Transcatheter aortic valve replacement (TAVR) has emerged as an alternative treatment for patients with severe, symptomatic aortic stenosis who have a high surgical risk.\(^1\) The data from a multicenter, randomized trial have also recently supported TAVR as an alternative to surgery in low-risk patients.\(^2\) Evidence-based clinical data have led clinicians to expand this procedure to nearly all patients who have severe aortic stenosis. Technological improvements, increased operator experience, and pro-

**Abstract**

An 81-year-old man who had dyspnea was admitted to our hospital with a diagnosis of severe aortic stenosis. A transcatheter aortic valve implantation was successfully performed with a 29 mm Edwards Sapien XT valve using a transfemoral access. After the procedure, the echocardiography showed a restrictive ventricular septal defect (VSD) in the membranous septum. As the patient had no symptoms, it was decided to follow him up conservatively. However, he was readmitted within three weeks with symptoms suggestive of biventricular failure. A control echocardiography revealed a membranous VSD, 8 mm in size, right chambers dilatation with moderate tricuspid regurgitation, and systolic pulmonary artery pressure of 60 mm Hg. The previously deployed aortic valve was normal in function. The decision to perform a percutaneous VSD closure was made. The defect was then closed with a 10 mm muscular VSD occluder. During and after the procedure, there was no dysfunction in the bioprosthetic aortic valve. At the one-year follow-up, the patient was still asymptomatic.

**Keywords:** Iatrogenic disease, ventricular septal defect, transcatheter aortic valve replacement

**Özet**

81 yaşında erkek hasta nefes darlığı şikayeti ile başvurduğu hastaneme ileri aort darlığı ile yatırıldı. Transfemoral yolla, 29 mm Edwards Sapien XT kapakçığı başarıyla implante edildi. İşlemden sonra, ekokardiografide membranöz septumda restriktif bir ventriküler septal defekt (VSD) görüldü. Hastanın semptomu olmadığı için konservatif takip kararı verildi. Ancak hasta 3 hafta sonra biventriküller yetersizlik düşündürdüğü nefes darlığı ve periferik ödem şikayeti ile tekrar başvurdu. Kontrol ekokardiografisinde 8 mm boyutunda membranöz VSD, orta derecede triküspit yetersizliği ile sağ kalp boşluklarında dilatasyon ve 60 mm Hg sistolik pulmoner arter basınç gösterildi. Önceden yerleştirilmiş biyoprotez aort kapağı fonksiyonu idi. Hastaya perkütan VSD kapatma kararı verildi. Defekt 10 mm’lik bir VSD Occluder ile kapatıldı. İşlem sırasında ve sonrasında biyoprotez aort kapağında herhangi bir işlev bozukluğu olmadı. Bir yıllık takipte hasta hala asemptomatiktı.

**Anahtar Kelimeler:** Iatrogenik, ventriküler septal defekt, transkateter aortik kapak replasmanı

**Percutaneous closure of an iatrogenic ventricular septal defect associated with transcatheter aortic valve implantation**

Transkateter aort kapak implantasyonu sonrasında görülen iatrojenik ventriküler septal defektin perkütan kapatılması

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Procedural simplification have contributed to decreased complication rates in TAVR; however, broader use of this procedure in patients with aortic stenosis who often have coexisting conditions has resulted in an increased cumulative number of complications, such as stroke, major vascular complications, coronary occlusion, and aortic annular rupture or ventricular septal defect (VSD).[3,4]

Diagnosing, preventing, and treating these procedure-related complications have gained importance, and more patients with severe aortic stenosis now undergo TAVR than surgical aortic valve replacement. Here, we describe the case of an 81-year-old patient with iatrogenic VSD following TAVR who went on to have a successful percutaneous VSD closure.

