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CASE REPORT

CLINICAL CASE

On-Pump Beating-Heart Redo Mitral Valve Surgery

A Personalized, Risk-Adapted Surgical Strategy for Plug-Induced Hemolysis

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ABSTRACT

BACKGROUND Severe mechanical hemolysis following the use of a paravalvular leak occluder plug is a challenging complication, particularly for patients with multiple comorbidities who face prohibitive risks with repeat surgery.

CASE SUMMARY A 63-year-old multimorbid man with end-stage renal disease presented with severe microangiopathic hemolytic anemia after transcatheter paravalvular leak closure. Ten months earlier, he had undergone aortic and mitral valve replacements and coronary bypass, complicated by a difficult recovery requiring temporary mechanical circulatory support with an Impella. Now, to minimize the operative risk and avoid the difficult postoperative course experienced after the previous surgery requiring mechanical circulatory support, a modified, infrequent surgical strategy was used: On-pump, beating-heart redo mitral valve replacement with extraction of the occluder plug. It successfully circumvented global myocardial ischemia and simplified complex redo surgery. Postoperatively, the hematologic parameters normalized within days.

DISCUSSION This personalized, risk-adapted surgical strategy mitigates operative risk in a high-risk patient, achieving rapid, definitive resolution of hemolytic anemia.

TAKE-HOME MESSAGES Eliminating the source of mechanical hemolysis results in rapid normalization of laboratory parameters within days. On-pump beating-heart surgery is a valuable strategy to simplify complex redo procedures while minimizing high perioperative risk. (JACC Case Rep. 2026;■:111123) © 2026 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

HISTORY OF PRESENTATION

A 63-year-old multimorbid man with end-stage renal disease on chronic hemodialysis presented with profound fatigue and shortness of breath because of severe microangiopathic hemolytic anemia. Ten months earlier, he had undergone aortic valve replacement, mitral valve replacement, and double

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ABBREVIATIONS AND ACRONYMS

CABG = coronary artery bypass grafting

LDH = lactate dehydrogenase

PVL = paravalvular leak

coronary artery bypass grafting (CABG), requiring temporary mechanical circulatory support via a transaortic Impella device. After a prolonged intensive care stay and postoperative course, the patient recovered but subsequently developed a mitral paravalvular leak (PVL) managed with a transcatheter Amplatzer occluder plug. Thereafter, he developed severe mechanical hemolysis despite minimal residual micro-insufficiency on echocardiography. Preoperative laboratory work-up revealed significantly elevated lactate dehydrogenase (LDH) levels (approximately 700 U/L), undetectable haptoglobin (<10 mg/dL), and significantly elevated reticulocytes (approximately 3%).

PAST MEDICAL HISTORY

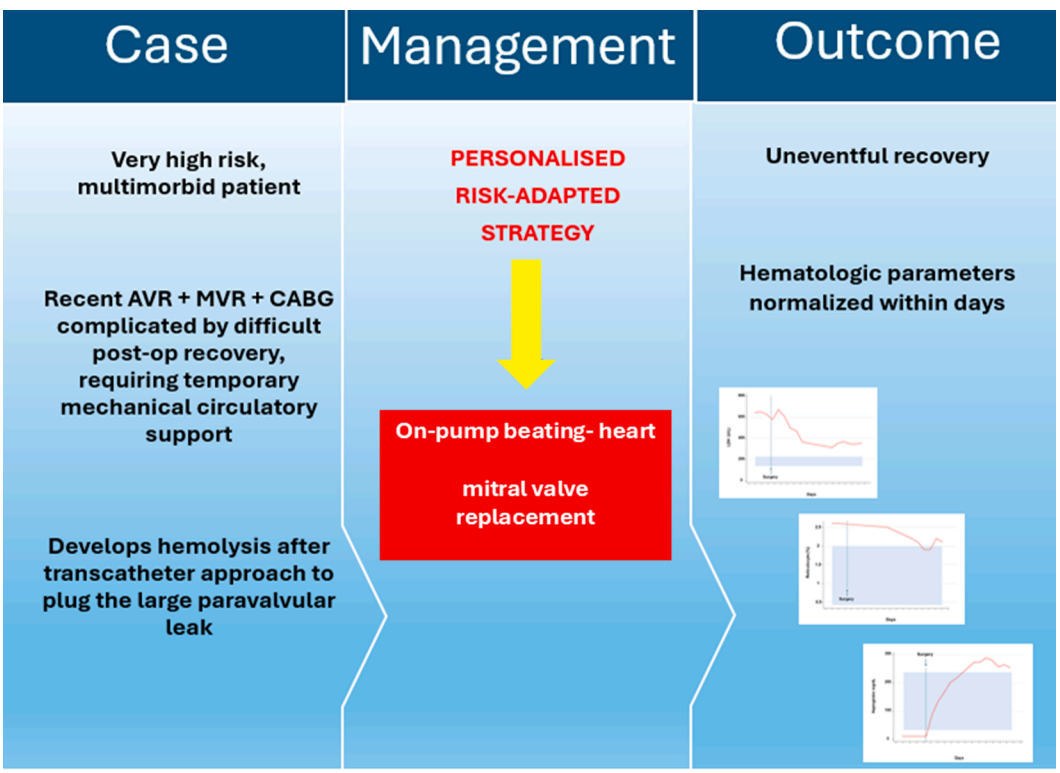
The patient has end-stage renal disease and heart failure with reduced ejection fraction (Figure 1).

