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Percutaneous closure of paravalvular mitral regurgitation with Vascular Plug III under the guidance of real-time three-dimensional transesophageal echocardiography

Paravalvüler mitral yetersizliğinin gerçek zamanlı üç boyutlu transözafajiyal ekokardiyografi eşliğinde "Vascular Plug III" ile perkütan olarak kapatılması

Mehmet Özkan, M.D., Ozan Mustafa Gürsoy, M.D., Mehmet Ali Astarcıoğlu, M.D., Nina Wunderlich, M.D.,[#] Horst Sievert, M.D.[#]

Department of Cardiology, Koşuyolu Kartal Heart Training and Research Hospital, Istanbul, Turkey;
[#]Department of Cardiology, Cardiovascular Center Frankfurt, Frankfurt, Germany

Summary– Transcatheter closure of mitral prosthetic paravalvular leak (PVL) has been hampered by technical challenges and the lack of closure devices specifically designed for this purpose. The oblong cross-sectional shape of the Amplatzer Vascular Plug III device (AVP) may be a more appropriate choice to be deployed for mitral PVL's. Real-time three-dimensional transesophageal echocardiography (RT-3D TEE) has emerged as an efficient tool that provides essential information concerning leakage size, location, and shape as well as navigation of catheters and wires. We assessed the feasibility and short, mid, and long-term efficacy of transcatheter mitral PVL closure using AVP-III under the guidance of RT-3D TEE. Three patients with severe symptomatic mitral PVL at high risk for repeat surgery underwent transcatheter leak closure with AVP III. Transfemoral approaches were used under RT-3D TEE guidance. Transcatheter closure of mitral PVLs was performed successfully in 3 patients using 5 devices. The first patient with 2 devices deployed had residual mitral regurgitation resulting in re-operation at the sixth month. The second patient had improved normally with a functioning prosthesis after the deployment of two devices, but had progressively worsening mitral regurgitation for which re-operation at the sixteenth month of follow-up was necessary. The third patient had no residual leak, with normal prosthetic function. At 24 months follow-up, all patients were in satisfactory clinical status. Although RT-3D TEE plays an essential role in guidance of transcatheter closure of mitral PVLs with AVP III, the absence of a specific closure device limits mid and long-term success rates.

Özet– Teknik zorluklar ve spesifik cihazların olmaması mitral kapağın paravalvuler kaçaklarının (PVK) perkütan olarak kapatılması sırasında sıkıntıya yol açmaktadır. Amplatzer Vascular Plug III (AVP) uzunca ve dikdörtgenimsi yapısı nedeniyle mitral kapak PVK'larının perkütan olarak kapatılmasında uygun seçenek gibi görünmektedir. Gerçek zamanlı 3 boyutlu transözafajiyal ekokardiyografi (GZ-3B TÖE) defektin boyutu, şekli ve yeri hakkında önemli bilgiler sağlar ve kapatma işleminde kateter ve tel kullanımına kılavuzluk eder. Bu çalışmada GZ-3B TÖE eşliğinde AVP III cihazı kullanılarak yapılan mitral kapağın PVK'sı perkütan olarak kapatma işleminin kısa ve uzun dönem sonuçları araştırıldı. Semptomlu ileri mitral kapak PVK'sı olan 3 hastaya yüksek cerrahi risk nedeniyle transkateter yolla PVK kapatma işlemi yapıldı. GZ-3B TÖE eşliğinde transfemoral yaklaşım uygulandı. Üç olguda da AVP III kullanıldı. Üç hastada toplam 5 cihaz kullanılarak işlem başarıyla tamamlandı. İlk hastada 2 cihaz yerleştirilmesine rağmen mitral yetersizliğinin devam etmesi ve artması üzerine 6. ayda cerrahi onarım yapıldı. İkinci hastada 2 cihaz implantasyonuyla kapak fonksiyonları düzelmesine karşın, daha sonra ilerleyici paravalvuler yetersizlik gelişmesi sebebiyle 16. ayda cerrahi girişimle kaçak düzeltildi. Üçüncü hastanın işlem sonrası ve takip süreci sorunsuz seyretti. Tüm hastaların klinik durumu 24 aylık izleme süresince kararlı idi. Bir tanı yöntemi olan GZ-3B TÖE, mitral kapak PVK'sının perkütan olarak kapatılması sırasında önemli bir yardım sağlamasına rağmen, defekte spesifik cihazların geliştirilmemiş olması orta ve uzun dönemde işlem başarısını düşürmektedir.