**CASE REPORT**

An 81-year-old man with a history of coronary bypass surgery, hypertension, and diabetes mellitus was admitted with dyspnea. As the New York Heart Asso-

**ABBREVIATIONS**

LVOT  Left ventricular outflow tract  
STS  Society of Thoracic Surgeons  
TAVR  Transcatheter aortic valve replacement  
VSD  Ventricular septal defect
Table 1. Clinical features of reported cases

| Publication Author/ Year | Age/Sex | Comorbidities | STS/Logistic Euro Score (%) | Annulus Size - CT (mm) | LVOT Calcification Severity | Prosthesis | Valve type/Size of valve | Access | Predilatation/ Postdilatation (mm) |
|--------------------------|---------|---------------|-----------------------------|------------------------|-----------------------------|------------|-------------------------|--------|----------------------------------|
| Tzikas A et al. 2009[4]  | 89/M    | None          | NR; 15                      | NR                     | NR                          | Self- expandable | Core Valve /29-mm | transfemoral | 23/25                           |
| Al-Attar N et al. 2009[4]| NR      | NR            | NR                          | NR                     | NR                          | NR         | Edwards Sapien/ 26-mm   | transapical | NR/NR                           |
| Massabuau P et al. 2011[4]| 86/M    | CAD, HLD      | 7;28                        | NR                     | NR                          | Balloon- expandable | Edwards Sapien/ 26-mm | transapical | NR/NR                           |
| Martinez R et al. 2012[4]| 76/F    | COPD,HTN      | NR;17                       | NR                     | moderate                   | Self- expandable | Core Valve /26-mm | NR      | 22/25                           |
| Gerckens U et al. 2013[5]| 86/M    | AF,CKD, HF    | NR; 21                      | 27.2                   | severe                     | Self- expandable | Core Valve /31-mm | transfemoral | 22/28                           |
| Aminian A et al. 2013[4] | 85/F    | CAD, CKD      | NR; 18.5                    | NR                     | NR                          | Balloon- expandable | Edwards Sapien XT/ 23-mm | transfemoral | 20/None                          |
| Rodgers V et al. 2014[4] | 82/F    | NR            | 17x20                       | severe                 | Balloon- expandable         | Edwards Sapien XT/ 23-mm | transfemoral | 18/None                          |
| Baruteau AE et al. 2014[4]| 89/M    | NR            | NR                          | NR                     | NR                          | Balloon- expandable | Edwards Sapien/ 26-mm | NR      | NR/NR                           |
| Salizzoni S et al. 2014[4]| 88/F    | HF            | 10.9; 26.64                 | severe                 | Balloon- expandable         | Edwards Sapien XT/ 26-mm | transfemoral | 20/25                           |
| Yanes-Bowden G et al. 2014[4]| 87/M    | None          | NR; 13.92                   | 21x23                  | NR                          | Balloon- expandable | Edwards Sapien XT/ 26-mm | transfemoral | NR/NR                           |
| Patel Y et al. 2014[4]   | 85/F    | HTN,CAD, HLD  | >10; NR                     | NR                     | NR                          | Balloon- expandable | Edwards Sapien XT/ 23-mm | transfemoral | 20/None                          |
| Patel Y et al. 2014[4]   | 89/F    | HTN,CAD, HLD, DM | 16; NR                  | NR                     | NR                          | Balloon- expandable | Edwards Sapien/ 26-mm | transfemoral | 22/None                          |
| Patel Y et al. 2014[4]   | 88/F    | HTN, CKD, AF  | 16; NR                     | NR                     | NR                          | Balloon- expandable | Edwards Sapien/ 23-mm | transfemoral | 20/None                          |
| Garrido JM et al. 2014[4] | 79/F    | HTN, AF, COPD | NR; 11.66                  | NR                     | moderate                   | Balloon- expandable | Edwards Sapien XT/ 23-mm | transfemoral | NR/NR                           |
| Mauri L et al. 2014[16]  | 78/F    | HF            | NR;NR                       | NR                     | NR                          | Balloon- expandable | Edwards Sapien XT/ 23-mm | transfemoral | NR/NR                           |
| Dursun H et al. 2015[4]  | 73/F    | NR            | NR; 33.8                    | NR                     | mild                       | Balloon- expandable | Edwards Sapien XT/ 26-mm | transfemoral | 23/None                          |
| Levi DS et al. 2015[4]   | 57/F    | MVR           | NR;NR                       | NR                     | NR                          | Balloon- expandable | Edwards Sapien/ 23-mm | transapical | 20/NR                           |
| Shakoor MT et al. 2015[4] | 89/M    | COPD,CAD, Aorta Valvuloplasty | NR;NR                | 26x28                  | NR                          | Balloon- expandable | Edwards Sapien/ 29-mm | transfemoral | NR/NR                           |
| Mark SD et al. 2015[4]   | 89/M    | NR            | 5.6;NR                      | NR                     | Balloon- expandable         | Edwards Sapien/ 29-mm | NR | NR/NR                           |
