

## CASE REPORT

## ADVANCED

## CLINICAL CASE SERIES

# Percutaneous Tricuspid Valve Repair



## A Promising Treatment for Heart Transplant Patients With Severe Tricuspid Regurgitation

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## ABSTRACT

Two heart transplant patients aged 80 and 83 years with recurrent heart failure due to severe tricuspid regurgitation are reported. In view of their high perioperative risk, both patients underwent percutaneous transcatheter edge-to-edge tricuspid valve repair, and both experienced excellent technical success, with favorable 2-year clinical outcome.

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**T**ricuspid regurgitation (TR) is one of the leading pathologies following longstanding orthotopic heart transplantation (OHT), with an incidence of 19% to 84%. The main etiologies are annular dilatation caused by atrial dilatation and iatrogenic regurgitation as a consequence of multiple endomyocardial biopsies with incidental biopsy of

septal chords (1). Severe TR is associated with increased morbidity and mortality. However, tricuspid valve (TV) surgery in OHT patients is also associated with high perioperative risk, and therefore, alternative treatment options are warranted (2). We present 2 cases of elderly OHT patients with severe TR who underwent percutaneous treatment.

## LEARNING OBJECTIVES

- To identify TR as the most common valvular disease after longstanding OHT with negative impact on morbidity and mortality.
- To understand that OHT patients with severe TR need evaluation by heart teams experienced in patient selection and the treatment (both interventional and surgical) of patients with complex valvular disease.
- To recommend transcatheter edge-to-edge repair for suitable high-risk OHT patients with severe TR because successful treatment may lead to favorable clinical outcome at up to 2 years.

## CASE 1

The 83-year-old patient was admitted for New York Heart Association functional class IV dyspnea, 29 years after OHT by bicaval technique for heart failure caused by dilatative cardiomyopathy. The patient had undergone 71 endomyocardial biopsies, with the most recent in 2018 showing no rejection. TR was first noticed 12 years after OHT. The baseline findings can be seen in **Table 1**. Echocardiographic assessment and grading of TR were performed based on current guidelines (3). In this patient, Doppler echocardiography revealed grade V TR (4) (torrential: mean biplane vena contracta of 13 mm, effective regurgitant orifice area of 0.88 cm<sup>2</sup>, and regurgitant flow of

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**ABBREVIATIONS  
AND ACRONYMS**

- OHT** = orthotopic heart transplantation
- RV** = right ventricle
- TR** = tricuspid regurgitation
- TV** = tricuspid valve

78.6 mL) due to a combination of several flail septal leaflets (the result of erroneous biopsies of septal chords, with a septal-anterior coaptation gap of 8 mm) and severe right ventricle (RV) and right atrium dilatation (Table 1, Figure 1). Recent heart catheterization showed unobstructed inferior vena cava access, normal coronary status, and mild elevation of the pulmonary vascular resistance (333 dyne·s/cm<sup>5</sup>) but normal systolic pulmonary artery pressure (31 mm Hg).

**CASE 2**

The 80-year-old patient was admitted for progressive and now severe lower-extremity edemas and dyspnea (New York Heart Association functional class III). At

the age of 57 years, he underwent bicaval OHT for dilatative cardiomyopathy. A total of 80 endomyocardial biopsies had been performed. The first signs of right-sided heart failure due to TR were noted 16 years after OHT. His baseline findings can be seen in Table 2. Echocardiography also demonstrated an iatrogenic flail septal leaflet as the etiology for grade IV TR (massive: mean biplane vena contracta of 9 mm, effective regurgitant orifice area of 0.62 cm<sup>2</sup>, and regurgitant flow of 44.0 mL). TR quantification in this patient was performed on only the larger of 2 eccentric jets, with an anterior-septal coaptation gap of 6 mm. The integration of all jets made this a grade IV TR. Heart catheterization showed unobstructed inferior vena cava access and no pulmonary vascular resistance elevation (136 dyne·s/cm<sup>5</sup>) but mildly elevated systolic pulmonary artery pressure

