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Tricuspid Valve-in-Valve Procedure: What to Do When the Bioprosthetic Valve Is Not Visible on Fluoroscopy? Challenges and Step-by-Step Description of the Procedure

Triküspit Valve-in-Valve İşlemi: Biyoprotez Kapak Floroskopide Görünmediğinde Ne Yapmalı? Zorluklar ve Prosedürün Adım Adım Açıklaması

ABSTRACT

The main disadvantage of bioprosthetic heart valves is their potential for degeneration in the medium to long term. Due to the high risk associated with reoperation, the percutaneous valve-in-valve (ViV) approach is preferred for patients with bioprosthetic degeneration following tricuspid valve replacement. However, the procedure can be challenging when the implanted bioprosthetic valve is not radio-opaque. We present three cases performed at our hospital, detailing a step-by-step approach and alignment techniques when the valve is not visible on fluoroscopy. All patients were admitted with right heart failure and demonstrated severe dysfunction of their tricuspid bioprosthetic valves. In the first case, the bioprosthetic valve was clearly visible on fluoroscopy, which facilitated the alignment process. In the other two cases, the valves were not visible. Predilation was performed, and the resulting indentation line served as a reference. Echocardiographic (ECHO) imaging, along with right atrial and ventricular angiograms, was used to guide the alignment of the balloon-expandable valve. The ViV procedure was successful in all three cases. The transcatheter ViV approach appears to be an effective treatment option for patients with tricuspid bioprosthetic valve degeneration. In cases where the valve is not radio-opaque, the procedure can be safely performed by using the indentation point from balloon dilatation, right ventricular and atrial angiography, and transthoracic or transesophageal echocardiography to guide valve alignment.

Keywords: Bioprosthetic valve dysfunction, percutaneous valve replacement, tricuspid bioprosthetic valve, tricuspid valve-in-valve

ÖZET

Biyoprotez kalp kapaklarının en büyük dezavantajı orta ve uzun vadede dejenerasyon gelişmesidir. Triküspit kapak replasmanı sonrası biyoprotez dejenerasyonu gelişen hastalarda yeniden ameliyat riskinin yüksek olması nedeniyle perkütan valve in valve (ViV) yaklaşımı tercih edilmektedir. Biyoprotez kapak radyo-opak olmadığında işlemin zorlayıcı yönleri olabilir. Hastanemizde gerçekleştirilen 3 tirküspit ViV olgusunu sunmayı, işlemin adım adım yapılışını ve floroskopide kapak görünmediğinde hizalamanın nasıl gerçekleştirildiğini tarif etmeyi amaçladık. Sağ kalp yetersizliği ile başvuran hastaların triküspit biyoprotez kapaklarında ciddi disfonksiyon görüldü. Ameliyat notları gözden geçirildi ve ViV aplikasyonu kullanılarak kapak boyutları belirlendi. İlk hastada biyoprotez kapak floroskopide açıkça görülüyordu ve kapağı hizalarken zorluk yaşanmadı. Ancak diğer iki hastanın biyoprotez kapakları floroskopide görülmüyordu. Predilatasyon yapıldı ve indentasyon çizgisi referans olarak kullanıldı. Balonla genişletilebilir kapak hizalanırken EKO görüntüleme ve sağ atriyal/ventriküler anjiyogramlar yapıldı. ViV işlemi her 3 vakada da başarılı oldu. Transkateter ViV işlemi triküspit biyoprostetik kapak dejenerasyonu olan hastalar için iyi bir tedavi seçeneğidir. Kapağın radyo-opak olmadığı durumlarda, balon dilatasyonu sırasındaki indentasyon noktasına dikkat edilerek, sağ ventrikülografi ve sağ atriyografiler yapılarak ve EKO kılavuzluğundan faydalanılarak yeni kapağın istenilen şekilde hizalanması gerçekleştirilebilir.

Anahtar Kelimeler: Biyoprotez kapak disfonksiyonu, perkütan kapak replasmanı, triküspit biyoprotez kapak, triküspit valve in valve

CASE REPORT
OLGU SUNUMU

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The primary drawback of bioprosthetic heart valves is their tendency to degenerate over the medium to long term.[1] In tricuspid valve surgery, bioprosthetic valves are often preferred; however, degeneration can occur in these valves as well. When significant degeneration develops, reoperation is generally considered high risk.[2,3] Therefore, transcatheter treatment options are increasingly considered in these patients. Among these, the percutaneous valve-in-valve (ViV) procedure appears to be one of the most effective options.