| Lee CW et al. 2015[4]    | 80/F    | COPD          | NR;NR                       | NR                     | Balloon- expandable         | Edwards Sapien/ 23-mm | NR | NR/NR                           |
| Publication Author/ Year | Age/Sex | Comorbidities | STS/Logistic Euro Score (%) | Annulus Size - CT (mm) | LVOT Calcification Severity | Prosthesis | Valve type/Size of valve | Access | Predilatation/ Postdilatation (mm) |
|--------------------------|---------|---------------|----------------------------|------------------------|-----------------------------|------------|-------------------------|--------|-------------------------------|
| Rene AG et al. 2016[6]   | 89/M    | AF            | 5.7;NR                     | 24x30                  | severe                      | Balloon-expandable         | Edwards Sapien/ 29-mm      | transfemoral | NR/NR                         |
| Rene AG et al. 2016[6]   | 86/F    | COPD,HTN, CKD | 4.8;NR                     | 23x28                  | moderate                    | Balloon-expandable         | Edwards Sapien XT/ 29-mm   | transfemoral | NR/NR                         |
| Rene AG et al. 2016[6]   | 82/F    | COPD, CAD, AF | 14.2;NR                    | 26.2x29                | severe                      | Balloon-expandable         | Edwards Sapien XT/ 29-mm   | transaortic  | NR/NR                         |
| Rene AG et al. 2016[6]   | 93/M    | CKD, HF, AF, HTN | 9.37;NR               | 18.6x27                | severe                      | Balloon-expandable         | Edwards Sapien XT/ 26-mm   | transfemoral | NR/NR                         |
| Sardar MR et al.2017[4]  | 87/M    | AF, CAD, CKD  | 6.1;17.5                  | 23.6x29                | mild                        | Balloon-expandable         | Edwards Sapien XT/ 29-mm   | transfemoral | 22/None                        |
| Sardar MR et al.2017[4]  | 90/F    | AF            | 8.1;15.8                  | 23x25                  | severe                      | Balloon-expandable         | Edwards Sapien/ 26-mm       | transfemoral | 22/None                        |
| Ohlow MA et al.2017[3]   | 83/F    | HF            | NR;27                     | NR                     | severe                      | Balloon-expandable         | Edwards Sapien XT/ 26-mm   | transfemoral | NR/NR                         |
| Almanfi A et al. 2017[6] | 92/M    | CAD,HF, obesity | NR;NR                   | NR                     | NR                          | Balloon-expandable         | Edwards Sapien XT/ 29-mm   | transfemoral | NR/NR                         |
| Zeniou V et al.2018[7]   | 83/F    | NR            | NR;NR                     | NR                     | NR                          | Balloon-expandable         | Edwards Sapien XT/ 29-mm   | NR         | NR/NR                         |
| Zeniou V et al.2018[7]   | 87/F    | NR            | NR;NR                     | NR                     | severe                      | Self- expandable            | Core Valve /26-mm           | NR         | NR/NR                         |
| Zeniou V et al.2018[7]   | 82/M    | NR            | NR;NR                     | NR                     | moderate                    | Balloon-expandable         | Edwards Sapien/ 29-mm       | NR         | NR/NR                         |
| Zeniou V et al.2018[7]   | 79/M    | NR            | NR;NR                     | NR                     | severe                      | Self- expandable            | Core Valve Evolut/26-mm     | NR         | NR/NR                         |
| Zeniou V et al.2018[7]   | 84/F    | NR            | NR;NR                     | NR                     | severe                      | Self- expandable            | Core Valve Evolut/26-mm     | NR         | NR/NR                         |
| Zeniou V et al.2018[7]   | 81/M    | NR            | NR;NR                     | NR                     | severe                      | Balloon-expandable         | Edwards Sapien/ 29-mm       | NR         | NR/NR                         |
| Ancona M et al. 2018[9]  | 87/F    | CKD           | 8;NR                      | NR                     | NR                          | Self- expandable            | Core Valve Evolut/29-mm     | NR         | None/24                        |
| Chourdakis E et al. 2018[11] | 86/M   | AF, HTN, HF, CKD | NR;41                   | NR                     | NR                          | Balloon-expandable         | Edwards Sapien/ 29-mm       | transfemoral | 20/None                        |
| Kooistra NHM et al. 2018[22] | 90/F   | HTN, AF, DM, CKD | NR;3.74                | 22.9x26.5              | NR                          | Self- expandable            | Core Valve /29-mm           | NR         | 25/None                        |
| Our Case                 | 81/M    | HTN, DM, CAD  | NR;25.4                   | 24x26                  | severe                      | Balloon-expandable         | Edwards Sapien XT/ 29-mm    | transfemoral | 25/None                        |