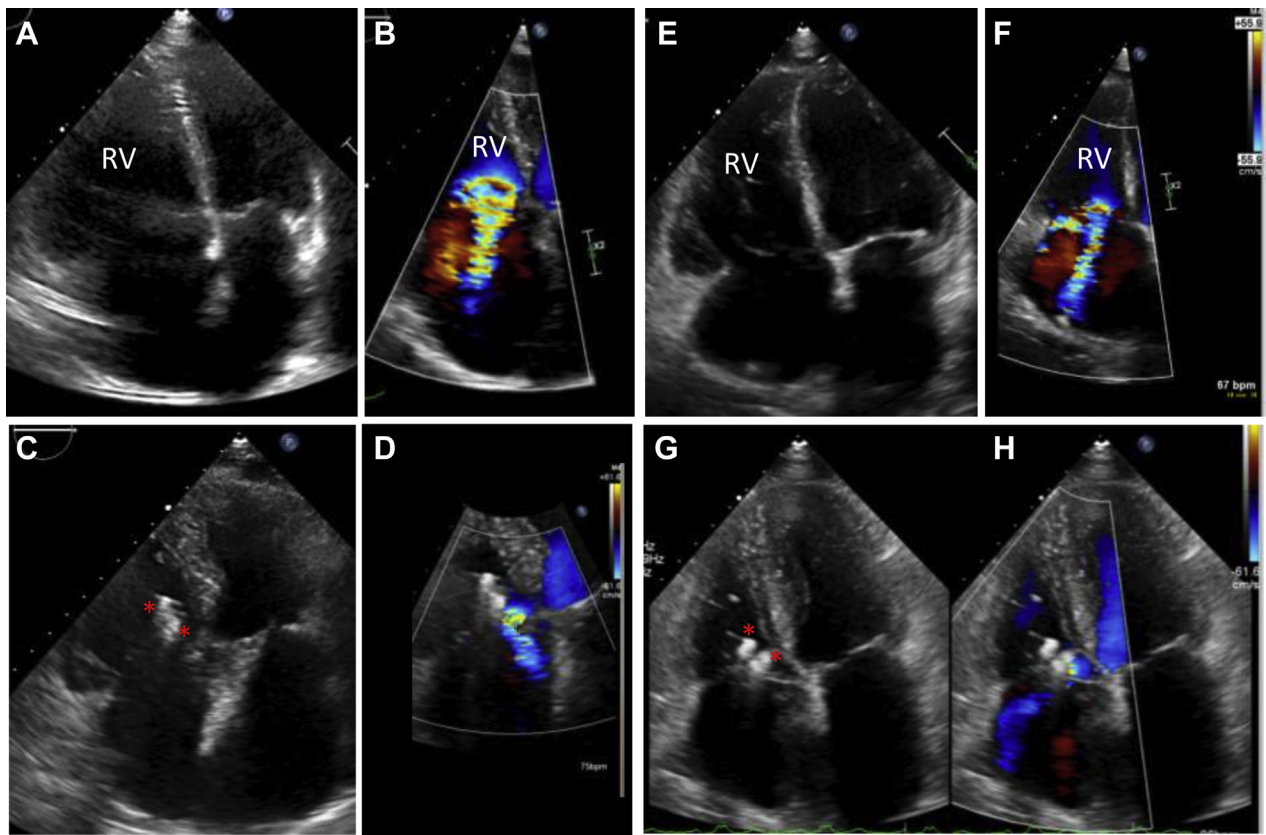
**TABLE 1 Baseline and Follow-Up Data of Patient 1**

