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CLINICAL CORRESPONDENCE

Severe aortic regurgitation after percutaneous transcatheter aortic valve implantation: on the importance to clarify the underlying pathophysiology

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Abstract Severe symptomatic aortic stenosis in a 90-year-old man was treated with percutaneous aortic valve implantation (TAVI) with a 29-mm CoreValve Revalving™ system. Following implantation, severe aortic regurgitation occurred. Echocardiography showed a small paravalvular and a huge valvular leakage, probably due to one malfunctioning valve leaflet. Concerning this pathophysiology, a further TAVI was performed using a second 29-mm CoreValve Revalving™ system, as a "valve-in-valve" implantation.

Keywords Aortic stenosis · Aortic valve · Transcatheter aortic valve implantation · Aortic regurgitation

Background

Percutaneous transcatheter aortic valve implantation (TAVI) has been introduced by Cribier et al. [2] for the treatment of severe symptomatic aortic stenosis in patients not suitable for surgical valve replacement. Currently, the retrograde approach over the femoral artery and retrograde passage of the aortic valve is preferred [4, 5, 16]. Either the balloon-expandable Sapien-Edwards™ prosthesis (Edwards Lifesciences, Irvine, CA) or the self-expanding CoreValve Revalving™ system (CoreValve, Irvine, CA) can be used. Alternatively to the transfemoral approach a minimally invasive transapical approach [11, 13, 14] or a transsubclavian/transaxillary approach [1] is feasible.

Data from a European TAVI registry showed acceptable acute and mid-term results for this new therapeutic option in high-surgical risk patients [7]. One of the major problems of TAVI is the development of severe aortic insufficiency after valve implantation, which occurs in about 10% of patients [3, 5]. There may be different reasons for such insufficiencies:

1. para-valvular insufficiency, either due to
   (a) incomplete prosthesis apposition to the native annulus, due to remaining material of the native valve or
   (b) incomplete prosthesis apposition to the native annulus, due to a prothesis-patient mismatch, with a too small prosthesis for a large annulus or
   (c) a too low implantation of the valve leading to paravalvular leakage through the uncovered cells of the prosthesis.
2. valvular regurgitation, either due to
   (a) valvular damage during the implantation procedure or
   (b) a prosthesis-patient mismatch, with a too large prosthesis for a small annulus, resulting in a valve deformation or
   (c) impairment of the valve due to severe calcification of the native valve, leading to deformation of the frame of the valve.

Depending on the underlying pathophysiology, different methods to resolve or to reduce implantation-related aortic insufficiency can be applied [3, 8, 9].

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To the best of our knowledge, we report on the first case with severe aortic insufficiency after implantation of the CoreValve Revalving™ system, due to malfunction of one leaflet of the prosthesis.

Case

A 90-year-old patient presented with recurrent heart failure due to severe aortic stenosis with preserved left ventricular function. Regarding his age and co-morbidities transfemoral percutaneous aortic valve implantation (TAVI) was considered [2, 4, 7.] Transoesophageal echocardiography (TEE) showed an annulus size of the aortic valve of 25 mm.

Following initial balloon valvuloplasty with a 25-mm Nucleus™ balloon (Numed) TAVI was performed using a 29-mm CoreValve Revalving™ system. The implantation procedure was uneventful with a correct positioning of the valve (Fig. 1).

However, immediately after the implantation angiography demonstrated a moderate to severe aortic insufficiency. Under the assumption of a paravalvular leakage, a balloon valvuloplasty (25-mm nucleus balloon™; Numed) was performed to reduce the regurgitant volume. During this procedure, rupture of the balloon occurred. The remaining aortic insufficiency was graded as moderate and a "wait and see" strategy pursued.

During the following days, the patient developed heart failure despite diuretic therapy. Auscultation and transthoracic echocardiography showed severe aortic insufficiency and a first TEE failed to determine the underlying cause of the insufficiency. Owing to continuing deterioration of the heart failure, a second TEE (Figs. 2, 3, 4, 5) was performed 3 days later, which now revealed a small paravalvular and a huge valvular leakage, probably due to one malfunctioning valve leaflet.

