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Multistage cardiac surgery, ECMO, and advanced wound care in a critically ill neonate: a case report

Gianluca Castiello¹, Alessandro Giamberti², Alessandro Varrica², Matteo Reali², Mauro Lo Rito², Federica Torchio², Giuseppe Isgrò³, Angela Satriano³, Corinne Messina², Massimo Chessa^{4,5}, Greta Ghizzardi⁶, Rosario Caruso^{7,8}

1. Intensive Care Unit, IRCCS Policlinico San Donato, Milan, Italy
2. Department of Congenital Cardiac Surgery, IRCCS Policlinico San Donato, Milan, Italy
3. Department of Cardiovascular Anesthesia and Intensive Care, IRCCS Policlinico San Donato, San Donato Milanese, Milan, Italy.
4. ACHD Unit, IRCCS-Policlinico San Donato, San Donato Milanese, Milan, Italy.
5. UniSR - Vita Salute San Raffaele University, Milan, Italy.
6. Health Professions Directorate, Bachelor in Nursing Course, ASST Lodi, Lodi, Italy
7. Health Professions Research and Evidence Transfer Unit, IRCCS MultiMedica, Sesto San Giovanni, Italy
8. Department of Biomedical Sciences for Health, University of Milan, Milan, Italy

Corresponding author:

Rosario Caruso, PhD, RN, FESNO, FAAN

Associate Professor, University of Milan

E-mail: rosario.caruso@unimi.it

Abstract

Background: Neonates with complex congenital heart disease (CHD) frequently require early and staged surgical interventions, which carry a high risk of postoperative complications. The coexistence of an interrupted aortic arch, ventricular septal defect (VSD), and mitral valve stenosis represents a rare and particularly high-risk constellation. This case is noteworthy for the integration of multistage cardiac surgery, prolonged extracorporeal membrane oxygenation (ECMO), and an innovative wound management strategy combining negative pressure wound therapy (NPWT) with topical oxygen-enriched gel.

Case presentation: We report the case of a one-month-old Romanian female infant diagnosed with type A interrupted aortic arch, VSD, and mitral valve stenosis. The initial surgical procedure included aortic arch reconstruction, VSD closure with a bovine pericardial patch, and mitral valve repair. Severe residual mitral regurgitation necessitated immediate initiation of veno-arterial ECMO, followed by mitral valve replacement with a Melody bioprosthesis. On postoperative day 19, thrombotic obstruction of the prosthetic valve required a third surgical intervention for clot removal, after which ECMO was discontinued. Delayed sternal closure was performed on day 26, but wound dehiscence developed on day 33. Management included NPWT combined with topical oxygen-enriched gel for 33 days, followed by gel monotherapy for 38 additional days. Complete secondary intention healing was achieved after 73 days. Despite developing *Pseudomonas aeruginosa* sepsis and late-onset *Staphylococcus haemolyticus* bacteremia, the patient recovered fully without neurological deficits or wound-related sequelae.

Conclusions: This case highlights the feasibility of combining advanced surgical management with innovative wound care strategies in critically ill neonates with complex CHD. The successful integration of NPWT and topical oxygen therapy promoted wound healing after delayed sternal closure, even in the context of severe infection and prolonged ECMO support. These findings suggest that tailored, multidisciplinary approaches may optimize outcomes in high-complexity neonatal cardiac cases.

Keywords: neonatal cardiac surgery; extracorporeal life support; sternal wound dehiscence; vacuum-assisted closure; topical oxygen therapy; complex wound healing

Background

Neonates with complex congenital heart defects (CHD) such as interrupted aortic arch (IAA), ventricular septal defect (VSD), and mitral valve anomalies frequently require early and staged surgical interventions. These procedures are associated with a high risk of postoperative complications, including impaired sternal wound healing, prosthetic valve dysfunction, nosocomial infections, and prolonged extracorporeal support dependency [1,2]. While the management of these complications is well-documented individually, few reports describe the interplay of multiple high-risk conditions, namely, the triad of repeated cardiac surgery, veno-arterial extracorporeal membrane oxygenation (VA-ECMO), and wound dehiscence managed via negative pressure wound therapy (NPWT), in a single neonatal case. This case report details the hospital course of a one-month-old infant with multiple CHD anomalies who underwent three open-heart surgeries in rapid succession, required extended VA-ECMO support, and was successfully managed with NPWT for secondary intention healing. The case highlights the feasibility and potential benefits of integrating NPWT in complex cardiothoracic postoperative care during critical illness in early infancy. This report has been prepared following the checklist derived from the Consensus-based Clinical Case Reporting Guideline to ensure transparency and completeness in clinical case reporting [3] (see CARE Checklist of information in the Supplementary File 1).