* NR: not reported, HTN: Hypertension, AF: Atrial Fibrillation, CAD: Coronary artery Disease, CKD: Chronic Kidney Disease, COPD: Chronic Obstructive Pulmonary Disease, HF: Heart Failure, DM: Diabetes Mellitus, HLD: Hyperlipidemia, MVR: Mitral Valve Replacement
| Publication Author/ Year | Symptoms | Time of Diagnosis | VSD location | VSD shunt | VSD size | VSD severity (Qp/Qs or RVSP) | Treatment | Follow up |
|--------------------------|----------|------------------|--------------|-----------|---------|-----------------------------|-----------|-----------|
| Tzikas A et al. 2009[4]  | NR       | Peri-procedural   | Membranous   | LV to RV  | NR      | conservative                | at 12 days still alive |
| Al-Attar N et al. 2009[4] | NR       | Postmortem        | NR           | LV to RV  | small   | NR                          | death (at hospital)   |
| Massabuau P et al. 2011[4] | Dyspnoea | 12 months        | Apical       | LV to RV  | NR      | conservative                | at one year still alive |
| Martinez R et al. 2012[4] | Heart failure | Peri-procedural | Membranous   | LV to RV  | small   | NR                          | at one year still alive |
| Gerckens U et al. 2013[15] | Clinical deterioration | 7 days | Peri-membranous | LV to RV  | NR      | RVSP=65 mm Hg | percutaneous VSD closure | at 6 months still alive |
| Aminian A et al. 2013[4]  | Dyspnoea | 6 weeks          | Membranous   | LV to RV  | small   | mild                        | conservative         | at 6 months still alive |
| Rodgers V et al. 2014[4]  | Heart failure | 10 days | Peri-membranous | LV to RA  | NR      | Qp/Qs ratio=2.0             | conservative         | at 9 months still alive |
| Baruteau AE et al. 2014[4] | Clinical deterioration | 6 months | Peri-membranous | LV to RV  | NR      | Qp/Qs ratio=2.0             | percutaneous VSD closure | at 2 years still alive |
| Salizzoni S et al. 2014[4] | NR       | 7 days           | Atrio-ventricular septum | LV to RA  | NR      | Qp/Qs ratio=2.0             | conservative         | death (at 35 th day)   |
| Yanes-Bowden G et al. 2014[4] | Asymptomatic | Peri-procedural | Membranous   | LV to RV  | 6 mm    | Peak interventricular gradient 125 mm Hg | conservative         | at 2 years still alive |
| Patel Y et al. 2014[4]    | NR       | Peri-procedural  | Peri-membranous | LV to RV  | NR      | conservative                | at one month still alive |
| Patel Y et al. 2014[4]    | Asymptomatic | Peri-procedural | Peri-membranous | LV to RV  | small   | NR                          | death (at hospital)   |
| Patel Y et al. 2014[4]    | Asymptomatic | Peri-procedural | LVOT         | LV to RA  | NR      | 39 mm Hg gradient           | conservative         | alive (NR)            |
| Garrido JM et al. 2014[4] | Asymptomatic | Peri-procedural | Membranous   | LV to RV  | 1x2mm   | severe                      | surgery             | at 9 months still alive |
| Mauri L et al. 2014[16]   | Dyspnoea | 3 weeks          | sub aortic   | LV to RV  | 10x15mm | Qp/Qs ratio=3.0             | percutaneous VSD closure | at 6 months still alive |
| Dursun H et al. 2015[4]   | Asymptomatic | 4 days         | Membranous   | LV to RV  | 5mm     | Qp/Qs ratio=1.5             | percutaneous VSD closure | at 9 months still alive |
| Levi DS et al. 2015[4]    | Dyspnoea | Few days         | Peri-membranous | LV to RV  | 8x5 mm  | NR                          | percutaneous VSD closure | at 3 months still alive |