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Correspondence: Dr. Ozan Mustafa Gürsoy. Koşuyolu Kartal Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Kardiyoloji Kliniği, 34846 Cevizli, Kartal, İstanbul, Turkey.
Tel: +90 - 216 - 500 15 00 e-mail: m.ozangursoy@yahoo.com

Paravalvular leaks (PVLs) are potential complications of mitral valve replacement. Most are asymptomatic and benign, but some may cause symptoms due to heart failure, arrhythmia, endocarditis or hemolysis. Medical therapy is palliative, while re-operation is associated with significant morbidity and mortality.[1] Percutaneous transcatheter closure procedures have been performed for the treatment of PVLs using a variety of techniques. Evaluation of anatomic location and spatial orientation of the PVL by transthoracic echocardiography and two-dimensional transesophageal echocardiography (2D TEE) is difficult due to technical challanges. The introduction of real-time three-dimensional transesophageal echocardiography (RT-3D TEE) offers enhanced imaging quality of the mitral valve in real time.[2-5]

Abbreviations:

AVP	*Amplatzer Vascular Plug*
MR	*Mitral regurgitation*
NHYA	*New York Heart Association*
PVL	*Paravalvular leak*
RT	*Real time*
TEE	*Transesophageal echocardiography*
2D	*Two-dimensional*
3D	*Three-dimensional*

We present three patients who underwent percutaneous closure of mitral paravalvular regurgitation with Amplatzer Vascular Plug (AVP) III after informed consent was obtained.

CASE REPORT

Case 1– A 33-year-old woman was admitted to the hospital with tachycardia and progressive dyspnea. She had a mitral prosthesis which was replaced twice due to repeated prosthetic valve endocarditis. She had haemolytic anemia and she required frequent blood transfusions over a period of 4 months. 2D-TEE and full volume RT-3D TEE (transducer X7-2t, Philips Electronics, Andover, MA) revealed two separate severe mitral regurgitations (MR) (Fig. 1a, 1b). PVL defects (Zone-II, clockwise, between 04-05 and Zone-III, clockwise, between 08-09.30) were defined as previously[3] described (Fig. 2). The size of the PVLs was measured (11x3 mm and 13x4 mm) using calibration markings on the RT-3D TEE image grid (Fig. 3a, Table 1). Percutaneous PVL closure was scheduled due to the high risk of redo surgery and an AVP III (12x3 mm, AGA, Medical Corporation, Minneapolis, MN) was deployed (Fig. 3b). A second device, AVP III (14x5 mm) was placed to the second

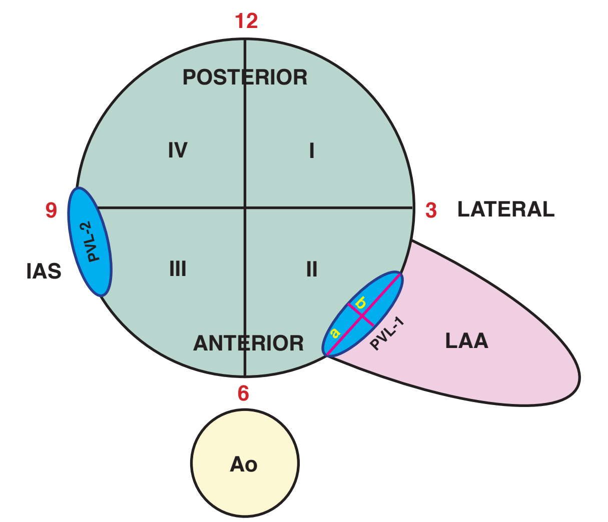

Figure 2. Patient 1: Schematic view of paravalvular leak localizations arranged in relation to the anterior aspect of the aorta as defined on a clock format scale. IAS: Interatrial septum; Ao: Aorta; LAA: Left atrial appendage; a: Maximum length of the defect (mm); b: Maximum width of the defect (mm); PVL-1, and 2: Paravalvular leak localizations.