TAKE-HOME MESSAGES

- Eliminating the source of mechanical hemolysis results in rapid normalization of laboratory parameters within days.
- On-pump beating-heart surgery is a valuable strategy to simplify complex redo procedures while minimizing high perioperative risk.

Additional history includes multiple myeloma diagnosed 24 months earlier, status-post stem cell transplant 18 months earlier requiring high-dose chemotherapy and intensive inpatient care. Frequent post-transplant bone marrow biopsies have shown persistent minimal residual disease indicating excellent disease control of myeloma. The patient continues on monthly daratumumab maintenance therapy initiated 17 months earlier.

VISUAL SUMMARY Overview of the Clinical Presentation, Personalized Management, and Outcome



Case: A very high-risk, multimorbid patient presenting with a recent history of aortic valve replacement (AVR), mitral valve replacement (MVR), and coronary artery bypass grafting (CABG) complicated by difficult postoperative recovery requiring temporary mechanical circulatory support. Subsequently, the patient developed severe hemolysis following a transcatheter approach to plug a large paravalvular leak. Management: Implementation of a personalized, risk-adapted strategy using an on-pump beating-heart mitral valve replacement. Outcome: Uneventful recovery with rapid normalization of hematological parameters within days postsurgery, as demonstrated by the corresponding laboratory trends.

Recent medical history includes prior cardiac surgery 10 months ago consisting of aortic valve replacement (25-mm Avalus valve), mitral valve replacement (27-mm Mosaic valve), and double CABG with simultaneous left atrial appendage ligation and temporary transaortic Impella support with a prolonged intensive care stay and postoperative course. Intraoperative pathology of the aortic valve reportedly found evidence of infective endocarditis with an unidentified pathogen, which was treated with a 6-week course of vancomycin and cefepime.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for severe hemolytic anemia in this patient primarily encompasses mechanical erythrocyte shear stress and destruction secondary to the transcatheter Amplatzer occluder plug, paravalvular regurgitation, or prosthetic valve dysfunction. Additional considerations include dialysis-related factors such as mechanical or chemical stress within the extracorporeal circuit, as well as microangiopathic hemolytic syndromes like thrombotic thrombocytopenic purpura and hemolytic uremic syndrome. Nonmechanical contributors must also be addressed, including anemia of chronic kidney disease due to erythropoietin deficiency, iron or vitamin deficiencies, chronic blood loss, and anemia of chronic disease driven by systemic inflammation. Other factors to weigh include therapy-related bone marrow suppression from prior high-dose chemotherapy and stem cell transplantation for multiple myeloma, alongside persistent subclinical erythrocyte trauma related to prior mechanical circulatory support devices.

INVESTIGATIONS

Before the procedure, laboratory evaluations confirmed severe intravascular mechanical hemolysis. Serum haptoglobin was profoundly suppressed at <10 mg/dL, whereas LDH levels were markedly elevated, peaking at 670-700 U/L.

Reticulocyte counts showed a compensatory response, reaching up to 3.2%. Baseline preoperative laboratories ruled out nutritional deficiencies and myeloma relapse, and admission platelet counts were normal (120s-140s).