If the ring of a surgically implanted bioprosthetic valve is visible under fluoroscopy, valve alignment and implantation are typically straightforward. However, when the bioprosthetic valve is not radio-opaque, the procedure can present several challenges. In this report, we present three patients who underwent ViV procedures—two of whom had bioprosthetic valves that were not radio-opaque. We describe the step-by-step process of the procedure, focusing on how alignment was achieved when fluoroscopic visualization of the valve was not possible.

Case Reports

Informed consent was obtained from all three patients described below.

Case 1

A 68-year-old male patient underwent surgery in 2008 due to infective endocarditis. A mechanical valve (SORIN no: 27) was implanted for mitral valve replacement (MVR), and a bioprosthetic valve (MORE no: 31) was used for tricuspid valve replacement (TVR). Eleven months prior to the current procedure, balloon dilation had been performed due to severe stenosis of the tricuspid bioprosthetic valve. Following the recurrence of severe stenosis (mean gradient: 16 mmHg) and severe regurgitation in the tricuspid bioprosthetic valve, the case was evaluated by the heart team. The Tricuspid Valve Replacement Risk Score (TRI-SCORE) was calculated to estimate surgical and in-hospital mortality risk,[4] yielding a score of 22. Due to the high surgical risk, a decision was made to proceed with a percutaneous ViV procedure. Under sedation and local anesthesia, a 29 mm Meril Myval balloon-expandable transcatheter aortic valve implantation (TAVI) valve was implanted into the tricuspid bioprosthetic valve. Since the frame of the bioprosthetic valve was clearly visible, there was no difficulty in aligning the new valve (Figure 1). Postoperative right ventriculography showed no paravalvular regurgitation (Video 1). The patient experienced significant symptomatic improvement after the procedure, with functional status improving from New York Heart Association (NYHA) Class III-IV to Class II.

Case 2

A 62-year-old female patient with a history of three prior cardiac surgeries for rheumatic valve disease was admitted with signs and symptoms of right heart failure. Her first surgery, in 2003, involved mitral and tricuspid valvotomy with KAY annuloplasty. In the second surgery, performed in 2005, MVR was done using a 29 mm mechanical ATS valve. The third surgery, on November 22, 2013, involved TVR with a 29 mm Labcor bioprosthetic valve. Echocardiographic examination revealed severe stenosis (mean gradient: 15 mmHg) and severe regurgitation in the tricuspid bioprosthetic valve (Video 2). Her tricuspid annular plane systolic excursion (TAPSE) was measured at 12 mm. Given the high surgical risk (TRI-SCORE: 14), a decision was made to proceed with a percutaneous ViV procedure. Upon investigation, the Labcor bioprosthetic valve was found to be non-radio-opaque. Even with high-dose fluoroscopy and cine imaging, the valve was not visible. After reviewing the ViV application, a 27.5 mm Meril Myval valve was selected. During valve alignment, right ventriculography, right atrial angiography, and transthoracic echocardiography (TTE) were used for guidance (Figure 2, Videos 3–5). The procedure was completed successfully, and no paravalvular leakage was observed on post-procedure right ventriculography (Video 6). The patient experienced significant symptomatic improvement following the intervention. Unfortunately, she died six months later due to heart failure.

ABBREVIATIONS

CT	Computed tomography
EF	Ejection fraction
NYHA	New York Heart Association
MVR	Mitral valve replacement
RA	Right atrium
RV	Right ventricle
TAPSE	Tricuspid annular plane systolic excursion
TAVI	Transcatheter aortic valve implantation
TEE	Transesophageal echocardiography
TVR	Tricuspid valve replacement
TTE	Transthoracic echocardiography
ViV	Valve-in-valve