	Baseline	Discharge	1-Year Follow-Up	2-Year Follow-Up	Change, Baseline to 2-Year Follow-Up, %
<b>Clinical data</b>					
Weight, kg	60	54	53	53	↓ 11.0
Sinus rhythm	Yes	Yes	Yes	Yes	—
Heart rate, beats/min	80	105	65	81	↑ 1.3
Systolic blood pressure, mm Hg	125	125	145	117	↓ 6.4
Diastolic blood pressure, mm Hg	80	65	99	81	↑ 1.3
<b>Clinical symptoms and signs</b>					
NYHA functional class	IV	I†	I	II	↓ 50.0
Peripheral edema*	1	0†	0	0	—
<b>Echocardiographic parameters</b>					
RA area, end systolic, cm <sup>2</sup>	44.0	32.9	31.1	27.3	↓ 38.0
RV area, end diastolic, cm <sup>2</sup> /m <sup>2</sup>	23.7	17.3	12.2	12.1	↓ 48.9
RV/RA pressure gradient, mm Hg	36.3	33.1	29.8	23.9	↓ 34.2
RV FAC, %	44.2	25.1	34.7	33.8	↓ 23.5
TAM, cm	1.7	1.5	2.0	1.8	↑ 5.9
TR grade‡	5	2	1	1	↓ 80.0
Flail	Several	1	1	1	—
TV mean PG, mm Hg	—	2.9	1.8	1.4	—
LV EDVi, mL/m <sup>2</sup>	29.3	22.8	43.6	36.3	↑ 23.9
LV EF, %	62.1	66.7	60.3	55.6	↓ 10.5
LAVI, mL/m <sup>2</sup>	50.0	55.7	111.4	81.9	↑ 63.8
MR grade‡	0	0	1	0	0
<b>Laboratory parameters</b>					
Hemoglobin, g/L	139	76	124	106§	↓ 23.7
NT-proBNP, ng/L	22,250§	9,743	—	—	—
<b>Medications</b>					
Torsemide, mg	20	10	10	10	↓ 50.0
Bisoprolol, mg	5	5	5	5	0
Spironolactone, mg	25	25	25	25	0
Molsidomine, mg	8	8	8	0	↓ 100

\*Peripheral edema: 0 = none; 1 = mild; 2 = moderate; 3 = severe. †88 days later. ‡TR grade/MR grade: 0 = none/minimal; 1 = mild; 2 = moderate; 3 = severe; 4 = massive; 5 = torrential. §25 days earlier.

EDVi = end-diastolic volume indexed; EF = ejection fraction; FAC = fractional area change; LAVI = left atrial volume indexed; LV = left ventricle; MR = mitral regurgitation; NT-proBNP = N-terminal pro-brain natriuretic peptide; NYHA = New York Heart Association; PG = pressure gradient; RA = right atrium; RV = right ventricle; RV area Di = right ventricular area indexed; TAM = tricuspid annular motion; TR = tricuspid regurgitation; TV = tricuspid valve.

**FIGURE 1** Grade of Tricuspid Regurgitation and Right Ventricular Dimensions of Patient 1 and 2 Before and 2 Years After the Intervention



Baseline (top) and 2-year follow-up (bottom) echocardiography of (A to D) patient 1 and (E to H) patient 2. The asterisks indicate a clip. RV = right ventricle.

(54 mm Hg). Furthermore, mild but nonsignificant graft atherosclerosis was noted.

### HEART TEAM ASSESSMENT, TREATMENT, AND OUTCOME

Our heart team board reviewed the patients, and both were found at high risk for surgical TV repair (Euro-Score II and STS scores: 12.8% and 9.9%, respectively [patient 1]; 7.9% and 6.1%, respectively [patient 2]). However, because of good visibility by transesophageal echocardiography and the given anatomy, both patients appeared to be good candidates for transcatheter TV repair without further access route imaging. Both patients underwent TV edge-to-edge repair using 2 XTR MitraClips (Abbott Vascular), each with right femoral vein access. Compared to mitral valve edge-to-edge repair, there are a few differences when using the MitraClip device for TV edge-to-edge repair: the baseline orientation of the steering device is 90° counterclockwise to the normal

orientation; the A-knob is used to descend to the valve, while the + knob corrects for septal hugging; and less straddling is applied to gain sufficient height above the valve, enabling proper leaflet grasping. In patient 1, we identified the target area in the posterior part of the septal leaflet and grasped it together with the anterior leaflet. Good reduction of TR was achieved, but there remained flail segments on each side of the device. A second device was placed anteriorly to the first one, with remaining TR from both sides of the 2-device edge-to-edge repair. Given the reduction in TR by 3 grades, the team accepted this as the final result (Figure 2). In patient 2, the initial strategy was the same as in patient 1. After release, the first device tilted somewhat superiorly, leaving substantial TR caused by a small flail posteriorly. The second device closed this gap, with a remaining mild TR from a residual flail of the superior part of the septal leaflet (Figure 3). At discharge, TR reduction remained stable, and both patients were clinically compensated. The 1- and 2-year follow-up data showed persistent

