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Roeleveld, P.P.; Blom, N.A.; Hazekamp, M.G.

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Residual Lesions and ECMO: Seek and You Shall Find Ways to Narrow the ECMO Gap

Peter P. Roeleveld, MD, PhD¹ ,
Nicolaas A. Blom, MD, PhD¹, and
Mark G. Hazekamp, MD, PhD¹

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In the first hours to days following neonatal and/or pediatric heart surgery, extracorporeal membrane oxygenation (ECMO) is a standard modality which can be used to temporarily support the circulation in cases of cardiogenic shock when conventional means are not sufficient.¹ The goal of venoarterial ECMO is to provide adequate systemic oxygen delivery while creating the ideal circumstances to give the heart the chance to recover. Indications for ECMO include failure to wean from cardiopulmonary bypass (CPB), low cardiac output state, hypoxia, pulmonary hypertension, arrhythmias, and/or cardiac arrest. Postcardiotomy ECMO is utilized in $\approx 2.4\%$ of congenital cardiac surgery patients with substantial interhospital variation according to the Society of Thoracic Surgeons (STS) database and is associated with an increased rate of mortality compared to patients who do not receive ECMO support.² Generalized survival outcomes of postcardiotomy ECMO are 40% to 50% and are determined by many factors such as age, underlying congenital diagnosis, the reason for ECMO, severity of disease and degree and duration of support prior to ECMO, lactate clearance while on ECMO, complications of ECMO, identification of residual lesions, and duration of ECMO support.^{3,4}

As we seek to improve the outcomes of our ECMO patients, several challenges still lie ahead. Patient selection and timing of ECMO initiation remain major challenges, as no evidence-based criteria for ECMO initiation exist and, therefore, it remains a multidisciplinary team decision based on local experience and protocols. Consideration for early initiation of ECMO is advised according to the Extracorporeal Life Support Organization cardiac ECMO guidelines, as extended cardiogenic shock is associated with worse outcomes.¹ Children who fail to wean from CPB, compared to children who are cannulated because of low cardiac output in the intensive care unit, have been shown to have increased ECMO duration and hospital length of stay in 1 large multicenter study and increased mortality in smaller single-center studies.⁵⁻⁷ Other important challenges include anticoagulation, complications, ECMO duration, and long-term neurodevelopmental outcomes. As ECMO duration negatively impacts on survival, it is important to shorten the ECMO duration as much as possible by identifying and treating the reason for the ECMO requirement as soon as possible while providing sufficient systemic blood flow and relieving the myocardium as much as possible by making sure it is properly offloaded.

In the literature there are already a few important suggestions that far more residual lesions can be identified with cardiac catheterization than by echocardiography alone, and that identifying residual lesions earlier improves outcomes.⁸⁻¹² And now, Soynov et al¹³ also shared their experience in identifying residual lesions in this issue of the *World Journal for Pediatric and Congenital Heart Surgery*. The authors performed a retrospective analysis of their patients who received postcardiotomy ECMO support. They compared 2 groups of patients based on the additional diagnostic tests they underwent. Very interestingly, they also analyzed autopsy results. Patients in the echo-only group ($n=28$) underwent only echocardiography while on ECMO support, while patients in the echo-plus group also underwent either cardiac catheterization ($n=18$) or computerized tomographic (CT) angiography ($n=10$). Both groups were otherwise similar (age, RACHS score, type of repair, indication for ECMO, etc). Residual lesions were defined as hemodynamically significant lesions of the heart, coronary arteries, or great arteries that required surgery for weaning from ECMO. Their main finding was that survival in the echo-plus group was significantly higher compared to the echo-only group (53% vs 14%; $P=.004$) and that performing cardiac catheterization or CT-angiography was safe. More residual lesions were identified in the echo-plus group while on ECMO, although the difference was not statistically significant (32% vs 14%; $P=.32$). The authors were able to perform an autopsy on almost all deceased children and found no residual lesions in the echo-plus group, suggesting that all residual lesions were identified while on ECMO. In the echo-only group however, residual lesions that could have contributed to mortality were identified in 40% of deceased children. The authors also showed that earlier diagnosis of residual lesions leads to significantly shorter ECMO duration (190 vs 590 h, $P=.002$) and better hospital survival (72% vs 20%, $P=.01$). The identified residual lesions (either during ECMO or during autopsy) were mainly extracardiac lesions (eg

¹ Leiden University Medical Center, Leiden, The Netherlands

Corresponding Author:

Peter P. Roeleveld, Department of Pediatric Intensive Care, Leiden University Medical Center, Leiden, Albinusdreef 2 2300RC, the Netherlands.
Email: p.p.roeleveld@lumc.nl

pulmonary artery stenosis, aortic arch obstruction, coronary artery compression), but also intracardiac (eg residual VSD). These findings described by Soynov et al confirm earlier studies that echocardiography alone is not sufficient in identifying all residual lesions and should prompt us all to look proactively for the cause of circulatory compromise as soon as possible in order to improve outcomes. Cardiac catheterization can safely be performed on patients supported by ECMO and can often lead to direct treatment of hemodynamic and/or anatomic abnormalities.¹⁴ Furthermore, Soynov et al¹³ have now also shown benefit of CT-angiography, which also allows for assessment of other organs (eg lung, brain), but unlike cardiac catheterization does not allow for direct intervention in the course of the diagnostic study. Another interesting challenge illustrated in the current study by Soynov et al¹³ is the so-called “ECMO-gap,” which represents mortality after successful ECMO weaning.¹⁵ In the echo-plus group 5 patients (25%) died after successful ECMO weaning. But, in the echo-only group, an impressive 13 patients (65%) died despite successful ECMO weaning. Keeping in mind that 40% of the patients in the echo-only group who did not survive had residual lesions on autopsy, this could suggest that unidentified residual lesions play an important role in the ECMO gap in postcardiotomy ECMO in children.

Identifying factors that can help us improve outcomes of postcardiotomy ECMO patients requires further study as many challenges still lie ahead. And as no randomized controlled trials have been performed, we all have to rely on retrospective single-center studies such as this current report by Soynov et al.¹³ Despite its small size and single-center retrospective limitations, it adds important information. Enough suggestions now exist to support quick proactive identification and treatment of residual lesions to improve outcomes. If echocardiography fails to provide clues to explain the circulatory compromise leading to ECMO, one should not hesitate to perform either CT-angiography and/or cardiac catheterization as soon as possible.

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ORCID iD

Peter P. Roeleveld  <https://orcid.org/0000-0001-5491-9408>

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