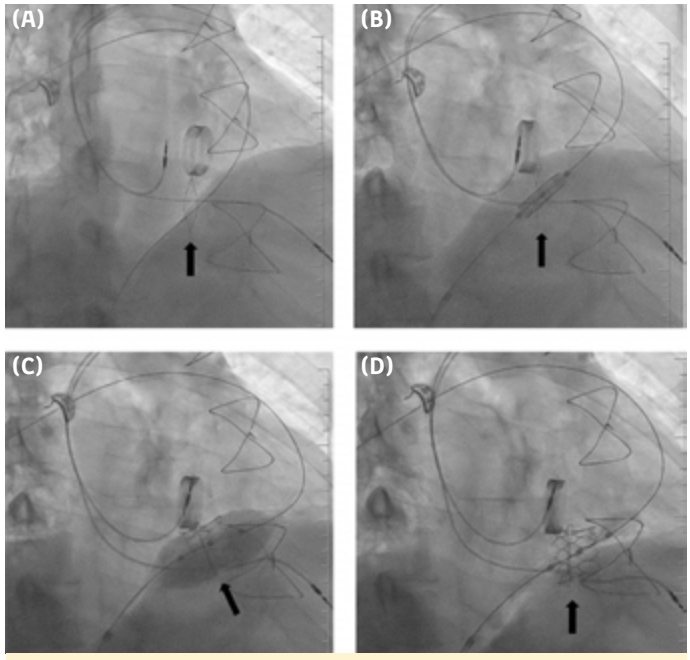

Figure 1. Fluoroscopic images: (A) Right cranial projection showing the ring of the bioprosthetic valve (arrow); (B) "Dog bone" appearance during low-pressure inflation of the balloon-expandable valve; (C) Full expansion of the valve within the bioprosthetic valve; (D) Appearance of the valve after deployment, with the arrow indication the ring.

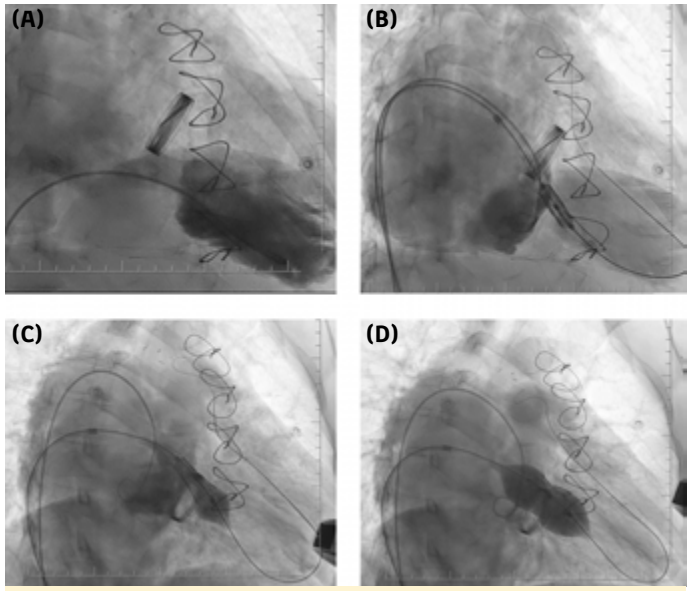

Figure 2. (A) Right ventriculography in the right cranial projection delineating the tricuspid annulus and the right atrium-right ventricle (RA-RV) relationship; (B) Right atrial angiography during alignment of the balloon-expandable valve; (C) Right atrial angiography showing the "dog bone" appearance during low-pressure inflation of the Myval balloon-expandable valve; (D) Full inflation of the Myval valve at nominal pressure within the bioprosthetic valve.