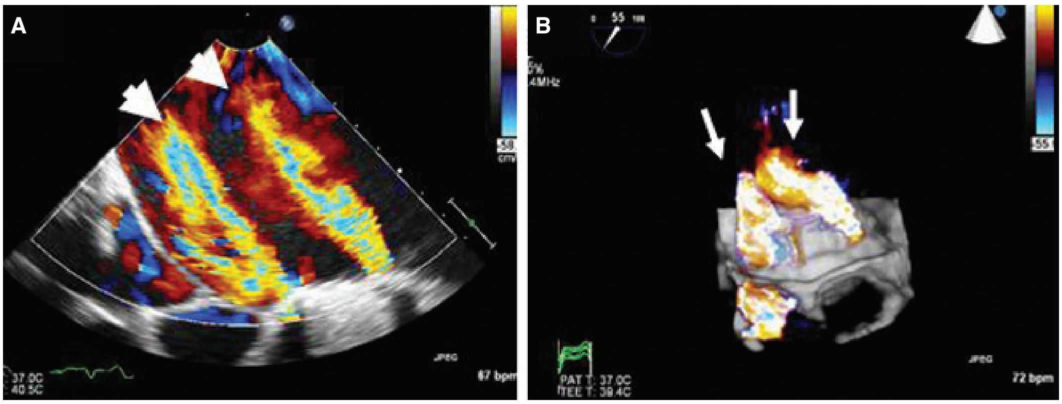

Figure 1. Patient 1: Multidimensional echocardiographic evaluation of a prosthetic mitral paravalvuler leak. **(A)** A 2D TEE with colour flow demonstrating (arrowheads) severe paravalvular regurgitation. **(B)** Real-time-3D TEE full volume reconstruction demonstrating paravalvular leaks.

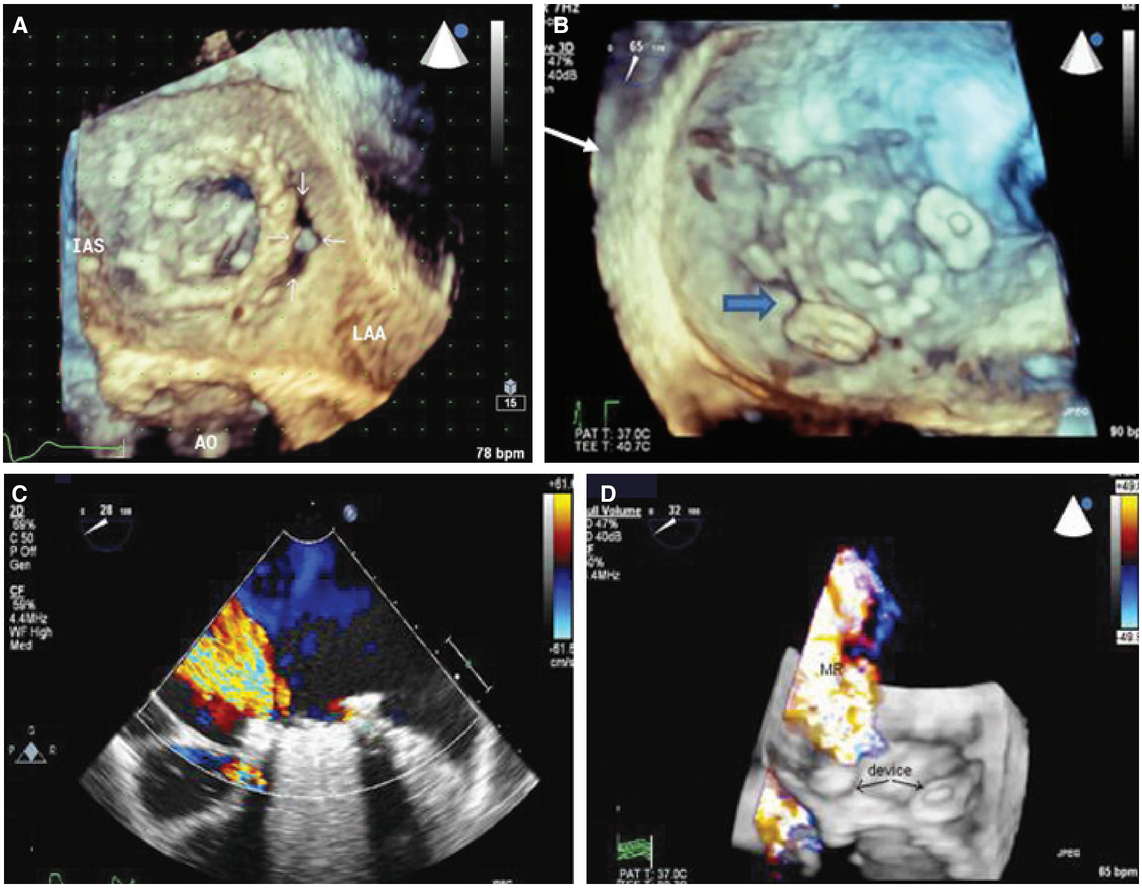

Figure 3. Patient 1: **(A)** One of the irregular shaped defects (arrows) causing paravalvular regurgitation. Size was measured by image grid method. The distance between two points is 5 mm. IAS: Interatrial septum; LAA: Left atrial appendage; Ao: Aorta. **(B)** Two Amplatzer AVPIII occluders. A residual defect next to the device which was not properly covered by the occluder device is seen in Zone III (arrow). Persisting moderate MR through one of the occluder devices (medial, Zone III) on **(C)** 2D TEE colour flow and, **(D)** full volume image of RT-3D TEE.

