

Review

Not peer-reviewed version

Pediatric Cardiology in Wartime: The Hidden Burden of Delayed Care and the Imperative of Reversibility

[Antoine Abdel Massih](#)*, Julia Ehab Doss, [Ornella Milanesi](#)

Posted Date: 12 January 2026

doi: 10.20944/preprints202601.0834.v1

Keywords: reversibility of congenital heart disease; wartime ethics



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a [Creative Commons CC BY 4.0 license](#), which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Disclaimer/Publisher's Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.

Review

Pediatric Cardiology in Wartime: The Hidden Burden of Delayed Care and the Imperative of Reversibility

Antoine Abdel Massih ^{1,2}, Julia Ehab Doss ³ and Ornella Milanese ⁴

- ¹ Pediatric Cardiology unit, Faculty of Medicine, Cairo University, Cairo, Egypt
- ² Pediatric Cardiology division, Pediatrics' Department, Sheikh Khalifa Medical City, Pure Health Group, Abu Dhabi, UAE
- ³ Research Accessibility Team (AbdelMassih's Undergraduate research initiative), Faculty of Medicine, New Giza University, Cairo, Egypt
- ⁴ Pediatric Cardiology division, Pediatrics' Department, Padova University, Padova, Italy
- * Correspondence: antoine.abdelmassih@kasralainy.edu.eg

Abstract

Armed conflicts disrupt healthcare systems, creating profound challenges for children with congenital heart disease (CHD). Time is a critical determinant of cardiac physiology, disease progression, and surgical feasibility. This editorial highlights how delays in diagnosis and treatment transform otherwise reversible conditions into advanced, irreversible, and life-limiting disease. Focusing on pulmonary vascular disease in neglected shunt lesions, truncus arteriosus, and left ventricular (LV) deconditioning in D-transposition of the great arteries (D-TGA), we outline the pathophysiological pathways through which delayed intervention limits therapeutic options. We also emphasize the ethical responsibility of the global pediatric cardiology community to develop wartime-resilient care models.

Keywords: reversibility of congenital heart disease; wartime ethics

Background: The Principle of Reversibility in Congenital Heart Disease

CHD are the most frequent congenital malformations, accounting for 0,8 1% of all the live born. Warfare exerts a devastating impact on children with congenital heart disease (CHD), a population uniquely dependent on early detection and timely intervention [1]. Congenital heart lesions follow very specific natural histories shaped by age-related changes in vascular physiology, myocardial conditioning, and cardiopulmonary adaptation. When war disrupts health systems, children lose access to screening, transport, and cardiac surgery, and these narrow therapeutic windows close. As a result, lesions that are fully correctable in infancy progress to irreversible cardiopulmonary disease, often transforming a surgically treatable condition into lifelong morbidity or early mortality. The central concept that emerges is that **reversibility in CHD is time-dependent**, and conflict settings accelerate the loss of this reversibility [2].

Reversibility refers to the capacity to restore normal or near-normal cardiovascular physiology if a lesion is corrected within the appropriate developmental window. Many congenital heart defects have a benign trajectory when repaired early but evolve into irreversible disease when diagnosis and treatment are delayed. Wartime conditions—marked by limited access to echocardiography, absence of referral pathways, and collapse of surgical services—push children far beyond the threshold at which surgery can restore normal physiology. This phenomenon is illustrated starkly in three clinical contexts encountered frequently in war-affected regions.

Main Body

1. Pulmonary Vascular Disease in Neglected Left-to-Right Shunt Lesions (accounting for 20-40% of CHD)

In peacetime, defects such as ventricular septal defects (VSD), patent ductus arteriosus (PDA), and complete atrioventricular septal defects (AVSD) are typically repaired within the first year of life. Early closure prevents the progression of pulmonary vascular remodeling and preserves normal pulmonary artery pressures. However, children growing up in war zones often present years after the optimal window has passed. Long-standing exposure to high pulmonary blood flow induces medial hypertrophy, intimal fibrosis, and progressive elevation of pulmonary vascular resistance. Once resistance approaches systemic levels, physiology becomes irreversible, and Eisenmenger syndrome develops. At this stage, shunt closure is contraindicated and survival is significantly reduced, leaving transplantation as the only theoretical solution—an unavailable option in most conflict settings. Thus, a curable lesion becomes an untreatable chronic disease solely due to delay. [3,4]

2. Truncus Arteriosus: When Delay Means Loss of Operability

Truncus arteriosus is a lesion that demands early neonatal intervention. Ideally, repair is performed within the first few weeks of life, before the onset of accelerated pulmonary vascular disease and long-term damage to the truncal valve. In wartime, newborns with truncus arteriosus rarely receive timely diagnosis or referral. By the time they reach medical attention, severe pulmonary hypertension, significant truncal valve regurgitation, ventricular dilation, and malnutrition are often already established. These late changes dramatically increase surgical risk, and for many children, operative repair becomes either extremely hazardous or no longer feasible. A condition that is surgically correctable in early infancy becomes effectively lethal when health systems collapse [5,6].