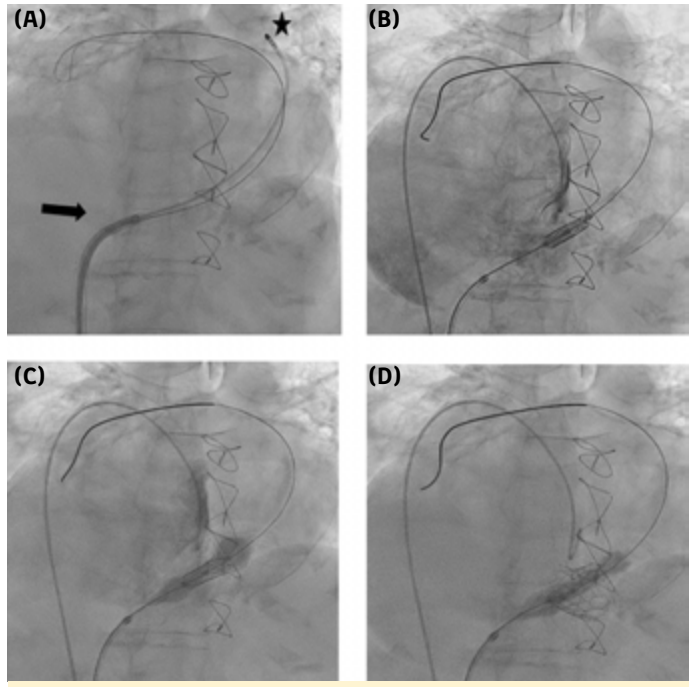

Figure 3. (A) Advancement of the stiff wire into the right pulmonary artery using a FlexNavi catheter (arrow) and an ablation catheter (star) for support; (B) Right atrial angiography during alignment of the balloon-expandable Myval valve; (C) Right atrial angiography showing the "dog bone" appearance during low-pressure inflation of the Myval valve; (D) Balloon deflation after full deployment of the Myval valve.

Case 3

A 54-year-old female patient with a history of MVR using a mechanical prosthesis in 1997 underwent TVR with a bioprosthetic valve in 2015. She had a history of hospitalizations over the past year due to advanced-stage right heart failure. Her functional status was classified as NYHA Class IV, with 4+ leg edema and severe cardiomegaly on chest X-ray. Echocardiography revealed severe dysfunction of the tricuspid bioprosthetic valve, with maximum and mean gradients of 20 mmHg and 12 mmHg, respectively, along with severe valvular regurgitation. The right atrium (RA) and right ventricle (RV) were both severely dilated. Her calculated TRI-SCORE was 22. Based on heart team evaluation, a decision was made to proceed with a transcatheter ViV procedure. Surgical notes indicated that a 27 mm Labcor bioprosthetic valve had been implanted, which is non-radio-opaque and not visible under fluoroscopy. After reviewing the ViV application, a 24.5 mm Meril Myval valve was selected. Right ventriculography, right atrial angiography, and transesophageal echocardiography (TEE) were used to guide valve alignment (Figure 3). The procedure was successful, and significant improvement was observed in the patient's symptoms afterward.

Step-by-Step Procedure Description

1. Surgical notes of the patients were reviewed to assess the characteristics of the tricuspid bioprosthetic valves. The appropriate size of the balloon-expandable valve was determined using the ViV application.[5] A Myval valve (Meril Life Sciences Pvt. Ltd., Vapi, Gujarat, India) was used in all three cases. This is a transcatheter balloon-expandable heart valve designed for transcatheter aortic valve implantation that received CE Mark approval in April 2019. The valve has a height of 21 mm and is implanted through a 14-16 mm peripheral sheath.
2. The procedures were performed under sedation and local anesthesia for the first two patients, and under general anesthesia for the third.
3. A 6F venous sheath (for additional access, such as pigtail catheter placement) was inserted into the left femoral vein. A 5F vascular sheath was placed in the left femoral artery for pressure monitoring.
4. Unfractionated heparin was administered at a dose of 100 U/kg.
5. A 7F vascular sheath was inserted via the right femoral vein. In the first two patients, using TTE guidance and fluoroscopy, a multipurpose A (MPA) catheter was advanced through the bioprosthetic tricuspid valve into the right ventricle. In the third patient, due to severe right atrial dilation, a 12F FlexCath steerable catheter was advanced through the bioprosthetic valve with the assistance of an ablation catheter to provide sufficient support for guidewire advancement (Figure 3).
6. The tip of the MPA catheter was directed into the pulmonary artery using a hydrophilic wire. A stiff wire (Amplatz Superstiff) was then advanced through the catheter into the distal pulmonary artery. Either the right or left pulmonary artery could be accessed, with a preference for the left side to provide better support. In the third patient, a Meier stiff wire was used to achieve improved backup support.