Transesophageal echocardiography demonstrated an Amplatzer occluder device with trivial residual paravalvular regurgitation (Figure 2). Coronary angiography revealed diffuse disease of the left main trunk, significant multivessel disease with severe calcification (Figure 3), left anterior descending artery stenoses, moderate left circumflex stenoses, a proximal chronic total occlusion of the right coronary artery, ostial stenosis in the saphenous vein graft to the right posterior descending artery, and patent flow with mild narrowing in the vein graft to the second diagonal branch.

Positron emission tomography-computed tomography with fluorodeoxyglucose demonstrated mitral valve replacement-associated heterogeneous uptake (maximum standardized uptake value: 7.7) (Figure 4) without focal abnormal uptake at the aortic valve (Figure 5), alongside uptake in a distal occluded or ligated aortic Impella graft (Figure 6).

Hematology evaluated the patient, confirming mechanical red blood cell shearing on the peripheral smear and noting that the severe anemia was multifactorial, driven by both mechanical hemolysis and end-stage renal disease, while coordinating with nephrology regarding erythropoiesis-stimulating agent optimization.

FIGURE 1 Cardiomegaly on Chest X-Ray



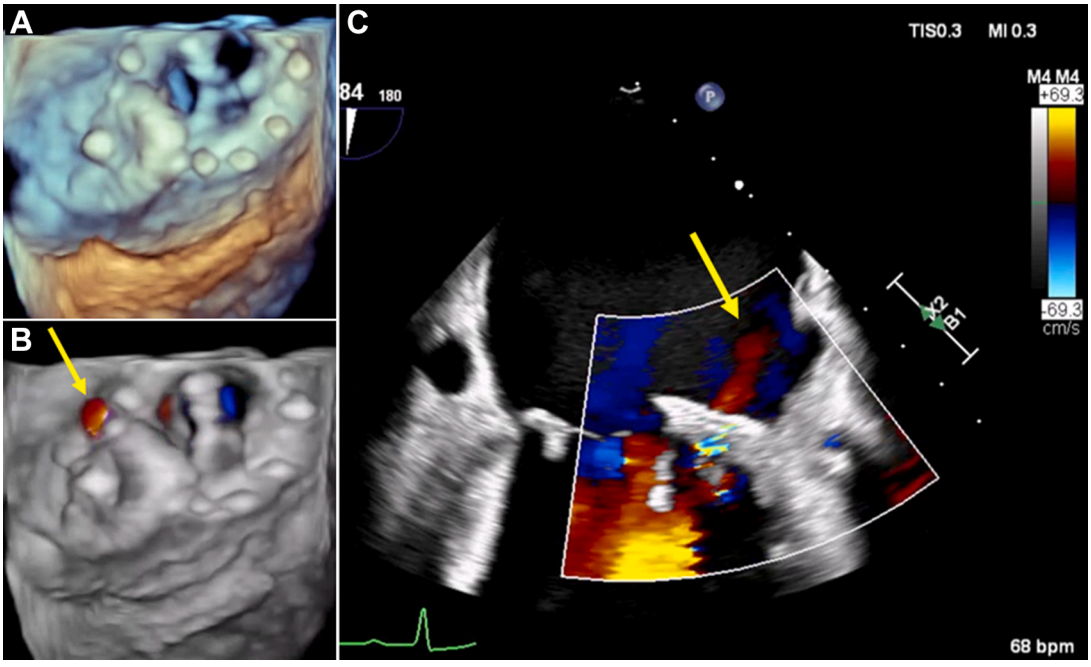
Posteroanterior chest radiograph demonstrating generalized cardiomegaly and poststernotomy sternal wires.

MANAGEMENT

The patient underwent a personalized, risk-adapted surgical strategy using a beating-heart technique on cardiopulmonary bypass to avoid global myocardial ischemia, reduce operative trauma, and minimize extensive surgical dissection and aortic manipulation.

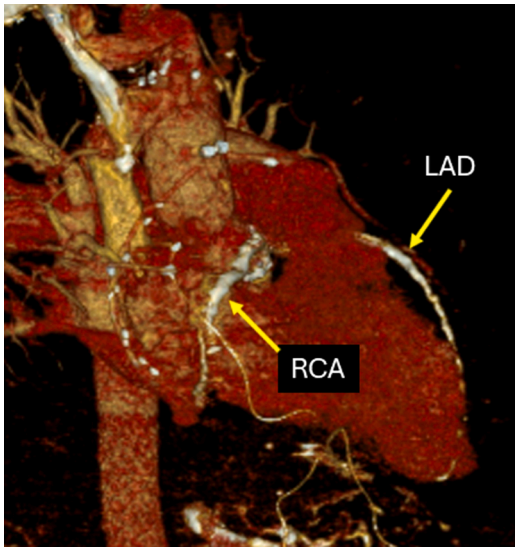
Following induction of general anesthesia and an uneventful redo midline sternotomy using an oscillating saw, localized lysis of mediastinal adhesions