| Shakoor MT et al. 2015[4] | Dyspnoea | 30 days          | Membranous   | LV to RV  | small   | NR                          | conservative         | death (few days later) |
| Mark SD et al. 2015[4]    | Dyspnoea | Peri-procedural  | Membranous   | LV to RV  | NR      | Qp/Qs ratio=1.6             | percutaneous VSD closure | alive (NR)            |
| Lee CW et al. 2015[4]     | NR       | Peri-procedural  | Peri-membranous | LV to RV  | small   | NR                          | conservative         | at 2 months still alive |
| Rene AG et al. 2016[6]    | Dyspnoea | 1 day            | LVOT         | LV to RV  | NR      | Qp/Qs ratio=2.3             | percutaneous VSD closure | death (four months after) |
| Publication Author/ Year | Symptoms | Time of Diagnosis | VSD location | VSD shunt | VSD size | VSD severity (Qp/Qs or RVSP) | Treatment | Follow up |
|--------------------------|----------|-------------------|--------------|-----------|----------|----------------------------|-----------|----------|
| Rene AG et al. 2016[6]   | Asymptomatic | Peri-procedural | Peri-membranous | LV to RV | NR | 124 mm Hg gradient | conservative | death (at one month) |
| Rene AG et al. 2016[6]   | Dyspnoea | 3 days | Peri-membranous | LV to RV | NR | Qp/Qs ratio=1.6 | percutaneous VSD closure | at 14 months still alive |
| Rene AG et al. 2016[6]   | Asymptomatic | Peri-procedural | Peri-membranous | LV to RV | small | 94 mm Hg gradient | conservative | at one month still alive |
| Sardar MR et al.2017[4]  | Ventricular tachycardia | 9 days | Membranous | LV to RV | 4 mm | NR | conservative | at 6 months still alive |
| Sardar MR et al.2017[4]  | Clinical deterioration | Peri-procedural | Membranous | LV to RV | large | severe | valve in valve | death on the third day |
| Ohlow MA et al.2017[9]   | Heart failure | Peri-procedural | Membranous | LV to RV | NR | Qp/Qs ratio=1.7 | percutaneous VSD closure | At 16 day still alive |
| Almanfi A et al. 2017[8] | Asymptomatic | 1 day | Aortic root-RV | Aorta to RV | small | NR | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Membranous | LV to RV | <2 mm | 140 mm Hg gradient | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Membranous | LV to RV | small | minimal | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Membranous | LV to RV | 4 mm | 130 mm Hg gradient | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Muscular-near the apex | LV to RV | NR | 66.5 mm Hg gradient | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Muscular-near the apex | LV to RV | 6 mm | 88 mm Hg gradient | conservative | at one year still alive |
| Zeniou V et al.2018[7]   | NR | NR | Membranous | LV to RV | NR | 64 mm Hg gradient | conservative | at one year still alive |
| Ancona M et al. 2018[10] | Clinical deterioration | Peri-procedural | Interventricular septum | LV to RV | 10 mm | NR | surgery | at 14 day still alive |
| Chourdakis E et al. 2018[11] | Asymptomatic | Peri-procedural | Aortic root-RV | Aorta to RV | small | Qp/Qs ratio=1.75 mm Hg gradient | conservative | at 25 day still alive |
| Kooistra NHM et al. 2018[2] | Heart failure | 12 days | LVOT | LV to RV | 5 mm | 64 mm Hg gradient | percutaneous VSD closure | at one year still alive |
| Our Case                 | Heart failure | 3 weeks | Membranous | LV to RV | 8 mm | 100 mm Hg gradient, Qp/Qs ratio=1.6 | percutaneous VSD closure | at one year still alive |

