REVIEW DERLEME

The Importance of Functional Echocardiography in Neonatal Resuscitation: Two Newborn Case Reports and a Literature Review

Yenidoğan Resüsitasyonunda Fonksiyonel Ekokardiyografinin Önemi: İki Yenidoğan Olgu Sunumu ve Literatür İncelemesi

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Abstract

Introduction: Functional echocardiography has been used to identify the etiologies of cardiac arrest and to evaluate the benefit of continued resuscitation after cardiac arrest. It gains more importance in the detection of treatable causes, especially in cardiopulmonary resuscitation of newborns with a diagnosed disease that may develop complications such as massive pericardial effusion and thrombosis.

Case Report: Here, we present the findings and results of functional echocardiography performed during cardiopulmonary resuscitation of two newborns with neonatal lupus syndrome and congenital nephrotic syndrome.

Conclusions: More studies are needed to clarify the usability of functional echocardiography in neonatal cardiopulmonary resuscitation. It is gaining more importance, especially in newborns with a possible diagnosis of complications. The most important situation here is that echocardiography should be performed without affecting the continuity of resuscitation. Accompanied by an experienced user, it will allow rapid identification of reversible causes of cardiac arrest.

Keywords
Resuscitation, neonatal lupus syndrome, point-of-care ultrasound, pericardial effusion, cardiac thrombus

Öz

Giriş: Fonksiyonel ekokardiyografi, kardiyak arrest etiyolojilerini belirlemek ve kardiyak arrest sonrası devam eden resüsitasyonun yararını değerlendirmek için kullanılmaktadır. Özellikle masif perikardiyal efüzyon ve tromboz gibi çeşitli komplikasyonların gelişebileceği hastalığı olan yenidoğanların kardiyopulmoner resüsitasyonunda tedavi edilebilir nedenlerin saptanmasında daha da önem kazanmaktadır.

Olgu Sunumu: Burada, neonatal lupus sendromu ve konjenital nefrotik sendromu olan iki yenidoğanın kardiyopulmoner resüsitasyonu sırasında yapılan fonksiyonel ekokardiyografi bulguları ve sonuçları sunulmuştur.

Sonuç: Yenidoğan kardiyopulmoner resüsitasyonunda fonksiyonel ekokardiyografinin kullanılabilirliğini netleştirmek için daha fazla çalışmaya ihtiyaç vardır. Özellikle olası komplikasyon tanısı olan yenidoğanlarda daha fazla önem kazanmaktadır. Burada en önemli durum, ekokardiyografinin resüsitasyonun sürekliliğini etkilemeden yapılması gerektiğidir. Deneyimli bir kullanıcı eşliğinde, kardiyak arrestin geri dönüşümlü nedenlerinin hızlı bir şekilde tanımlanmasına olanak sağlayacaktır.

Anahtar kelimeler
Resüsitasyon, neonatal lupus sendromu, hastabaşı ultrasonu, perikardiyal efüzyon, kardiyak trombüs

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Introduction

Despite its growing use in neonatal intensive care, no functional echocardiography training process designed for neonatologists (1). Echocardiography can be used for structural or functional assessment. Functional echocardiography can be used at the bedside for additional physiological information to assist the clinician in specific clinical problems (2). Comprehensive echocardiography provides a cross-sectional assessment, whereas serial functional echocardiography can immediately reveal changes in the patient's hemodynamic status.

Ideally, accession to functional echocardiography should be available in all neonatal intensive care units for the detection of treatable etiologies (particularly in the resuscitation of cardiopulmonary arrest) with quick intervention in clinics providing care to critically ill infants (1). Functional echocardiography has gained more importance, especially in the management of diseases with multiorgan involvement in newborns and follow-up of complications that may develop. In cases of cardiac arrest that may develop in these patients, functional echocardiography can be used in the detection of global heart contraction, the diagnosis of massive pericardial effusion and, other pathologies such as thrombus.