FIGURE 2 Paravalvular Regurgitation



Three-dimensional transesophageal echocardiography images (A and B) displaying the occluder plug, the mitral valve bioprosthesis, and the paravalvular leak (indicated by the arrow in panel B). (C) Midesophageal short-axis view with color Doppler demonstrating trivial residual paravalvular regurgitation (indicated by the arrow). bpm = beats/min; MI = mechanical index; TIS = thermal index soft tissue.

FIGURE 3 Coronary Calcification



Three-dimensional computed tomography reconstruction demonstrating severe, extensive coronary artery calcification, including a heavily calcified and diffusely diseased left anterior descending artery. LAD = left anterior descending artery; RCA = right coronary artery.

was performed. The previous venous bypass graft to the right coronary artery was completely mobilized and retracted (**Figure 7**, Video 1), and the old small graft used for transaortic Impella implantation was fully mobilized, showing complete endothelialization at its aortic connection with no signs of infection.

Following systemic heparinization, central aortic, superior vena cava, and right atrial 2-stage cannulation were performed to establish cardiopulmonary bypass. The procedure was performed entirely on a beating heart without cardioplegia or aortic cross-clamping (Video 2). Because of restricted mitral exposure, the superior vena cava was transected, and the interatrial groove incision was extended onto the left atrial roof. The previous mitral prosthesis was excised (Videos 3 and 4), revealing chronic ring infection without vegetations, and the PVL Amplatzer occluder device was successfully extracted from surrounding tissue (Video 5). Mitral valve replacement was performed using a 31-mm Biocor Epic Plus valve secured with 2-0 Prolene horizontal mattress sutures and bovine pericardial pledgets.

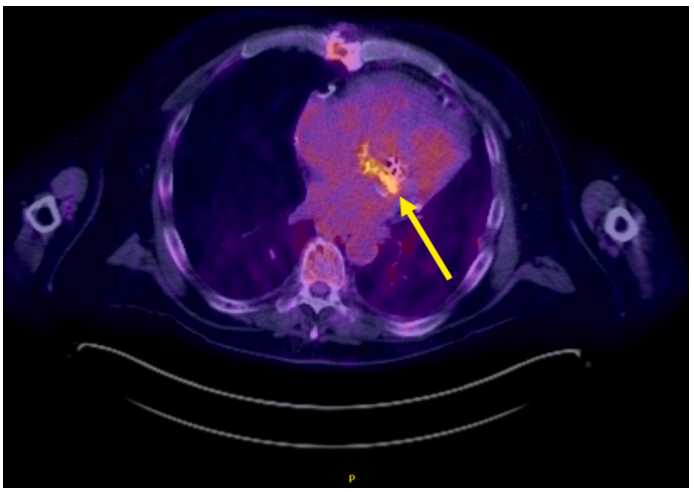
The left atrium was closed and de-aired under transesophageal echocardiography guidance, and the superior vena cava was reconstructed via direct end-

to-end anastomosis reinforced with bovine pledgets. Temporary epicardial pacing wires were placed. Following successful weaning from bypass, the previous aortic Impella graft was transected, and its stump was oversewn and reinforced. Meticulous hemostasis was achieved, drains were placed, and the sternum was closed with simple wires.

Perioperative antimicrobial prophylaxis used vancomycin and cefazolin, and the patient was successfully extubated on the first postoperative day. Infectious disease was consulted because of a single colony of *Staphylococcus epidermidis* from the old Impella graft specimen (with negative histopathology and universal bacterial polymerase chain reaction). The patient received vancomycin, was switched to oxacillin on the seventh postoperative day, and antibiotics were discontinued after pathological and microbiological investigations were completed.

For chronic management, the patient remained on darbepoetin alfa managed by nephrology for end-stage renal disease and anemia, along with single-agent daratumumab monthly for multiple myeloma in remission. Hematology recommended restarting pyridoxine (50 mg daily), repletion of thiamine and zinc, and concluded there was no hematological contraindication for potential future percutaneous coronary intervention or dual antiplatelet therapy if platelet counts remain stable.