**TABLE 2** Baseline and Follow-Up Data of Patient 2

	Baseline	Discharge	1-Year Follow-Up	2-Year Follow-Up	Change, Baseline to 2-Year Follow-Up, %
<b>Clinical data</b>					
Weight, kg	83	73	78	71	↓ 14.5
Sinus rhythm	Yes	Yes	Yes	Yes	—
Heart rate, beats/min	65	81	77	71	↑ 9.2
Systolic blood pressure, mm Hg	125	105	146	145	↑ 16.0
Diastolic blood pressure, mm Hg	80	60	98	86	↑ 7.5
<b>Clinical symptoms and signs</b>					
NYHA functional class	III	III	I	I*	↓ 66.0
Peripheral edema†	3	1	1	1*	↓ 66.0
Hepatojugular reflux	Positive	Negative	Negative	Negative*	—
<b>Echocardiographic parameters</b>					
RA area end systolic, cm <sup>2</sup>	34.3	29.2	29.5	23.6	↓ 31.2
RV area Di, cm <sup>2</sup> /m <sup>2</sup>	16.3	13.1	11.8	11.8	↓ 27.6
RV/RA pressure gradient, mm Hg	14.9	20.1	20.8	21.0	↑ 40.9
RV FAC, %	39.8	35.7	47.9	48.2	↑ 21.1
TAM, cm	1.5	2.0	1.8	2.2	↑ 46.7
TR grade‡	4	1	1	1	↓ 75.0
Flail	Several	1	1	1	↓ 100.0
TV mean PG, mm Hg	—	4.2	4.2	2.4	—
LV EDVi, mL/m <sup>2</sup>	62.9	72.7	66.0	44.9	↓ 28.6
LVEF, %	54.8	64.3	74.9	61.0	↑ 11.3
LAVI, mL/m <sup>2</sup>	103.8	106.1	108.0	78.6	↓ 24.3
MR grade‡	0	0	0	0	0
<b>Laboratory parameters</b>					
Hemoglobin, g/L	133	107	129§	127	↓ 4.5
NT-proBNP, ng/L	17,743	14,745	21,830§	5,649	↓ 68.2
<b>Medications</b>					
Torsemide, mg	20	10	5	—	—
Furosemide, mg	—	—	—	80¶	—
Perindopril, mg	—	—	—	5	—
Spirinolactone, mg	25	25	—	—	—

\*153 days earlier. †Peripheral edema: 0 = none; 1 = mild; 2 = moderate; 3 = severe. ‡TR grade/MR grade: 0 = none/minimal; 1 = mild; 2 = moderate; 3 = severe; 4 = massive; 5 = torrential. §92 days earlier. ||152 days later. ¶Since exacerbation of edema at an earlier date.  
Abbreviations as in Table 1.

reduction of TR to grade I (Figure 1, bottom), with normalization of the RV size and function (Tables 1 and 2). While patient 1 remained stable for the whole 2 years, patient 2 had a recurrence of lower-extremity edemas in the second year treated by an increase in diuretics. However, neither patient was hospitalized for heart failure symptoms. Patient 2 even survived a COVID-19 pneumonia, and both patients live independently at the time of publication.