Case Presentation

A one-month-old Romanian female infant was admitted with a prenatal diagnosis of complex congenital heart disease, including type A IAA, VSD, and mitral valve stenosis. Family history and perinatal course were unremarkable. At admission, the patient presented with signs of heart failure requiring urgent surgical correction.

The initial operation included end-to-side aortic arch reconstruction, closure of the VSD using a bovine pericardial patch, and mitral valve repair involving papillary muscle splitting and cleft closure of the anterior mitral leaflet. To facilitate left atrial decompression and accommodate postoperative hemodynamics, a fenestrated atrial septal defect (ASD) was created.

Weaning from cardiopulmonary bypass proved unsuccessful due to severe residual mitral regurgitation, and central VA-ECMO was initiated. Eight days later, a second surgery was performed to replace the mitral valve with a Melody bioprosthesis. The infant returned to the intensive care unit (ICU) on high-dose inotropic support (adrenaline, milrinone, dopamine,

levosimendan) and remained on central VA-ECMO.

Despite initial recovery of left ventricular function, the patient developed thrombotic obstruction of the prosthetic valve, prompting a third surgical intervention on postoperative day 19 to remove the clots. ECMO support was discontinued the same day, with a total ECMO duration of 19 days. Throughout this period, the patient required multiple blood product transfusions.

Delayed sternal closure (DSC) was performed on postoperative day 26. To minimize tension and avoid infection, soft tissue and skin edges were deliberately left unsutured to promote secondary intention healing. On postoperative day 33, marked separation of the wound edges was observed, consistent with wound dehiscence (**Figure 1**).

A combined wound management strategy was initiated, including NPWT, with dressing changes every two days and a topical oxygen-enriched gel. NPWT was administered using a vacuum-assisted closure (VAC) system. After 33 days of combined therapy, NPWT was discontinued (**Figure 2**), and the oxygen-enriched gel was continued as monotherapy for an additional 38 days (**Figure 3**). The wound fully re-epithelialized after 73 days of treatment, with healing by secondary intention (**Figure 4**). All wound swabs remained negative throughout the course.

Infection control measures were maintained during the open chest period. While nasal swabs remained negative, rectal swabs were positive for extended-spectrum beta-lactamase (ESBL)-producing organisms. The antimicrobial regimen included vancomycin, amikacin, and ceftazidime initially. During the hospital stay, the infant developed *Pseudomonas aeruginosa* sepsis treated with meropenem and vancomycin, followed by late-onset *Staphylococcus haemolyticus* bacteremia managed with daptomycin.

The patient was extubated on day 48 and transferred to the pediatric ward on day 58. Neurological assessments during the hospital stay and at discharge were within normal limits. No adverse events were associated with wound management interventions.

A chronological summary of the main clinical events, surgical interventions, and wound-care milestones is provided in Table 1.

Table 1. Timeline of the clinical course

Timepoint	Clinical event/intervention
Admission	Prenatal diagnosis of complex congenital heart disease (type A IAA, VSD, mitral valve stenosis); signs of heart failure requiring urgent surgical correction
Day 0 (first operation)	End-to-side aortic arch reconstruction, VSD closure with bovine pericardial patch, mitral valve repair (papillary muscle splitting, cleft closure of anterior leaflet), and creation of a fenestrated ASD; weaning from cardiopulmonary bypass failed due to severe residual mitral regurgitation → central VA-ECMO initiated
Day 8 (second operation)	Mitral valve replacement with a Melody bioprosthesis; high-dose inotropic support and central VA-ECMO continued
Day 19 (third operation)	Surgical removal of prosthetic-valve thrombus; VA-ECMO discontinued (total ECMO duration 19 days)
Day 26	Delayed sternal closure; soft tissue and skin edges left unsutured to promote secondary intention healing
Day 33	Wound dehiscence (Figure 1); combined wound therapy started — NPWT (vacuum-assisted closure, dressing change every 2 days) + topical oxygen-enriched gel
Day 48	Extubation
Day 58	Transfer to the pediatric ward

After 33 days of combined therapy	NPWT discontinued (Figure 2); oxygen-enriched gel continued as monotherapy
After 38 further days of gel monotherapy	Progressive healing (Figure 3)
After 73 days of wound treatment	Complete re-epithelialization; healing by secondary intention (Figure 4)
During the hospital course	Rectal swabs positive for ESBL-producing organisms; <i>Pseudomonas aeruginosa</i> sepsis (meropenem + vancomycin); late-onset <i>Staphylococcus haemolyticus</i> bacteremia (daptomycin); neurological assessments within normal limits at discharge

Discussion and Conclusions

This case underscores the multifactorial challenges of managing critically ill neonates with complex CHD, particularly when multiple anomalies and staged surgeries are involved [4]. Type A IAA in combination with mitral valve stenosis is a rare and high-risk presentation that complicates both intraoperative strategy and postoperative recovery. The mitral valve in neonates is notoriously difficult to repair due to the small annular dimensions and delicate subvalvular apparatus [5]. Persistent regurgitation following attempted repair can jeopardize cardiac output and significantly impair the ability to wean from extracorporeal life support.