FIGURE 4 Positron Emission Tomography-Computed Tomography Mitral Uptake

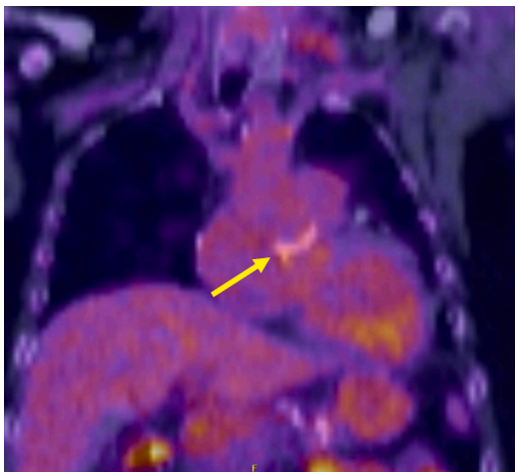


Positron emission tomography-computed tomography with fluorodeoxyglucose demonstrating mitral valve replacement-associated heterogeneous uptake.

OUTCOME AND FOLLOW-UP

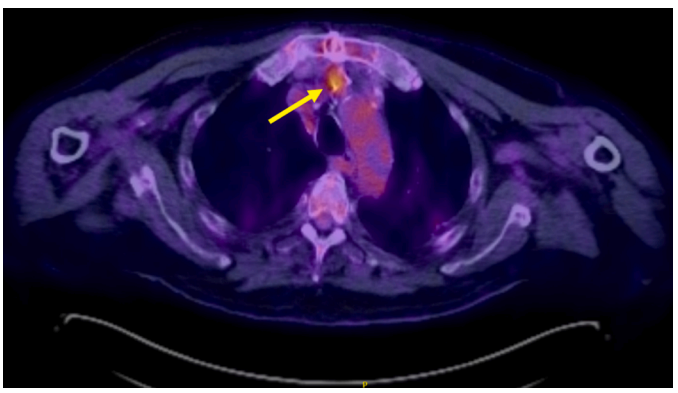
Following surgical intervention, the patient demonstrated rapid and complete resolution of mechanical hemolytic anemia. Serial postoperative tracking confirmed the immediate cessation of intravascular red blood cell destruction. LDH steadily trended down from a preoperative peak of 670-700 U/L, stabilizing to a baseline postoperative range of 310-355 U/L (Figure 8). Haptoglobin, previously

FIGURE 5 Positron Emission Tomography-Computed Tomography Aortic Valve



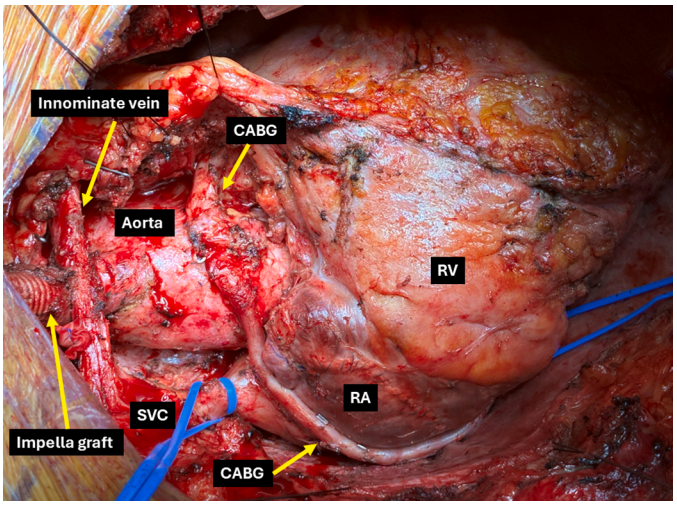
Positron emission tomography-computed tomography with fluorodeoxyglucose showing no focal abnormal uptake at the aortic valve.

FIGURE 6 Positron Emission Tomography-Computed Tomography Impella Graft



Positron emission tomography-computed tomography with fluorodeoxyglucose showing uptake in a distal occluded or ligated aortic Impella graft.