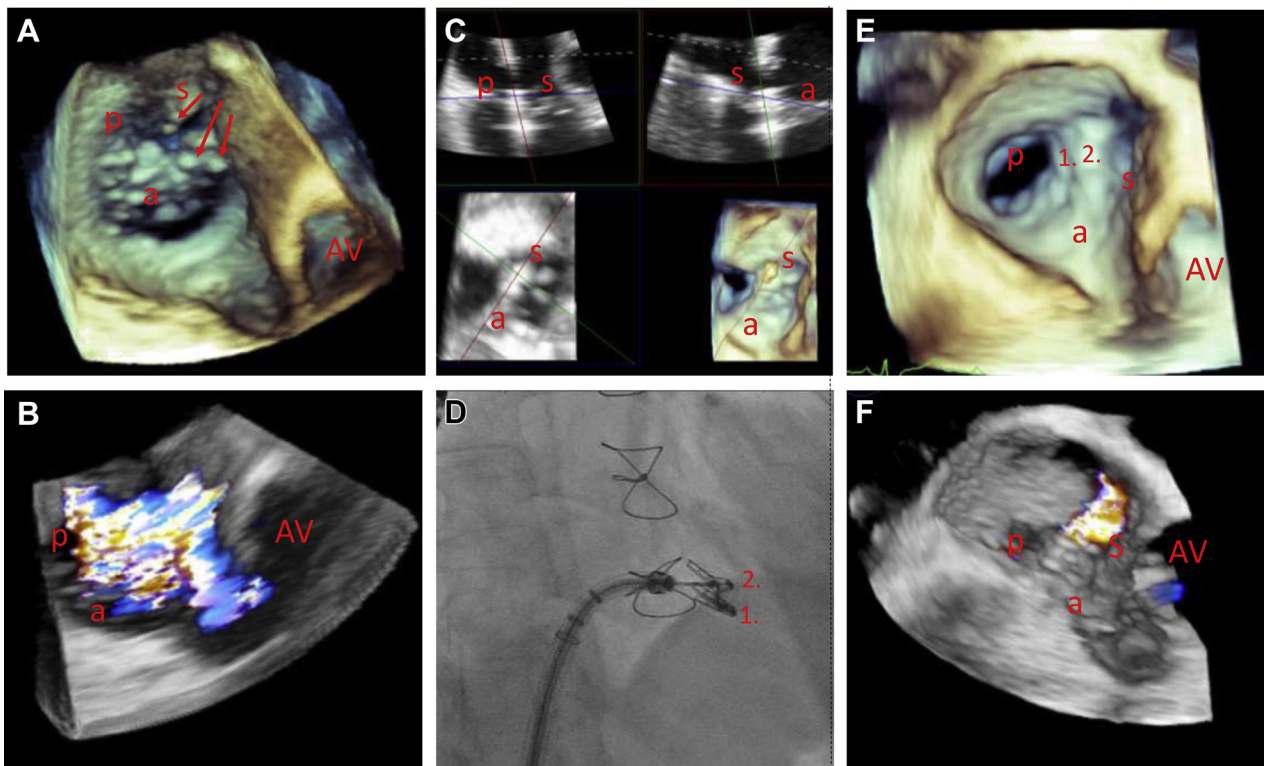
## DISCUSSION

This case series reports the treatment and midterm outcome of 2 elderly OHT patients with recurrent heart failure due to most severe TR. In view of the high perioperative risk, a percutaneous edge-to-edge repair of the TV was performed using the MitraClip system. The cases demonstrate the feasibility of this procedure after bicaval OHT and given good leaflet

visibility by 3-dimensional transesophageal echocardiography; the procedure does not differ from non-transplant patients. Both patients experienced excellent short- and 2-year technical and clinical outcomes. Only 3 other cases with percutaneous treatment of severe TR in OHT patients have been published to date. Two groups have published 1 patient each using the MitraClip system (5,6), reporting good 3- and 6-month outcomes, respectively. One patient was successfully treated by percutaneous annuloplasty using the Cardioband system (Edwards Lifesciences) (7). This series represents the longest published follow-up so far and adds to the current sparse published reports for this patient population.

Several factors must be met to achieve a favorable technical outcome using transcatheter TV repair. Heart teams assessing and treating such patients must be specialized in many aspects, including clinical management of OHT patients, advanced imaging

**FIGURE 2** Peri-Interventional Images of Patient 1



(A, B) Anatomy and regurgitation grade V before treatment. (C) Control before release of the first clip by 3-dimensional echocardiography. (D) Positioning of the second clip. (E, F) Reduction of regurgitation to grade II after placement of the second clip. The arrows highlight flail segments of the septal leaflet; numbers represent the first and second clips. a = anterior leaflet; AV = aortic valve; p = posterior leaflet; s = septal leaflet.