defect in Zone-III which was considered irregularly shaped. This resulted in considerable reduction of mitral regurgitation severity delineated by conventional TEE and full volume RT-3D TEE. However, moderate MR persisted adjacent to one of the devices (Fig. 3c, 3d). Six months later, the patient was admitted to our institution with New York Heart Association (NYHA) class III heart failure. Dehiscence around the proximal part of the occluder device was detected by RT-3D TEE. The MR was finally, considered as moderate to severe by full volume RT-3D TEE. The patient was referred to surgery and underwent a successful re-operation. 2D and RT-3D TEE performed at 1, 6, and 12 months after surgery showed a normally functioning mechanical mitral valve without signs of any PVL. Clinical, laboratory and echocardiographic parameters were improved during this follow-up period (Table 1).

Case 2– A 42-year-old man who had a history of combined mitral (twice) and aortic valve replacement presented to the emergency department with dyspnea (NYHA class III) and pulmonary edema. 2D TEE detected a mitral prosthetic PVL defect measuring 5 mm in width (Fig. 4), and severe MR was demonstrated both by 2D TEE and RT-3D TEE. RT-3D TEE revealed an irregular, slope tunnel shaped defect (19x6 mm) measured by the grid method (Fig. 5a). Following stabilization of the patient's clinical status, percutaneous closure of PVL was scheduled due to the high risk of re-operation and an AVP III (14x3 mm) was deployed. A second AVP III (12x3 mm) was required and placed (Fig. 5b) adjacent to the first under RT-3D TEE guidance, with a final residual mild to moderate MR. Residual MR persisted and worsened on serial 2D TEE and RT-3D TEE follow-up at 1, 6, 9, 12 and 14 months with progression of hemolytic anemia. The

Table 1. Clinical, echocardiographic and laboratory findings of the 3 patients during 24 months of follow-up

Case		1						2							3				
Month	BP	1	6	12	18	24	BP	1	6	12	16	18	24	BP	1	6	12	18	24
NHYA	III	II	III	I	I	I	III	II	II	III	III	I	I	III	I	I	I	I	I
EF%	53	60	61	65	65	65	63	65	58	60	55	60	66	55	60	57	62	65	67
LVEDD	6.2	5.7	5.9	5.7	5.5	4.9	4.2	4.3	4.5	4.6	4.8	4.6	4.6	4.6	4.0	4.5	4.6	4.5	4.6
LVESD	4.9	4.5	4.7	4.2	4.0	3.3	2.5	2.6	2.7	3.5	3	2.8	2.9	2.6	2.4	2.3	2.4	2.4	2.5
LA	6.3	6.0	6.3	6.1	6.0	5.9	4.6	4.6	4.7	4.9	4.9	4.8	4.6	4.6	4.5	4.4	4.4	4.4	4.5
MG	10	7	10	4	4	4	9	6	6	8	8	5	4	9	4	3	3	4	4
PAP	45	40	45	28	25	25	45	40	39	45	51	40	32	70	55	55	45	45	40
Hb	8.6	11	10	14	14	14	8.8	12.4	9.8	9.7	8.9	11.9	13	8.5	10.9	12.2	12.1	12.6	13
Hct	28	35	31	40	40	41	29	36.6	33.1	30	30	37	42	27	33	37.5	37	37	41
CRP	0.6	0.6	0.4	0.2	0.5	0.3	1.2	0.7	0.9	0.3	0.8	0.2	0.3	6	0.6	0.7	0.1	0.6	0.3
LDH	1748	1215	1512	588	350	380	1617	804	1042	1401	2416	790	452	1408	683	590	550	662	516
BNP	588	298	328	60	41	49	631	437	350	448	588	291	112	496	150	103	61	63	52
*RT-3D	PVL-1	11.3x3					19x6							12x4					
TEE (mm)	PVL-2	13x4																	
**2D	PVL-1	4					5									N/A			
TEE (mm)	PVL-2	N/A																	

BP: Before the procedure; NYHA: New York Heart Association; EF%: Ejection fraction; LVEDD: Left ventricle end-diastolic diameter; LVESD: Left ventricle end-systolic diameter; LA: Left atrium; MG: Mechanical mitral valve mean gradient; PAP: Pulmonary artery pressure; Hb: Hemoglobin; Hct: Hematocrit; CRP: C-reactive protein; LDH: Lactate dehydrogenase; BNP: Brain natriuretic peptide; PVL: Paravalvular leak; RT-3D TEE: Real time three dimensional transesophageal echocardiography; 2D-TEE: Two dimensional transesophageal echocardiography; N/A: Not applicable.

patient was referred to surgery at the 16th month of follow-up and underwent successful reoperation. 2D TEE and RT-3D TEE revealed a normally functioning mitral mechanical valve without signs of PVL at the post-operative 6th month. Clinical and laboratory findings were significantly improved (Table 1).