* NR: not reported. LVOT: left ventricular outflow tract, LV: left ventricular, RV: right ventricular.
ciation Class III symptoms and systolic murmur in the aortic area were suggestive of an aortic stenosis, the patient underwent a transthoracic echocardiography that revealed decreased left ventricular ejection fraction (30% by Modified Simpson’s rule) and severe aortic stenosis with peak and mean aortic valve gradients of 62 mm Hg and 41 mm Hg, respectively. The calculated aortic valve area was 0.89 cm². The mean diameter of the aortic annulus was 26 mm by multi-slice computer tomography. The subsequent coronary angiogram revealed that all bypass grafts were still patent. His calculated Society of Thoracic Surgeons (STS) risk score was 25.4%. The patient was evaluated by the heart team and referred for TAVR.

The procedure was performed using a transfemoral access. The aortic valve was pre-dilated with a ZMED II 25 mm×5 cm×100 cm valvuloplasty balloon. A 29 mm Edwards Sapien XT valve was deployed during rapid ventricular pacing. Post-procedural echocardiography showed a well-seated aortic valve with a mild paravalvular leak, a peak transvalvular gradient of 9 mm Hg, and a new VSD on the membranous septum (Figure 1A). The defect was 8 mm in size, and there was a shunt directed from the left to the right ventricle with a peak systolic velocity of 5 m/s across the defect. The decision to manage the patient conservatively was made by the heart team. Subsequently, the patient showed symptomatic improvement and was discharged home on medical therapy after five days.

Three weeks after discharge, he was admitted with symptoms suggestive of biventricular failure (shortness of breath and peripheral edema). On examination, he was found to be in marked respiratory distress with oxygen saturation of 85%. The chest radiography showed pulmonary congestion (Figure 1B). The transthoracic echocardiography revealed membranous VSD, 8 mm in size, dilatation of the right chambers with moderate tricuspid regurgitation, and systolic pulmonary artery pressure of 60 mm Hg. The previously deployed aortic valve was normal in function. A subsequent transesophageal echocardiography confirmed the VSD (Video 1*). Cardiac catheterization revealed a large VSD with pulmonary to systemic blood flow ratio (Qp/Qs) of 1.6 (Video 2*). The decision to perform a percutaneous VSD closure was made. Under general anesthesia, the right femoral artery and vein were cannulated. The defect was crossed from the LV side with a Judkin’s 6 Fr right catheter and Terumo wire. This wire was advanced into the left pulmonary artery, snared, and externalized from the right femoral vein to form a wire rail (Figure 2A). A 7 Fr delivery catheter was advanced through the defect from the femoral vein to the aorta. A 10 mm VSD Occluder (AGA Medical Corp, Plymouth, MN, USA) was loaded onto its delivery system, and the distal tip of the device was partially unloaded in the ascending aorta. The entire delivery system was withdrawn until the device was placed at an appropriate site across the defect and then released (Figure 2B, Video 3*). The transesophageal echocardiography confirmed there was no residual shunting through the device. The patient reported pronounced improvement in his symptoms and was discharged home after three days. He remained stable at the one-year follow-up.

**DISCUSSION**

With favorable results from sequential randomized clinical trials, TAVR has been increasingly performed in nearly 66,000 patients annually in USA, and the occurrence of rare complications has become more apparent. In retrospective analyses, iatrogenic VSD occurs in 0.4% to 1.5% following TAVR. However, to date, only 37 cases of those have been published in English literature. Owing to late or uncertain presentation and lack of suspicion, the diagnosis of VSD after TAVR in most patients is thought to have been missed. Here, we report a case of VSD after TAVR, the first event in 220 case series performed at our center, which was successfully treated by percutaneous VSD closure. We have also sought to describe reported literature, the patient characteristics, possible risk factors, procedural details, and clinical outcomes. The clinical features of the reported cases are summarized in Tables 1 and 2.