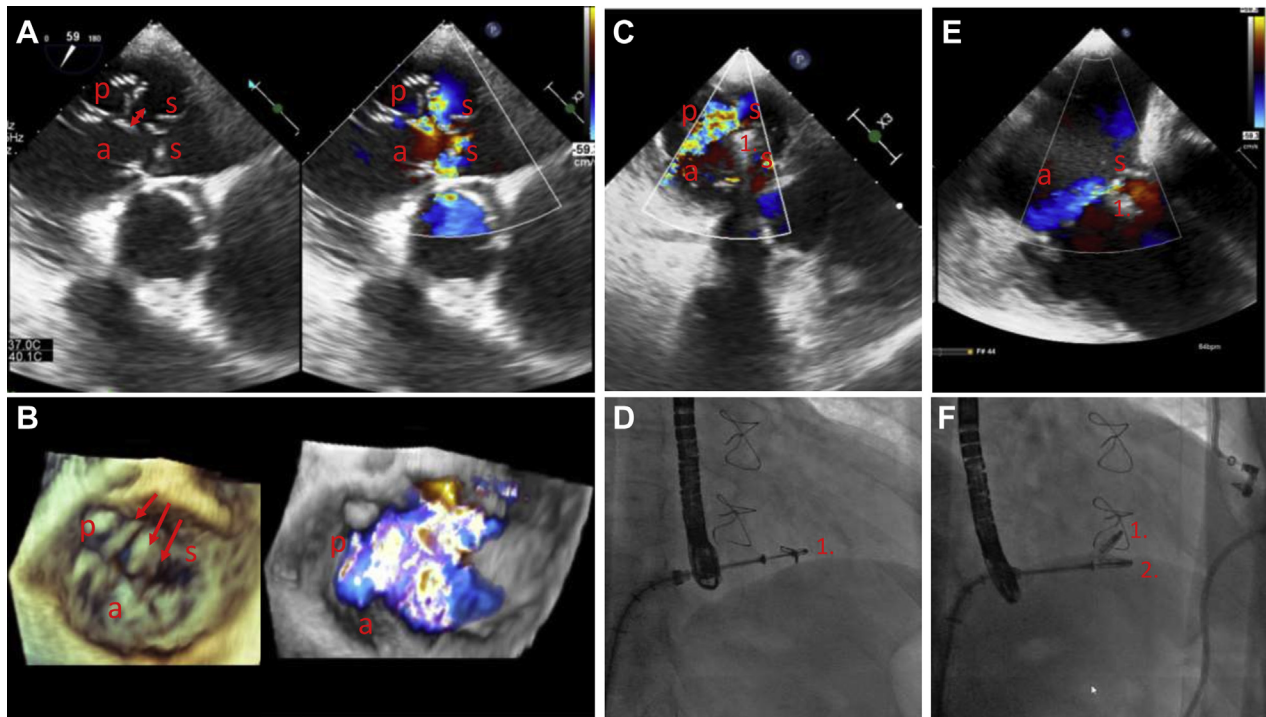
for complex valvular disease, competency in percutaneous valve treatment options, and expert knowledge in valvular heart surgery (mitral and tricuspid valve surgeons) (8,9). Furthermore, anatomic assessment of the TV is critical for the choice of the procedure. In our cases, the flail leaflets needed to be corrected to reduce TR, and therefore, an edge-to-edge technique was chosen.

Long-term outcome, however, is likely determined by RV function. Severe TR inevitably leads to RV dilatation combined with a potential overestimation of RV function. However, RV function is an important determinant of the most common postoperative complications in OHT patients (cardiogenic shock and acute kidney injury) (2). Both our patients had dilated RVs with seemingly normal function. However, given the severity of TR (particularly in patient 1), RV function was most likely overestimated and posed a substantial perioperative risk. Not surprisingly, patient 1 demonstrated a mild RV dysfunction in the days following the intervention, which likely corresponded to the true RV function once afterload had

been increased. After the course of 1 year, gradual normalization of RV size and function was noted (Table 1). The RV size and function of patient 2 adapted quickly after the intervention, had likely been normal at the time of the intervention, and remained normal over the whole follow-up time (Table 2). In contrast to surgical correction of severe TR, percutaneous treatments are performed on the beating heart without additional myocardial ischemia. This may represent a major advantage of percutaneous TV treatments in OHT patients.

We conclude that in OHT patients with severe TR and high surgical risk, percutaneous TV repair should be evaluated as a treatment alternative to TV surgery. In patients with favorable anatomy and in the hands of experienced heart teams, percutaneous TV repair is feasible and safe, and it can lead to good technical and clinical 2-year outcomes. Follow-up echocardiography revealed persistent reduction of TR and normalization of both RV size and function, and both patients lived an independent life without further hospital stays because of heart failure. Larger studies are necessary

**FIGURE 3** Peri-Interventional Images of Patient 2



(A, B) Anatomy and regurgitation grade IV before treatment. (C, D) Placement of the first clip with residual regurgitation posterior to the first clip. (E, F) Reduction of regurgitation to grade I after placement of the second clip. The **double arrow** denotes the initial coaptation gap. Abbreviations as in [Figure 2](#).

in this patient population regularly excluded from current trials to increase our understanding of patient selection for different treatment strategies.

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