal tricuspid and mitral valve stenosis (mean gradient 1 and 3 mm Hg, respectively). The atrial septal defect was completely closed by the occluder.

After a procedure duration of 202 min with fluoroscopy time of 25 min the patient left the hybrid operating room in a stable hemodynamic condition. Fortunately, he was extubated on the same day and discharged at day 8 after the procedure in good clinical status without in-hospital complications under antithrombotic treatment of apixaban 2.5 mg twice and clopidogrel 75 mg once daily. During the short-term follow-up of 10 weeks his clinical symptoms improved to NYHA II–III.

Tricuspid regurgitation is a common finding in patients with aortic or mitral valve disease, and it is independently associated with a poor prognosis [5]. High-risk or inoperable patients with severe aortic stenosis in combination with mitral and tricuspid regurgitation pose a serious medical challenge. New percutaneous transcatheter methods represent potential techniques to treat these patients with favorable results. Aortic stenosis treatment using TAVI and mitral regurgitation treatment with MitraClip are well established. Successful transcatheter tricuspid valve edge-to-edge repair using the MitraClip system has been reported in high-risk or inoperable patients with severe tricuspid regurgitation [6, 7].

Recently bivalvular simultaneous (mitral plus tricuspid valve clipping) and sequential transcatheter intervention (TAVI plus tricuspid valve clipping) has been reported for surgically inoperable patients as a feasible and safe alternative approach [8, 9].

This first-in-human report describes a simultaneous trivalvular intervention with transapical TAVI in addition to transfemoral transcatheter edge-to-edge repair of the mi-

tral as well as tricuspid valve using the MitraClip system completed by occlusion of a postinterventional atrial septal defect using a PFO Occluder. An improvement of clinical condition by effective elimination of the aortic stenosis and reduction of mitral and tricuspid regurgitation with successful occlusion of ASD could be achieved. Two- and three-dimensional transesophageal echocardiography as well as fluoroscopy were essential for the precise navigation and placement of the TAVI valve and MitraClip.

In conclusion, this described simultaneous trivalvular treatment using different accesses (transapical and transfemoral) will not be a routine procedure in the near future. However, it could be a feasible, safe and well-tolerated therapy for selected high-risk or inoperable patients, who are non-responders to conservative medical treatment, in experienced high-volume centers. Further clinical studies will be necessary to confirm long-term results of transcatheter edge-to-edge repair of tricuspid and mitral regurgitation using the MitraClip system itself and in combination with TAVI in a larger cohort of patients.

## Disclosure

Authors report no conflict of interest.

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