The patients were between 57 and 93 years old with a median age of 86 years, and 60% of them were women. The mean STS and Logistic Euro Scores risk scores were 9.4±3.9, n=13 and 21.1±9.4, n=16, respectively. In patients for whom access site data were available (n=26), the femoral artery was the most widely (n=22, 84%) used access site for TAVR. The balloon-expandable valves were predominantly used than self-expandable valves (75% vs. 25%, respectively). Post-dilatation data were available for 16 patients where post-dilatation was performed in five of them (31%).

Several potential risk factors have been implicated for VSD following TAVR including elliptic aortic annulus; severe, asymmetric calcification of the aortic annulus; oversizing or higher placement of the valve; and direct trauma of the rigid wire. In most cas-
Ventricular septal defect following TAVR

In this case report, we present a patient with iatrogenic VSD, a rare complication following TAVR, who was successfully treated by percutaneous VSD closure. We also reviewed the reported literature and the patient characteristics, possible risk factors, procedural details, and clinical outcomes. It is, now, the current review on iatrogenic VSD following TAVR. The insights gained from this report are that most patients with iatrogenic VSD following TAVR were hemodynamically stable and did not require VSD closure. The management was generally conservative; however, percutaneous closure seemed to be an applicable strategy.

*Supplementary video files associated with this article can be found in the online version of the journal.*

**Informed Consent:** Written informed consent was obtained from the patient for the publication of the case report and the accompanying images.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Materials – Ö.K.; Data Collection and/or Processing – G.S.; Literature Search – S.Y.; Writing – G.S., S.Y.; Critical Revision – S.T.

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**Conflict of Interest:** None.

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es, it is thought to emerge by perforation of the interventricular septum after implantation of the rigid stent frame into the aortic annulus. The injury can be associated with a wide variety of manifestations including extension into the RV outflow tract and the right or left atria and focal rupture of the annulus underneath the left coronary artery in which an aorta–ventricular gap occurs. The most vulnerable sections to injury can be predicted by assessing the severity and symmetry of calcification of the aorta and the adjacent structures. In a previous study evaluating the variables that increase the risk for aortic root rupture in patients who had undergone TAVR, the authors reported that the risk of sub-annular rupture was high if a narrow and bulky calcification of the left ventricular outflow tract (LVOT) was present.

After reviewing the previous cases, 19 patients had data on the grade of LVOT calcification of whom 13 (68.4%) had severe calcification. Both annulus and valve size were reported in 16 patients; however, oversizing had been detected in only three (18%) of them. The higher placement of the aortic valve was speculated to be a predisposing factor in only one case.

The location of VSD was predominantly membranous (n=16, 42%) or peri-membranous (n=10, 26%), and most of those (n=15, 39%) were diagnosed during or immediately after the procedure. Nine patients were asymptomatic at the time of diagnosis; however, dyspnea was the most common symptom (n=14, 36%). Management was generally conservative (n=23, 60%). One patient was treated by valve in valve therapy and two were treated by open heart surgery. In 11 (28%) patients, including our case, the preferred therapy was a percutaneous VSD closure, performed four days to six months following TAVR. An antegrade approach was used more than retrograde approach in patients treated with percutaneous closure (n=8 vs. n=3, respectively). Only in one patient with percutaneous closure, the femoral artery occluded during the procedure, and that patient was successfully treated with peripheral bypass surgery. The rest of the patients who underwent percutaneous closure had no complications of either vascular access or valve dysfunction.

In previous reports, follow-up periods for patients diagnosed with VSD following TAVR were variable in length. 12 days to two years. Total mortality was 18% (n=7) of which most were reported as in-hospital mortality (n=4). At the end of the follow-up periods, median nine months, 81% of the patients were still alive. Mor-
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