In this context, the decision to implant a Melody transcatheter pulmonary valve in the mitral position, although off-label, was guided by the urgent need for size-matched prosthetic alternatives [6]. Previous reports have described its feasibility in infants with structurally unsuitable mitral valves, providing short-term hemodynamic stability and the potential for later

balloon dilation as the child grows [4,5]. Nonetheless, the presence of VA-ECMO is known to increase the risk of intracardiac thrombosis, particularly in prosthetic valves, and requires diligent anticoagulation and close echocardiographic surveillance [7]. In our case, despite optimal management, thrombotic obstruction occurred and necessitated surgical clot removal, which is a known but rarely reported complication in this setting.

From a wound management perspective, the case also shows the complexity of healing following delayed sternal closure in neonates with prolonged ECMO exposure. Sternal wound dehiscence is a feared complication that significantly increases the risk of mediastinitis and mortality [8]. NPWT has gained increasing acceptance as a viable option to manage open chest wounds in pediatric cardiac patients, supporting granulation tissue formation, reducing edema, and preventing bacterial colonization [9]. In our patient, NPWT was combined with a topical oxygen-enriched gel in the early stages, followed by extended monotherapy with the gel. This sequential strategy led to full wound closure by secondary intention without requiring surgical re-intervention, despite colonization with ESBL-producing organisms and systemic infections.

Nonetheless, this case report has some limitations. As a single case, it does not allow for generalization of treatment efficacy or safety, especially regarding the off-label use of the Melody valve in the mitral position and the combined wound management strategy. The absence of long-term follow-up data also limits our ability to assess the durability of mitral valve function and the integrity of the healed sternal wound over time. Furthermore, the contribution of each component of the wound therapy protocol (NPWT vs. topical oxygen gel) could not be independently evaluated, and the role of systemic antibiotic therapy in infection control may have confounded the outcome. Despite these limitations, the case provides a valuable description of a rare and complex clinical course and highlights practical strategies for managing surgical and postoperative complications in high-risk neonates.

This case illustrates how a coordinated, multidisciplinary approach can enable full recovery in even the most critically ill neonates with complex congenital heart disease. The integration of advanced surgical techniques, proactive management of valve-related complications, and extended VA-ECMO support was crucial to patient stabilization. Equally important was the use of a structured wound care protocol combining negative pressure wound therapy and topical oxygen-enriched gel, which effectively promoted secondary intention healing after delayed sternal closure. Despite recurrent infections and multiple high-risk re-operations, the infant achieved complete recovery without long-term neurological or wound-

related sequelae. This report underscores the importance of individualized surgical planning, vigilant postoperative care, and innovative wound management in optimizing outcomes in high-complexity neonatal cardiac cases.

List of abbreviations

- ASD: atrial septal defect
- CHD: congenital heart disease
- DSC: delayed sternal closure
- ECMO: extracorporeal membrane oxygenation
- ESBL: extended-spectrum beta-lactamase
- IAA: interrupted aortic arch
- ICU: intensive care unit
- NPWT: negative pressure wound therapy
- VAC: vacuum-assisted closure
- VA-ECMO: veno-arterial extracorporeal membrane oxygenation
- VSD: ventricular septal defect

Declarations

Ethics approval and consent to participate

Ethical review and approval were waived for this study under institutional policies on case reports.

Consent for publication

Written informed consent was obtained from the patient's legal guardian for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

Availability of data and materials

The completed CARE checklist is provided as Supplementary File 1. All data generated or analyzed during this case are included in this article. Further information or supporting materials can be obtained from the corresponding author upon reasonable request (rosario.caruso@unimi.it).

Competing interests

The authors declare no competing interests.

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Authors' contributions

Conceptualization: GC, AGi, RC. Data curation: GC, MR, FT, ASa. Investigation: AV, MLR, GI, CM, MCh, GG. Methodology: AGi, RC. Project administration: AGi, RC. Supervision: AGi, RC. Validation: MCh, GG, RC. Visualization: GC, MR. Writing – original draft: GC, RC. Writing – review & editing: AGi, AV, MR, MLR, FT, GI, ASa, CM, MCh, GG, RC.

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Figure legends

Figure 1. Wound dehiscence after the latest surgery.

Figure 2. Dehiscence after 33 days of combined treatment (VAC therapy + oxygen-enriched gel).

Figure 3. Dehiscence after 38 days of treatment with oxygen-enriched gel.

Figure 4. Healed wound by secondary intention after 73 days of treatment with oxygen-enriched gel.





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