Case Presentation

Case 1

A male infant was born at the gestational age of 34th weeks to a mother with glucose 6 phosphate dehydrogenase enzyme deficiency and Sjögren's syndrome by emergency cesarean delivery because of preeclampsia. The Apgar scores were 7/9 at 1 and 5 min. The mother was asymptomatic and the planned quinine treatment was not given during pregnancy due to the risk of hemolytic crisis. Blood count and peripheral blood smear showed thrombocytopenia (platelet: 14,000/μL). Electrocardiography (ECG) revealed no block. On the second day of hospitalization, antiepileptic treatment was added due to myoclonic seizures. Cranial ultrasonography (USG) was normal. Laboratory examinations yielded as anti-Ro (anti-SSA): 305 U/mL (>22: positive), ANA:137 (>60: high positive), ketone, ammonia, lactic acid/pyruvic acid ratio, anti-ds DNA, anti-SSB (anti-La), AMA and cerebrospinal fluid amino acids resulted normally. Sudden cardiac arrest occurred on the 9th day of hospitalization. No block was observed in the ECG. There was minimal pericardial effusion on structural echocardiography and Holter ECG monitoring was normal. The umbilical venous catheter position was 0.5 cm below the diaphragm on the X-ray and echocardiography confirmed that it was not inside the heart. Nevertheless, the catheter was removed. Sudden cardiac arrest occurred again on the 19th day of hospitalization. The patient, who was intubated and started the cardiac massage, had no electrolyte abnormality. The lungs were evenly ventilated and pneumothorax was not considered, but there was no response to heart massage. Functional echocardiography was performed immediately on the patient, who underwent heart massage for 30 min, and diffuse pericardial tamponade was detected. Emergency pericardiocentesis was performed with a needle under the sternum, the rhythm in the ECG returned to sinus rhythm, and resuscitation was terminated. In the control echocardiography, minimal pericardial effusion was observed (Figure 1).

The pericardial fluid sample was transudate. İntravenous 2 mg/kg/day prednisolone treatment was initiated with the diagnosis of neonatal lupus. Pericardial effusion was not observed in control structural echocardiography. He was extubated on the 24th day. Complete enteral feeding was initiated on the 10th day. In electroencephalography, moderate background rhythm irregularity was detected. Cranial magnetic resonance imaging was normal. The patient was discharged on the 30th day of hospitalization. Prednisolone treatment was discontinued. At two months of age, repeated electroencephalography was normal, so antiepileptics were discontinued. The patient is currently one year old and his neurological development is compatible with his peers.

Case 2

A female infant was born at the gestational age of 36th weeks and 1900 g birth weight by emergency cesarean delivery because of the premature rupture of membranes. The Apgar scores were 7/9 at 1 and 5 min. The patient was admitted to the neonatal intensive care unit due to neonatal nephrotic syndrome, hypothyroidism, and right forearm tissue separation due to albumin extravasation. There were right forearm skin-subcutaneous tissue separation, diffuse

pretibial and periorbital edema, and diaper dermatitis. Her parents were second-degree relatives. Laboratory values Hg: 9.3 g/dL, PLT: 840x$10^3/\mu$L albumin: 11.9 g/L, thyroid function and viral serologies were normal. The microprotein concentration in spot urine was 1844 mg/dL, the creatinine concentration was 13.62 mg/dL, and the protein/creatinine ratio was calculated to be 135 (normal <2). Ultrasonographic examination of the kidneys was normal. Levothyroxine for hypothyroidism and aspirin for thrombocytosis and tendency to thrombosis were continued. Because of the diagnosis of congenital nephrotic syndrome, an analysis, of the *NPHS-1* gene mutation was planned. A left nephrectomy was performed at postnatal 86 days due to the ongoing need for albumin. Sudden cardiac arrest developed one day after nephrectomy. After approximately 15 min of cardiopulmonary resuscitation, the rhythm on the monitor returned to normal sinus rhythm. Pulse was detected and resuscitation was terminated. Functional echocardiography was immediately performed on resuscitation during the pulse control period and a 15x7 mm atrial thrombus originating from the superior vena cava was detected in the right atrium (Figure 2). Afterward, two additional thrombuses originated from the inferior vena cava-right atrium junction and the inferior vena cava were detected in structural echocardiography. A treatment dose of enoxaparin sodium was started and a femoral catheter was inserted. A systemic recombinant tissue plasminogen