Case 3– A 42-year-old woman presented with severe anemia and NYHA class III heart failure complicated by dehiscence of the prosthetic mitral valve. She had a history of mitral valve replacement twice. On admission, 2D TEE and full volume RT-3D TEE showed severe paravalvular MR. RT-3D TEE clearly depicted a 12x4 mm slit-like shaped PVL in Zone-II, clockwise between 04-06 (Fig. 6a).

A percutaneous transcatheter closure of the leak was performed. Regarding two previous surgical interventions, an AVP III (12x5 mm) was implanted (Fig. 6b). The patient was discharged 6 days later uneventfully

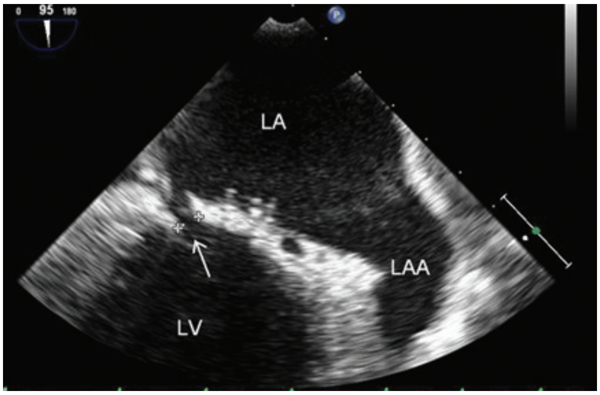

Figure 4. Patient 2: 2D TEE showing the width of the paravalvular defect (arrow). LV: Left ventricle, LA: Left atrium, LAA: Left atrial appendage.

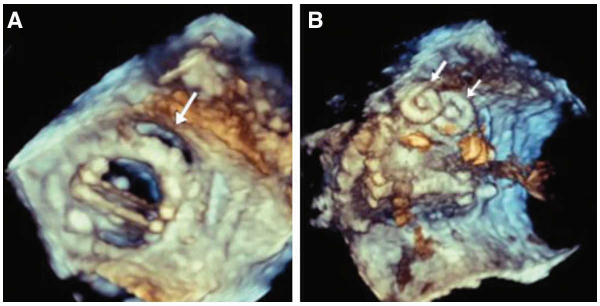

Figure 5. Patient 2: **(A)** RT-3D TEE visualization of the irregular, slope tunnel shaped and large paravalvular defect (arrow), in the Zone-1, clock format between 01 and 03. **(B)** RT-3D TEE appearance of the left atrial side of the closure devices (arrows) after positioning through the paravalvular defect.

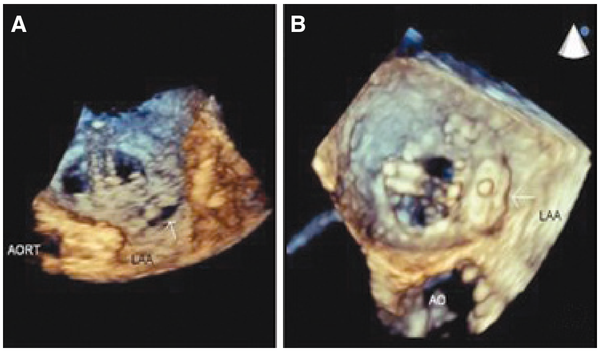

Figure 6. Patient 3: **(A)** RT-3D TEE image of the mitral annulus and mechanical valve en-face from the left atrium. White arrow shows the slit-like paravalvular defect **(B)** in the Zone II. Occluder device has been introduced and successfully deployed across the defect without impingement of the adjacent mechanical valve.

with improved clinical and laboratory findings, unaltered at 24 months follow-up (Table 1).

DISCUSSION

In 2009, five AVP III devices were deployed in 3 patients; two patients received two devices each. All procedures were performed successfully under 2D and RT-3D TEE and fluoroscopy guidance. In the first patient, a residual moderate leak was detected after deployment of two devices. However, MR became severe at the 6th month follow-up necessitating the surgical closure of PVLs. In the 2nd patient, two devices were implanted adjacently for severe paravalvular MR but resulted in a mild to moderate residual MR. However, later on, the leak caused moderate to severe MR, and surgical intervention became mandatory at 16 months of follow-up. The 3rd patient had a successful outcome without any clinical events during the follow-up period. At the end of 24 months, all patients were in satisfactory clinical status, with stable hematological parameters.