7. The 7F vascular sheath was exchanged for a 14F Phyton vascular sheath, which was then dilated with an 18F dilator to facilitate the passage of the valve.
8. Dilatation was performed within the bioprosthetic valve using a 25–40 mm balloon (Mammoth, Meril Life Sciences, Gujarat, India) until the indentation disappeared. Particular attention was paid to the location and angle of the indentation, which was noted as a reference point.
9. However, it was considered that this reference might not be sufficient for accurate alignment, as the valve was not visible on fluoroscopy or high-dose cine recordings in two patients. Therefore, a pigtail catheter was advanced into the right ventricle via the left femoral vein, and right ventriculography was performed in a right oblique-cranial projection. This allowed clear visualization of the tricuspid annulus and the RA-RV relationship (Figure 2, Video 3). The pigtail catheter was looped clockwise in the RA to approach the tricuspid annulus from above (Figures 2-3), and additional right atrial angiographies were performed during valve alignment (Videos 4, 5).
10. The Myval valve was advanced into the right ventricle. Alignment was carefully guided using echocardiography and right atrial angiography as needed.
11. The target placement of the valve was based on an RA/RV ratio of approximately 30/70. Initial inflation was performed at low pressure until the "dog-bone" effect was observed. If necessary, slight adjustments, either forward or backward, were made to optimize positioning. A final check was conducted by slightly inflating the valve to produce the dog-bone appearance while performing right atrial angiography. Once proper positioning was confirmed, the valve was fully deployed.
12. The balloon was deflated and withdrawn.
13. A pigtail catheter was advanced to the right ventricular apex, and right ventriculography was performed. Pressure measurements were taken from both the right atrium and right ventricle. Additional assessment was conducted using TTE. No paravalvular leak was observed, and the mean gradient in all patients was < 5 mmHg.
14. During withdrawal of the 14F vascular sheath, "figure-of-eights" stitches were placed at the access site, and manual compression was applied briefly. Reversal of heparin was not required.

The post-procedural findings were satisfactory. In all patients, the mean gradient across the newly implanted bioprosthetic valve was within normal limits (< 5 mmHg). Valve function was satisfactory, with good leaflet motion and no paravalvular insufficiency observed. One patient was transferred to the ward four hours after the procedure, while the other two were transferred after one night in the intensive care unit. The first patient remained hospitalized for three days, the second for two days, and the third for nine days. The third patient had significant edema prior to the procedure, and there was an increase in urine output after the procedure. Intravenous furosemide was administered in divided doses, resulting in a marked reduction in edema during follow-up. None of the patients developed hematoma or vascular complications at the procedural site.

Discussion

The transcatheter ViV procedure for tricuspid bioprosthetic valves was first performed in 2011.[6] Since then, experience in this field has grown, and various types of valves have been used for this purpose. As a first step in planning the procedure, the patient's surgical records should be reviewed. The characteristics of the previously implanted bioprosthetic valve should be known, and the appropriate transcatheter valve for the ViV procedure should be selected using the ViV application.[5] If surgical records are unavailable or there is uncertainty about the type of valve used, cardiac computed tomography (CT) should be performed to determine the correct size of the balloon-expandable TAVI valve. To minimize the risk of contrast-induced nephropathy, our patients did not undergo cardiac CT, as surgical notes were available.

The procedure can be performed under sedation and local anesthesia. However, if TEE is needed, or if the patient's condition is poor, general anesthesia is preferable. In our series, the first two procedures were performed under sedation, while the third patient underwent the procedure under general anesthesia due to her more compromised condition.

The transcatheter ViV procedure appears to be one of the most effective treatment options for patients with tricuspid bioprosthetic valve dysfunction. We observed significant clinical improvement in all three patients we treated. From a technical perspective, t several key points can be highlighted: passage through the bioprosthetic valve into the right ventricle can typically be achieved using an MPA or Swan-Ganz catheter. If difficulty is encountered, an Amplatz Left (AL) 2 or 3 catheter may be attempted. If these approaches are unsuccessful, a steerable catheter such as FlexCath or Agilis can be directed toward the valve, and passage can then be achieved using an MPA or vertebral catheter. In our third patient, we used a FlexNavi catheter.