3. Left Ventricular Deconditioning in Unoperated D-Transposition of the Great Arteries (D-TGA) the most frequent cyanotic CHD

The arterial switch operation (ASO) for D-TGA must be performed within the first 2–3 weeks of life. During this period, the left ventricle (LV) is still adapted to systemic pressures, a remnant of its intrauterine hemodynamic load. When surgery is delayed, the ductus closes, LV pressure drops, and the LV remodels into a thin-walled chamber suited only for pulmonary circulation. Once this deconditioning occurs, the LV is no longer capable of supporting systemic output, making a late ASO dangerous without a formal LV retraining process—something rarely available in conflict zones. As a result, many children receive atrial switch procedures (Mustard or Senning), which provide survival but lead to lifelong risks of systemic right ventricular failure, arrhythmia, baffle obstruction, and reduced exercise tolerance. The delay robs these children of the only truly physiological repair.

Wartime Cardiology: Beyond Physiology—Ethical and Systemic Obligations

The challenges of pediatric cardiology in wartime extend beyond individual lesions. Conflict dismantles the entire continuum of care—from prenatal diagnosis to neonatal stabilization, transportation, surgery, and long-term follow-up. Many children never undergo newborn screening, specialists are inaccessible, and parents lack safe transport to referral centers. Malnutrition, infections, and unstable living conditions further worsen surgical outcomes. These realities impose a moral responsibility on the global pediatric cardiology community to develop wartime-resilient strategies: remote echocardiography programs, emergency evacuation pathways for time-critical lesions, local provider training for duct-dependent stabilization, and humanitarian surgical missions with clear operability criteria. Without such systems, the burden of irreversible CHD will continue to escalate [7,8].

Conclusion

War deprives children with congenital heart disease of the most vital therapeutic resource: **time**. Delays in diagnosis and treatment transform reversible neonatal and infant lesions into advanced, irreversible physiologies. The progression of neglected shunt lesions to Eisenmenger syndrome, late-presenting truncus arteriosus, and LV deconditioning in unoperated D-TGA represent some of the most visible consequences of these delays. The pediatric cardiology community must prioritize

systems that preserve operability windows, ensure timely intervention, and protect children from preventable cardiac deaths—even in the most unstable circumstances. Safeguarding reversibility in CHD is not simply a clinical objective; it is a humanitarian necessity.

Institutional Review Board Statement: not applicable as this study is a hypothesis/Review article.

Informed Consent Statement: not applicable as this study is a viewpoint/editorial.

Data Availability Statement: All data is made available within the manuscript and are owned by the authors.

Acknowledgments: To every child who is struggling for basic needs during wartime.

Conflicts of Interest: The authors declare no conflict of interest. The manuscript is submitted under Creative Commons Licensing CC-BY-NC-ND. A large language model has been used to proofread the article.

References

1. Xu, J. *et al.* Global, regional, and national epidemiology of congenital heart disease in children from 1990 to 2021. *Front. Cardiovasc. Med.* **12**, (2025).
2. van der Feen, D. E., Bartelds, B., de Boer, R. A. & Berger, R. M. F. Assessment of reversibility in pulmonary arterial hypertension and congenital heart disease. *Heart* **105**, 276–282 (2019).
3. Li, Q., He, Y., Zhang, C. & Gu, H. Invasive Hemodynamic and Vasoreactivity Testing with Inhaled Iloprost in Children with Pulmonary Arterial Hypertension Associated with Congenital Heart Defects. *Cardiol. Discov.* **3**, 232–238 (2023).
4. Gerhardt, F. *et al.* Positive Vasoreactivity Testing in Pulmonary Arterial Hypertension: Therapeutic Consequences, Treatment Patterns, and Outcomes in the Modern Management Era. *Circulation* **149**, 1549–1564 (2024).
5. Hrfi, A. *et al.* Outcome of truncus arteriosus repair: 20 years of single-center experience comparing early versus late surgical repair. *Cardiol. Young* **32**, 1289–1295 (2022).
6. Hoashi, T. *et al.* Death, reoperation, and late cardiopulmonary function after truncus repair. *JTCVS Open* **14**, 407–416 (2023).
7. Martini, M., Valchi, L., Massaro, E., Parrella, R. & Orsini, D. War and Health: the devastating impact of conflict on Wellbeing and Humanitarian Crises. *J. Prev. Med. Hyg.* **65**, E464–E468 (2024).
8. Baatz, R. K., Ekzayez, A., Meagher, K., Bowsher, G. & Patel, P. Cross-border strategies for access to healthcare in violent conflict - A scoping review. *J. Migr. Heal.* **5**, 100093 (2022).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.