FIGURE 7 Surgical Field Preparation: Intraoperative View Demonstrating the State After Preparation of the Surgical Field, Where Everything Planned Has Been Released, and the Field is Fully Ready for Cannulation



The surgical view is from the operator's perspective standing on the right side of the patient, with the patient's head oriented to the left of the image. The footage shows the precise mobilization and release of the previous venous bypass graft to the right coronary artery—which was severely calcified and proximally totally occluded—during limited dissection and redo sternotomy to enable excellent access to the left atrium. The preparation is performed with high precision and is strictly limited to the targeted operative area: the right atrium (RA), the venous bypass to the right coronary artery, a portion of the right ventricle (RV), and the part of the aorta prepared for cannulation. The previous venous bypass graft to the right coronary artery was densely adhered to the RA in an essential region necessary for optimal exposure of the left atrium and mitral valve. Releasing this graft was crucial; failure to mobilize it would have caused traction, resulting in occlusion of the bypass graft, cessation of blood supply to that portion of the myocardium, and potentially fatal consequences. The aorta is visualized only for cannulation and the proximal part of the venous bypass to the right coronary artery is completely shown for better mobilization. The small remnant graft that was used for Impella placement during the initial surgery is also visible and completely prepared. The superior vena cava (SVC) and inferior vena cava are snared with blue elastic vessel loops, and the surgical field is fully prepared for cannulation. The surgical field remains dry with no active bleeding, demonstrating an exceptionally precise anatomical dissection and limited dissection approach. The left heart chambers, aside from the left and right atria, remain practically untouched, and calcified blood vessels are left unmobilized. This video corresponds to Video 1. CABG = coronary artery bypass graft.

suppressed or undetectable below 10 mg/dL because of severe valvular hemolysis, rapidly recovered and continuously increased to normalize between 253 and 288 mg/dL during the first postoperative week (**Figure 9**). Concurrently, elevated reticulocyte percentages stabilized toward baseline levels between 1.9% and 2.1%, and platelet counts steadily recovered (**Figure 10**).

Postoperative hemoglobin stabilized, with the patient continuing erythropoiesis-stimulating agent therapy under nephrology care. Serial multiple myeloma markers confirmed continued remission without evidence of disease relapse. Hematology concluded there was no contraindication for future percutaneous coronary intervention or dual antiplatelet therapy provided platelet counts remain stable, leaving this risk and benefit decision to cardiology. The patient was also advised to restart pyridoxine (50 mg daily) and replete thiamine and zinc.

The patient's postoperative course was completely uneventful except for brief episodes of atrial fibrillation. Postoperative echocardiography demonstrated no residual PVL and normal postoperative prosthetic valve function. The patient recovered well and was discharged home on postoperative day 13.

DISCUSSION

Severe mechanical hemolysis secondary to transcatheter PVL closure devices represents a critical and refractory complication. Current guidelines generally favor transcatheter closure for patients with multiple comorbidities who face a high risk of perioperative mortality with repeat open-heart surgery.[1,2] However, when transcatheter options fail or lead to severe hemolytic anemia, conventional redo surgical intervention carries a high risk. For this patient, who had a history of valve replacements, CABG, and Impella support, reoperative planning demanded a personalized, risk-adapted strategy. To avoid the high risks of aortic cross-clamping and cardioplegic arrest, such as graft injury, ischemia, and stroke in a calcified coronary bed, an on-pump beating-heart approach was chosen, maintaining continuous native coronary perfusion, reducing ischemia-reperfusion injury, and avoiding manipulation of calcified anatomy.[3-5]

Hemodynamically, a residual PVL creates a high-velocity, high-shear microenvironment. The mechanical friction of blood cells across the metallic frame and fabric of the Amplatzer occluder continuously shatters erythrocytes, resulting in refractory hemolytic parameters (LDH: 600-700 U/L, unmeasurable haptoglobin). This can significantly worsen preexisting chronic anemia in patients who are dependent on dialysis. In patients who are dependent on dialysis, this secondary mechanical

hemolysis severely worsens baseline chronic anemia, creating a vicious cycle of transfusion.[6]

The biological efficacy of our strategy is confirmed by the rapid postoperative reversal of laboratory markers. Routine tracking of LDH, haptoglobin, and reticulocyte counts serves as objective proof that prompt mechanical correction halts intravascular hemolysis instantly.

CONCLUSIONS

On-pump, beating-heart redo mitral valve replacement with extraction of the occluder plug successfully minimizes operative risk and circumvents global myocardial ischemia in our high-risk patient. This tailored strategy simplifies complex redo surgery and avoids the prolonged postoperative course associated with previous mechanical circulatory support, leading to rapid normalization of hematologic parameters within days.