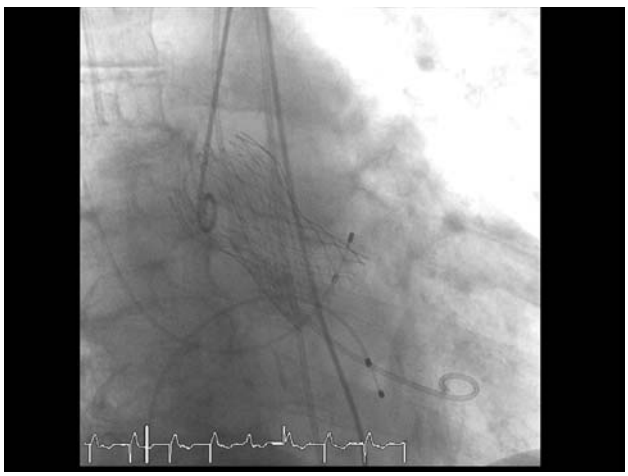

Fig. 1 Transfemoral aortic valve implantation (TAVI) of a 29-mm CoreValve Revalving™ system

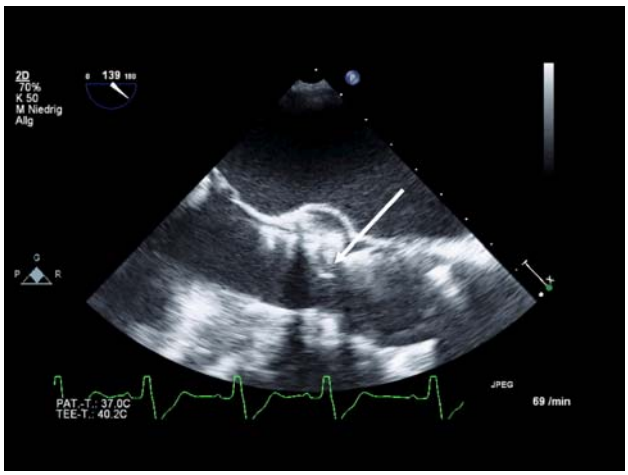

Fig. 2 Transoesophageal multiplane echocardiography after TAVI: longitudinal axis with one leaflet with pathologic movements (*white arrow*)

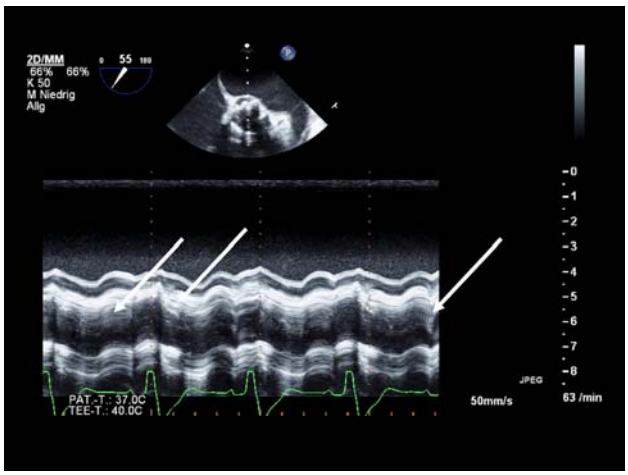

Fig. 3 Transoesophageal multiplane echocardiography (m-mode) after TAVI: short axis with one leaflet with pathologic movements (*white arrows*)

When concerning this pathophysiology, a further TAVI was performed using a second 29-mm CoreValve Revalving™ system, as a "valve-in-valve" implantation ("Russian doll concept") (Figs. 6, 7) [8].

Final angiography now revealed only a small para-valvular aortic insufficiency. The clinical situation of the patient improved rapidly and he was discharged 1 week after the second TAVI procedure. After 4 months of implantation, he is still well and the "valve-in-valve" shows a normal function.