Interventional PVL occlusion has been performed relatively recently in highly selected patient populations. Although the concept seems simple, these procedures present a technical challenge.

Long-term clinical success is limited with the use of off-label existing devices for PVL closure, necessitating the need to design a PVL specific closure device. Despite these challenges associated with transcatheter PVL closure, a new and exciting technique has emerged in the past few years as an imaging tool: RT-3D TEE. The advantages of RT-3D TEE over 2D TEE for PVL repair include: the rapid assessment of the size, site, and shape of the defect, assessment of the extent of the regurgitation with the use of 3D full volume, and more accurate positioning of devices in relation to surrounding structures. With the availability of RT-3D TEE, we are now able to manipulate the exchange guide wire and delivery catheter, to facilitate accurate positioning of the closure device. In addition, 3D echocardiography can be used immediately to assess device stability, interaction with surrounding structures, and to ensure proper functioning of the prosthetic valve, and to evaluate residual PVL after percutaneous closure.

Failure of the procedure can be related to several conditions. The first, is the inability to deploy the device properly in the defect. On the basis of our case series and some studies published on isolated cases, the anatomic characteristics of the leak (i.e. shape, size, localization) could effect the success rate of implantation, leading to highest success rates in the small, slit-like or small crescent shaped, and single defects, but poorer results in larger, irregular and slope tunnel shaped and multiple defects. Furthermore, the degree of regurgitation could persist despite implantation of more than one device. Regarding our observation in this case series, failure of closure is seen frequently in the larger defects that are covered partially by the device. In one of our cases, the failure was due to selection of an improper device unsuitable for a large, irregular and slope tunnel shaped defect, while in another case, it was due to presence of more than one defect. On the basis of these findings, we can suggest that larger, irregular, slope tunnel shaped and multiple defects are more likely to lead to significant postprosthetic insufficiency following percutaneous closure of PVLs, as observed in our Patients 1 and 2. To best of our knowledge, there is no cutoff values regarding recommended PVL sizes for percutaneous closure. However, if the defect is large (exceeding 25% of the circumference), a single device is unlikely to be sufficient. Additionally, when the defect is larger than 25% of the circumference the prosthesis may rock and it may be inadvisable to proceed with percutaneous closure because of the high risk of device embolization.[6,7] Also, an ongoing process of endocarditis should be excluded. If a leak is getting rapidly larger in a short period of time, it may indicate an ongoing process of suture/tissue rupture and percutaneous closure may be unreasonable.

One of the major problems is certainly the adaptation of the device to the shape of PVL. The off-label use of closure devices is likely a major reason for incomplete occlusion of the PVLs. A consistent protocol has not been agreed upon for the selection of occluder devices. A variety of devices have been used; most frequently Amplatzer Ductus Occluder and Amplatzer Vascular Plug II occluders. PDA or VSD-dedicated occluders can be used for round-shaped PVLs, whereas AVP III might be more appropriate for slit-like or small crescent-shaped PVLs, as deployed in the 3rd patient. The Amplatzer series have potential advantages of closing defects of different morphology and diameter with its flexible nitinol waist. The unique shape and oblong cross-sectional size of AVP III may provide greater conformability to a range of slit-like or small crescent shaped PVL; therefore AVP III is more suitable than a round device. AVP III also provides the fastest occlusion among all AVPs due to its unique lobe shape and additional layer(s) of dense nitinol mesh. Stability is enhanced by the extended rims of AVP III, in which 2 mm larger than the distal

Table 2. List of current literature for percutaneous closure of PVLs (2D TEE)