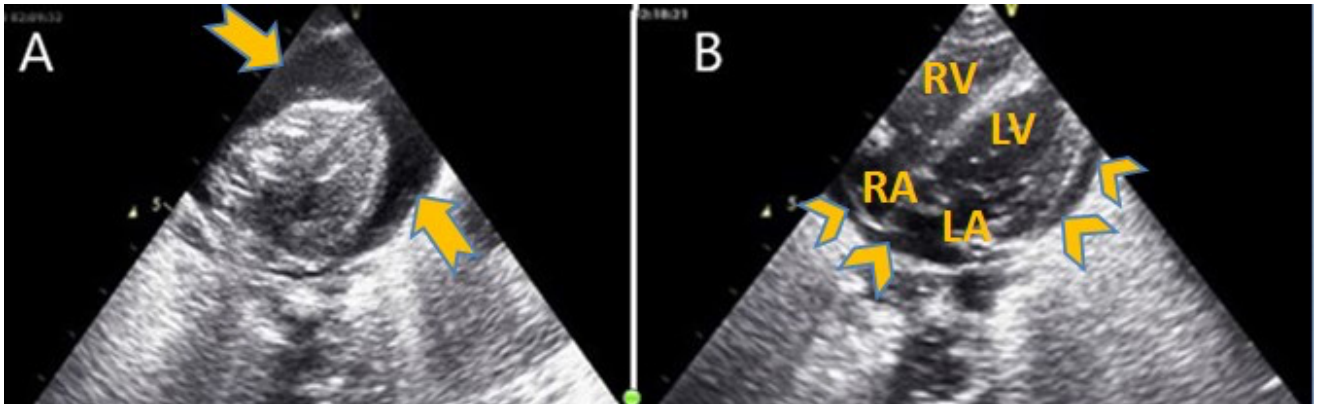

Figure 1. Functional echocardiography of a patient with neonatal lupus syndrome at the postnatal age of 19 days. **A,** Pericardial tamponade image (arrows). **B,** View of minimal pericardial effusion after pericardiocentesis (arrowheads). LA=left atrium; LV=left ventricle; RA=right atrium; RV=right ventricle.

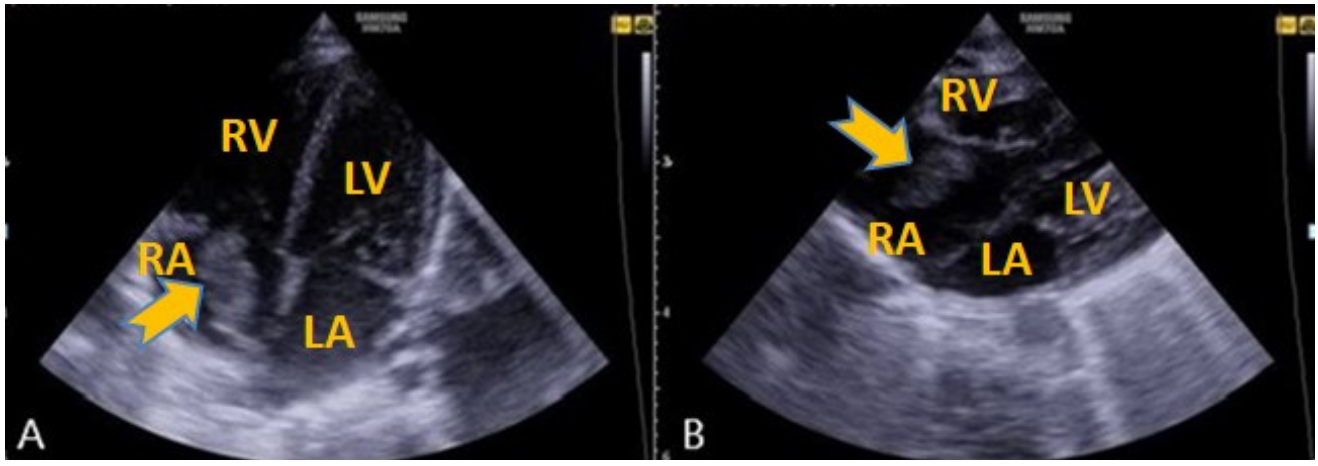

Figure 2. Functional echocardiography of a patient with congenital nephrotic syndrome during sudden cardiac arrest 1 day after left nephrectomy. Atrial thrombus, 15x7 mm in size, originating from the superior vena cava and extending towards the tricuspid valve (arrow) (**A.** Apical 4 chamber view, **B.** subcostal 4 chamber view). LA=left atrium; LV=left ventricle; RA=right atrium; RV=right ventricle.

activator could not be used due to the recent major surgery. Thrombectomy was not performed because of hemodynamic instability, and echocardiographic follow-up was continued. It was observed that the thrombus was organized and decreased within one week after the start of enoxaparin sodium. However, the patient died on the 68th day of hospitalization due to respiratory failure secondary to sepsis.