INSTITUTIONAL REVIEW BOARD APPROVAL Institutional review board approval was not required under Cleveland Clinic policy for case reports or case series involving patients.

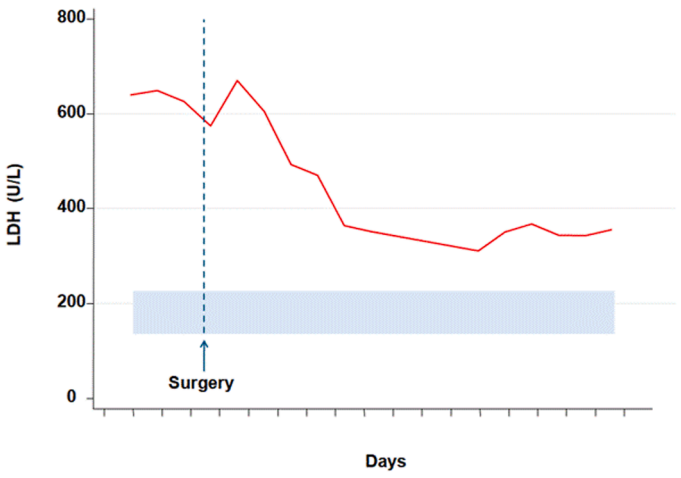
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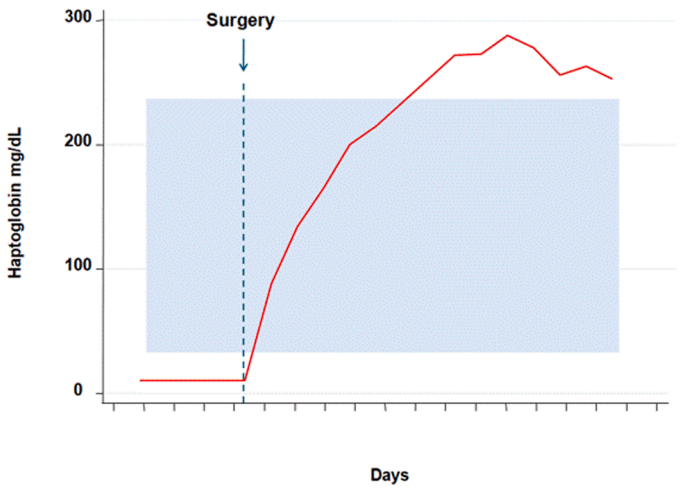
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FIGURE 8 Lactate Dehydrogenase Trend



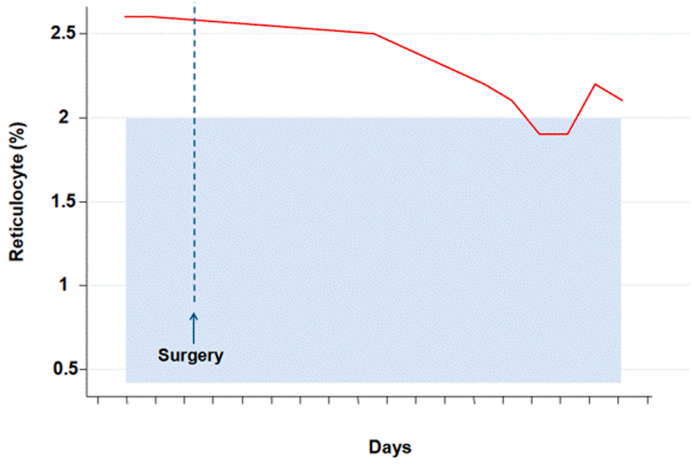
Graph showing the serial postoperative trend of lactate dehydrogenase levels rapidly decreasing from a preoperative peak toward baseline values. The reference range is indicated by the light blue shaded region. LDH = lactate dehydrogenase.

FIGURE 9 Haptoglobin Trend



Graph demonstrating the rapid recovery and normalization of serum haptoglobin levels during the first postoperative week following elimination of mechanical hemolysis. The reference range is indicated by the light blue shaded region.

FIGURE 10 Reticulocyte Trend



Graph illustrating the stabilization of reticulocyte percentages and platelet recovery following the surgical correction. The reference range is indicated by the light blue shaded region.

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KEY WORDS hemolysis, microangiopathic hemolytic anemia, paravalvular leak

APPENDIX For supplemental videos, please see the online version of this paper.