Proper alignment of the valve is the most critical stage of the procedure. An ideal alignment is achieved with an RA/RV ratio of approximately 30/70. Our first patient had a permanent pacemaker, but since the bioprosthetic valve was clearly visible on fluoroscopy, valve alignment was straightforward. In contrast, alignment was more challenging in our second and third patients due to the lack of visibility of their bioprosthetic valves. When aligning the valve in these patients, TTE/TEE, right ventriculography, and right atrial angiography were used. Predilatation should be performed, as the valve is typically very narrow, and the angle at which indentation occurs during balloon inflation can serve as a reference. However, this reference may be insufficient, as the heart is a dynamic, moving organ, and the patient may shift during the procedure. Right oblique-cranial ventriculography is particularly helpful in visualizing the tricuspid annulus and the RA-RV relationship (Video 2). For alignment, a pigtail catheter can be positioned near the tricuspid valve by looping it clockwise in the RA (circumnavigating from the superior aspect to the roof of the RA without obstructing the valve) (Figures 2-3, Videos 4, 5). Additional imaging can be obtained as needed by injecting a small amount of contrast near the tricuspid valve. TEE is also helpful during the alignment phase. Special care should be taken, as the height of the balloon-expandable valve used, such as the Myval, typically

ranges between 19 and 22 mm. This step is crucial, as excessive movement of the valve toward either the atrium or ventricle increases the risk of embolization. When the initial portion of the valve is inflated (showing the characteristic "dog-bone" shape), a final image should be taken to assess positioning. If necessary, small adjustments can be made toward the atrium or ventricle to achieve optimal alignment.

Since right-sided heart pressures are relatively low in tricuspid ViV procedures, rapid pacing is generally not required. However, it may be considered depending on the operator's preference. If difficulty is encountered while directing the stiff wire into the pulmonary artery, the procedure can be performed by placing a Safari tip-curved wire into the right ventricular apex. In such cases, rapid pacing over the stiff wire may be helpful. In our first case, we applied rapid pacing through the patient's permanent pacemaker at 140 bpm. In the second and third cases, the valve was implanted without the need for rapid pacing.

Having a permanent pacemaker in a patient may raise concerns. However, the application of tricuspid ViV therapy in the presence of a permanent pacemaker appears to be safe.[7] The implanted bioprosthetic valve generally does not adversely affect the pacemaker electrode. In our experience, we did not observe any impairment in pacemaker function. If negative effects on the pacemaker do occur, the lead can be repositioned through the valve, or a wireless pacemaker can be considered.

The long-term outcomes of the tricuspid ViV procedure are not yet well established. However, it is important to note that if bioprosthetic dysfunction develops during follow-up, repeat ViV implantation is feasible. Given the relatively large area of the tricuspid valve, favorable results are often achieved following ViV procedures.[8] Balloon-expandable valves used in TAVI are a good option for tricuspid ViV procedures. These valves have low profiles and are technically easy to implant. We did not encounter significant difficulties in valve placement in any of the three patients. The Meril Myval valve offers notable sizing advantages. In addition to the standard sizes, it also includes intermediate sizes, such as 20 mm, 21.5 mm, and 23 mm, up to 32 mm. Therefore, we selected slightly larger sizes than those suggested by the ViV app to improve anchoring and reduce the risk of both embolization and paravalvular leak.

Concerning post-procedural antithrombotic treatment, oral anticoagulation appears appropriate. More than 90% of these patients have atrial fibrillation (AF) and/or mechanical heart valves and are already receiving oral anticoagulants. For those without a specific indication, it still seems reasonable to prescribe oral anticoagulation, as this is a right-sided ViV procedure.

Conclusion

In conclusion, transcatheter ViV implantation in patients with tricuspid bioprosthetic valve degeneration appears to be a low-risk procedure with a high success rate. Therefore, it should be considered one of the preferred treatment options for appropriately selected patients.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Informed consent was obtained from all three patients described.

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Video 1. Right ventriculography showing no paravalvular regurgitation following successful deployment.

Video 2. Severe tricuspid regurgitation and stenosis of the bioprosthetic valve visualized on transthoracic echocardiography (TTE).

Video 3. Right ventriculography in the right oblique-cranial projection revealing the tricuspid annulus and the right atrium-right ventricle (RA-RV) relationship.

Video 4. Right atrial angiography during valve alignment.

Video 5. Right atrial angiography showing the valve in partial inflation with the "dog bone" appearance.

Video 6. Post-procedural right ventriculography showing no paravalvular regurgitation in a patient with a non-radio-opaque bioprosthetic valve.

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