Discussion

Several tools are used in the evaluation of the resuscitation process, aiming to optimize systemic and coronary blood flows and thus increase the probability of return of spontaneous circulation (ROSC). In the general cardiopulmonary resuscitation (CPR) process, point-of-care ultrasound (POCUS) is an important practice in the diagnosis of reversible causes of cardiac arrests, such as tamponade, hypovolaemia, and tension pneumothorax, and in distinguishing true asystole from false asystole (3).

Functional echocardiography is the use of cardiac ultrasound at the bedside to assess cardiac output, myocardial function, pericardial effusion, systemic and pulmonary blood flow, and cardiac shunts. This approach provides information about the cardiovascular physiology causing hemodynamic instability in sick neonates to enable targeted, noninvasive, rapid and accurate therapeutic interventions (4). The most important knowledge is that neonatal functional echocardiography should not replace a comprehensive examination by a pediatric cardiologist (5). Once major congenital heart diseases have been excluded, the patient can be followed up with functional echocardiography studies, and the scope of functional echocardiography includes suspected pericardial or pleural effusion and other pathologies.

Massive pericardial effusion is very rare in newborns but potentially fatal. Complications are usually associated with intracardiac placement of an indwelling catheter (5,6). More rarely, it can also occur secondary to diseases such as neonatal lupus syndrome, as in our first case. Pericardial effusion can be easily defined on functional echocardiography, and timely intervention in the presence of cardiac tamponade can be lifesaving.

The association between NLS and pericardial effusion is rarely reported in the literature. In these cases, the main causes of pericardial effusion are associated with hydrops secondary to blocks (7), heart failure (8) or dilated cardiomyopathy (9). In the follow-up of our first case, there was no heart block on the postnatal 9th day, but there was minimal pericardial effusion. On the 19th postnatal day, massive pericardial effusion was diagnosed with emergency cardiac ultrasound and drained immediately by pericardiocentesis. According to literature reviews, our case who developed pericardial effusion without developing congenital heart block, appears to be a first.

The incidence of intracardiac thrombosis in the neonatal intensive care unit is 0.7-2.4 per 1000 cases, 90% of which are central venous catheter-related (10). Catheter embolectomy, medical thrombolysis, and surgical resection are the main options for treatment. The cause of intracardiac thrombosis in this case was the urinary loss of antithrombin-3, which is common in congenital nephrotic syndrome, and increased protein-C and protein-S levels. Contrary to the literature, the clinical finding of our patient was sudden cardiac arrest due to the closure of the right atrial outflow tract with a thrombus, which was treated with enoxaparin sodium.

Current American Heart Association guidelines recommend that resuscitation management should focus on quality and continuous chest compressions, and the identification of reversible causes of cardiac arrest in nonshockable rhythms (11). Ultrasonography has also been of great interest as a potential aid in deciding on treatment (12). However, most studies in the current literature do not investigate the potential harms of pauses in chest compression during cardiac arrest. A few studies have shown that the use of ultrasonography during resuscitation leads to longer interruptions in CPR (13). The FEER study recommended evaluating the heart for no more than 10 seconds (14). Since our two cases had prolonged resuscitation, we used ultrasound within the pulse control period and ended for about 10 seconds.

Conclusion

More studies are needed to clarify the usability of functional echocardiography in neonatal cardiopulmonary resuscitation. It is gaining more importance, especially in newborns with a possible diagnosis of complications. The most important situation here is that echocardiography should be performed without affecting the continuity of

resuscitation. Accompanied by an experienced user, it will allow rapid identification of reversible causes of cardiac arrest.

Consent to participate: Written informed consent was obtained from the parents of the patient for publication of this case report and any accompanying images.

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Ethics

Conflict of Interest: No conflict of interest was declared by the authors.

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