Discussion

Percutaneous TAVI has extended our ability to treat patients with severe symptomatic aortic stenoses being no

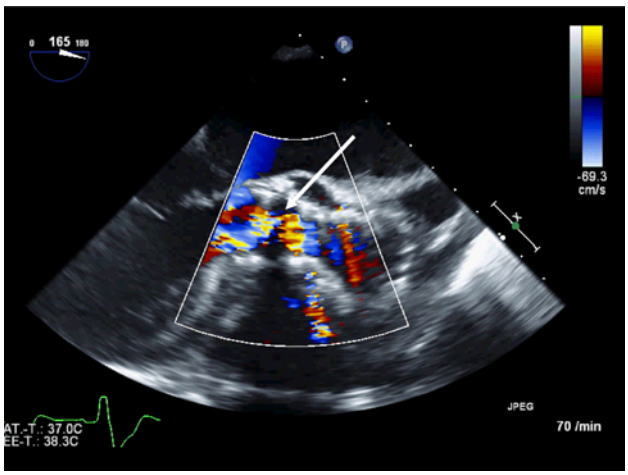

Fig. 4 Transoesophageal multiplane echocardiography (colour Doppler) after TAVI: longitudinal axis with severe valvular aortic insufficiency (*white arrow*)

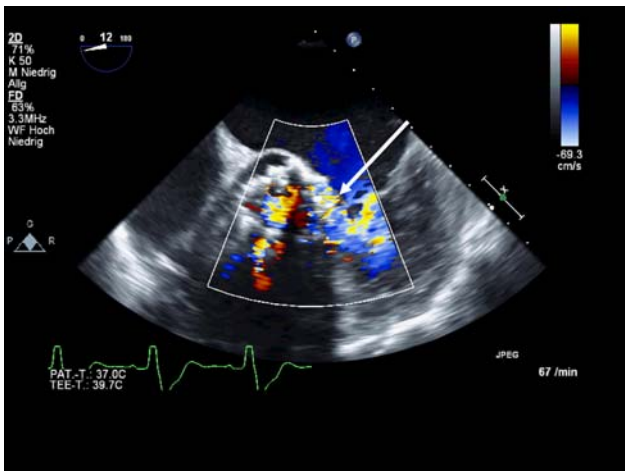

Fig. 5 Transoesophageal multiplane echocardiography (colour Doppler) after TAVI: longitudinal axis with small para-valvular aortic insufficiency (*white arrow*)

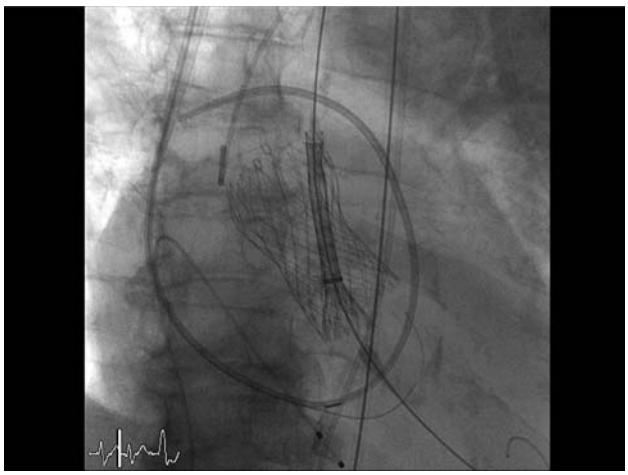

Fig. 6 Implantation of a second a 29-mm CoreValve Revalving™ system as a "valve-in-valve" implantation: system being partially released

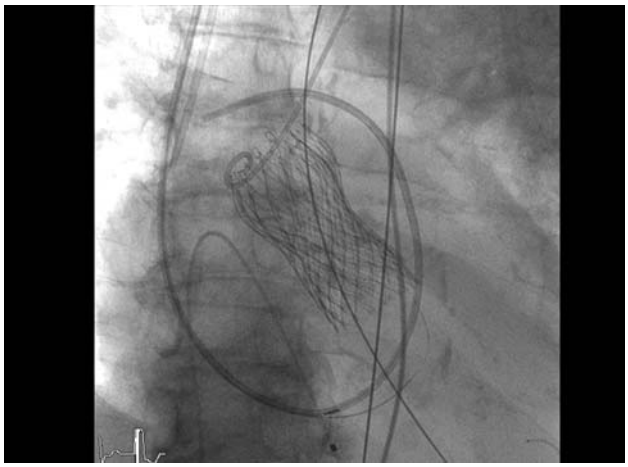

Fig. 7 Implantation of a second a 29-mm CoreValve Revalving™ system as a "valve-in-valve" implantation: system being completely released