Study performers	Year	A	B	Occluder device (Nr)	C	D*	E**	Imaging (TEE)
Hourihan et al.[10]	1992	8	Ao	Double Umbrella	9	87	50 (6-50)	2D
Moscucci et al.[11]	2001	1	M	Gianturco Coil	2	100	N/A	2D
Eisenhauer et al.[12]	2001	1	M	Gianturco Coil	1	100	100 (24)	2D
Boudjemlin et al.[13]	2002	1	M	ASO	2	100	N/A	2D
Webb et al.[14]	2005	1	Ao	ADO	1	100	100 (12)	2D
Pate et al.[6]	2006	10	M(9), Ao	ASO (2), ADO Coil(5)	7	70	40 (5)	2D
Dussaillant et al.[15]	2006	1	Ao	ADO	1	100	100 (12)	2D
Hein et al.[16]	2006	21	M	ADO(8), ASO(5),VSD(13)	26	57	33 (12)	2D
Feldman et al.[17]	2006	1	Ao	ADO	1	100	100 (0.5)	2D
Sivakumar et al.[18]	2007	1	M	ASO	1	100	100 (4)	2D
Ussia et al.[19]	2007	1	M	VSD-O	1	100	0 (2)	2D
Hildick et al.[20]	2007	1	Ao	VSD-O	1	100	N/A	2D
Shapira et al.[21]	2007	10	M(10), Ao(3)	ADO(6), ASO,VSD(5)	12	82	46 (6)	2D
Momplaisir et al.[22]	2007	1	M	ASO	1	100	N/A	2D
Sorajja et al.[23]	2007	16	M	ASO(6), ADO(14)	21	81	62 (3)	2D
Cortes et al.[24]	2008	27	M	ADO	37	63	37 (1)	2D
Lasorda et al.[25]	2008	1	M	ADO	1	100	N/A	2D
Bhindi et al.[26]	2008	1	Ao	VSD	1	100	N/A	2D
A.Briales et al.[27]	2009	8	M(4), Ao(4)	ADO	8	50	50 (12)	2D
Fernandez et al.[28]	2009	8	M	ADO	7	63	38 (15)	2D
Phillips et al.[7]	2009	1	Ao	ASO	2	100	N/A	2D
Kuehl et al.[29]	2009	1	M	ADO	1	100	0 (15)	2D
Alfirevic et al.[30]	2009	1	M	VSD-O		100	0 (N/A)	2D
Chiam et al.[31]	2010	1	M	ADO	1	100	100 (2)	2D
Sriratanaviriyakul et al.[32]	2011	1	M	AVP II	3	100	N/A	2D
Cappelli et al.[9]	2011	1	M	AVPIII	1	100	N/A	2D-ICE

A: Number of patients; B: Prosthetic valve with paravalvular leak; C: Number of occluder device; D: Initial success rate (%); E: Follow-up success rate (%) (months).
ADO: Amplatzer Duct Occluder; ASO: Amplatzer Septal Occluder; VSD-O: Ventricular septal defect occluder; TEE: Transesophageal echocardiography; 2D: Two-dimensional; RT-3D: Real-time three-dimensional; M: Mitral; Ao: Aort; N/A: Not available; AVP: Amplatzer vascular plug.
ICE: Intracardiac echocardiography (Additional imaging modality).
* Initial success rate includes successful deployment of occluder device with diminished degree of paravalvular leak.
** Follow-up success rate includes absence of death, stroke or severe paravalvular leak without need for reoperation during follow-up.

lobe body are designed to improve wall apposition. In addition, the small radiopaque marker located on the long edge of the distal rim provides improved visualization of orientation. The device is ideal for high flow situations, but still unsuitable for larger and irregular shaped defects, as observed in two of our patients. One solution would be to deploy a second or even third device. However, creating crescent-shaped or slit-like shaped devices of different sizes or devices covered with soft, adaptable tissue to minimize PVL would be an important step forward. Future perspectives may include characteristics of a defect-specific device having a double-disc of oblong form, variable waist length, and small, flange and dense body structure, made of bioabsorbable and anticoagulant-eluting material. Nowadays the transapical approach for certain defects in the mitral position[8,9] and improved visualization capabilities by intracardiac or RT-3D TEE especially for aortic position can be successfully performed. Transseptal closure first described in 1992,[10] is being increasingly used for closure, especially in poor surgical candidates. The published experiences

Table 3. List of current literature for percutaneous closure of PVLs (RT-3D TEE)

Study performers	Year	A	B	Occluder device (Nr)	C	D*	E**	Imaging (TEE)
Nikolic et al.[33]	2008	1	M	VSD-O	1	100	100 (6)	RT-3D
Little et al.[2]	2009	1	M	ADO	2	100	N/A	RT-3D
Hammerstingl et al.[34]	2009	1	M	AVP III	1	100	N/A	RT-3D
Wunderlich et al.[35]	2009	1	M	AVP III	1	100	N/A	RT-3D
Delabays et al.[36]	2009	1	M	ADO	1	100	N/A	RT-3D
Bavikati et al.[37]	2009	1	M	ADO	1	100	N/A	RT-3D
Biner et al.[4]	2010	6	M	N/A	7	100	N/A	RT-3D
Kursaklioğlu et al.[38]	2010	1	M	ADO	1	100	100 (15)	RT-3D
Fernandez et al.[5]	2010	14	M	ADO	15	28	N/A	RT-3D
Nietlispach et al.[39]	2010	5	M(4), Ao	AVPIII(5), ADO(2)	7	100	100 (6)	RT-3D
Yuksel et al.[40]	2011	1	M	VSD-O	1	100	N/A	RT-3D
Bugunovic et al.[41]	2011	1	M	AVP III	1	100	N/A	RT-3D
Hoffmayer et al.[42]	2011	1	Ao	VSD-O	2	100	100 (12)	RT-3D
Siddiqi et al.[43]	2011	1	M	VSD-O	1	100	100 (1.5)	RT-3D
Iyisoy et al.[44]	2011	1	Tr	ADO II	1	100	N/A	RT-3D
Ruiz et al.[45]	2011	43	M(38), Ao(11)	ADO, VSD-O AVPII, ASO (N/A)	49	86	65 (18)	4D-CTA 2D-TEE RT-3D#
Smolka et al.[46]	2011	1	Ao	AVP II	1	100	100 (1)	RT-3D
Hammerstingl et al.[47] †	2011	1	M	AVP III	1	100	100 (1)	RT-3D
Tay et al.[48]	2011	1	M	AVP II	1	100	N/A	RT-3D
Sorajja et al.[49]	2011	126	M(99), Ao(27)	ASO(12), ADO(20) AVPII(77), VSD(10)	119	76	57 (36)	2D-TEE RT-3D#
Swaans et al.[8] †	2011	7	M(6), Ao	AVP III	7	100	71 (3)	RT-3D
Present study	2011	3	M	AVP III	5	100	33 (18)	RT-3D

A: Number of patients; B: Prosthetic valve with paravalvular leak; C: Number of occluder device; D: Initial success rate (%); E: Follow-up success rate (%) (months).

Tr: Tricuspid; 4D-CTA: Four-dimensional computed tomographic anjiography; ADO: Amplatzer Duct Occluder; ASO: Amplatzer Septal Occluder; VSD-O: Ventricular septal defect occluder; TEE: Transesophageal echocardiography; 2D: Two-dimensional; RT-3D: Real-time three-dimensional; M: Mitral; Ao: Aort; N/A: Not available; AVP: Amplatzer vascular plug.

Number of RT-3D TEE studies not reported; † All of the patients were performed transapically using AVP III under the guidance of RT-3D TEE.

* Initial success rate includes successful deployment of occluder device with diminished degree of paravalvular leak.

** Follow-up success rate includes absence of death, stroke or severe paravalvular leak without need for reoperation during follow-up.

are relatively limited and generally based on case reports with a few large case series, mostly involving mitral PVLs. Table 2 and Table 3 list the current literature about transcatheter PVL closure excluding the very limited numbers of pediatric cases. The reported cases which involved mitral, aortic and tricuspid PVLs were 80.3%, 19.4%, 0.3% respectively.[2,4,6-49] Amplatzer Ductus Occluder, Amplatzer Vascular Plug II, Ventricular Septal Occluder, Amplatzer Septal Occluder, Amplatzer Vascular Plug III, Double Umbrella and Gianturco coil devices were used as 41%, 27%, 12%, 11%, 6%, 2% and %1, respectively. Although the mean initial short-term success rate was approximately 92 %, ≥3 months of follow-up success rate was 58% in data-available patients. Success rate seems to be gradually decreasing during long-term follow-up.

Clinical, laboratory and echocardiographic parameters such as improvement in NYHA class, resolution of anemia, gradual decrease in lactate dehydrogenase, brain natriuretic peptide and C reactive protein levels, improvement in mean gradients of mitral mechanical valve and pulmonary artery pressure were all evaluated during the 24 month follow-up of these 3 cases (Table 1).

Conclusion

We presented three patients who underwent percutaneous closure of PVLs with five AVP III devices under the guidance of RT-3D TEE which allows 'en-face' views of the PVL and unique perspectives of the catheter and device placement. All cases demonstrate the novel use of 3D full volume colour Doppler and image grid method in the assessment of localization, shape and size of the PVLs. Success rate of percutaneous closure of mitral valves, even with AVP III deployment, seems to be disappointing. Although RT-3D TEE may enhance immediate technical success, long-term clinical success is limited with the use of off-label existing devices for PVL closure, necessitating the need to design a specific closure device.

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Key words: Adult; angiography; heart catheterization/methods; heart septal defects, ventricular/therapy; instrumentation; mitral valve insufficiency/etiology.

Anahtar sözcükler: Erişkin; anjiyografi; kalp kateterizasyonu/yöntem; kalp septal defekti, ventriküler/tedavi; enstrümantasyon; mitral kapağı yetersizliği/etyoloji.