or poor candidates for open heart surgery [2–5, 7, 16]. However, TAVI may result in severe complications, starting with vascular access complications, cerebral or peripheral embolisation, pericardial effusion, ventricular rupture, conduction abnormalities, aortic dissections and aortic insufficiency.

In contrast to surgical aortic valve replacement, slight aortic insufficiency is a common finding after TAVI, being present in about 70% of patients for both available types of percutaneous valves [3, 15, 16]. In most cases, aortic insufficiency is clinical acceptable, however, severe insufficiency can occur. Current reports mention treatment of such severe insufficiencies only very briefly [3, 7]. However, the problem is not trivial because the underlying pathophysiology can be very different:

1. para-valvular insufficiency, either due to (a) incomplete valve adherence to the aortic annulus (b) prosthesis-patient mismatch or (c) due to too low implantation of the valve.
2. valvular insufficiency, either due to (a) valvular damage during the implantation procedure, or (b) due to a prosthesis-patient mismatch.

Furthermore, exact diagnosis may be difficult for angiography gives only the severity of the insufficiency but not always the underlying pathophysiology, whereas echocardiography may be difficult due to interference of the metal of the prosthesis with the ultrasound as well as underestimation of the severity of aortic insufficiency in the case of paravalvular leaks. Therefore, an integration of all

available data, that is, hemodynamic data, post-implantation angiography, auscultation, transthoracic, and TEE, as well as the clinical course is necessary to make a good judgement [12]. Furthermore, there will be a learning curve for exact judgement of post-implantation aortic insufficiency in TAVI.

Para-valvular insufficiency due to incomplete valve adherence to the aortic annulus because of remaining material of the native valve or a prosthesis-patient mismatch may be overcome by post-dilatation, which is normally discouraged, implantation of an plug device [6, 10] or in less severe cases by "faithful watching", for the self-expanding CoreValve™ might further expand in same cases during the days following the implantation resulting in a decrease of the regurgitation [3].

Para-valvular insufficiency due to too low implantation of the valve, leading to paravalvular leakage through the uncovered cells of the prosthesis, might be addressed by implantation of a second valve into the first valve ("valve-in-valve" implantation) as reported by Grube et al. [3] in 3 out of 102 patients treated with the 18French CoreValve™ prosthesis.

Piazza et al. [8] also reported 5 "valve-in-valve" implantation out of 59 patients (8.5%) treated with TAVI. In two of these five patients, the first valve was implanted to high and in the other three patients the valve was implanted too low. In all of the five patients, the valve-in-valve implantation resulted in a good hemodynamic result. In the same paper as cited above [3], Grube et al. reported on six patients with too low valve implantation and severe aortic insufficiency treated with gentle pulling of the valve using a standard snare.

To the best of our knowledge, this is the first case with severe aortic insufficiency after implantation of the CoreValve Revalving™ system, due to malfunction of one leaflet of the prosthesis. The reason for this malfunction may be (a) primary malfunction of the valve; however, routine inspection of the valve prior to mounting it on the delivery catheter did not show such a problem, (b) damage of the valve leaflet during the mounting and/or release procedure with the delivery catheter or finally (c) damage of the valve leaflet during the post-implantation balloon inflation with the rupture of the balloon. However, this would suggest that the aortic insufficiency observed directly after implantation had another aetiology that was resolved by the balloon inflation. For we did not do TEE during the TAVI procedure, we cannot give an exact answer. The angiographic appearance of the aortic insufficiency directly after implantation was not different to the final appearance.

This case shows the importance to determine the pathophysiology of aortic insufficiency after TAVI procedures to select the adequate therapy.

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