



ARAŞTIRMA / RESEARCH

Targeted neonatal echocardiography in neonatal intensive care unit

Yenidoğan yoğun bakım ünitesinde hedefe yönelik neonatal ekokardiografi

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Abstract

Purpose: The aim of the study is determining the frequency of use, and the patient characteristics and indications.

Materials and Methods: This retrospective cohort study included all neonates who underwent targeted neonatal echocardiography in the neonatal unit of Adana Şehir Training and Research Hospital between September 2016 and September 2018. All newborns who underwent echocardiography according to clinical findings within 24 months were included in the study. Data including gestational age, birth weight, respiratory support, timing and diagnosis of echocardiography were obtained from the review of clinical notes.

Results: A total of 355 echocardiographic evaluations were performed in 186 newborns. The most common indications for targeted echocardiography were patent ductus arteriosus (n = 148, 41.7%) followed by evaluation of myocardial performance and systemic blood flow (n = 99, 27.9%) and pulmonary hypertension (n = 72, 20.3%). The median time of echocardiographic evaluation was postnatal 22 (1-178) hours. More than half (59.7%) of the newborns received respiratory support (continuous positive pressure ventilation (21%), conventional mechanical ventilation (27.4%), and high frequency oscillation ventilation (11.3%).

Conclusion: Targeted echocardiography is often used and it can be a useful tool in guiding treatment. Assessment of patent ductus arteriosus, myocardial performance and systemic blood flow are the most common indications for use. Large, well-coordinated prospective studies are needed to confirm its usefulness.

Key words: Echocardiography, neonate, intensive care

Öz

Amaç: Çalışmanın amacı yenidoğan yoğun bakım ünitesinde hedefe yönelik ekokardiografinin kullanım sıklığını, hasta özelliklerini ve endikasyonlarını belirlemektir.

Gereç ve Yöntem: Bu retrospektif kohort çalışması, Eylül 2016 ve Eylül 2018 yılları arasında Adana Şehir Eğitim ve Araştırma Hastanesi yenidoğan ünitesinde hedefe yönelik neonatal ekokardiografi değerlendirilmesi yapılan tüm yenidoğanları içermektedir. Çalışmaya 24 aylık sürede klinik bulgulara göre ekokardiografi yapılan tüm yenidoğanlar dahil edildi. Gebelik yaşını, doğum ağırlığını, solunum desteğini, ekokardiografinin zamanlamasını ve tanıları içeren veriler klinik notların gözden geçirilmesinden elde edilmiştir.

Bulgular: Toplam 355 ekokardiografik değerlendirme 186 yenidoğanda yapıldı. Hedefe yönelik ekokardiografi endikasyonlarından en sık olanı patent duktus arteriozus değerlendirmesi (n = 148, %41,7), ardından miyokard performansı ve sistemik kan akımı değerlendirmesi (n = 99, %27,9) ve pulmoner hipertansiyon (n = 72, % 20,3) idi. Medyan ekokardiografik değerlendirme zamanı postnatal 22 (1-178) saattir. Yenidoğanların yarısından fazlası (%59,7) solunum desteği almaktaydı (sürekli pozitif basınçlı ventilasyon %21, konvansiyonel mekanik ventilasyon %27,4 ve yüksek frekanslı ossilasyon ventilasyonu % 11,3).

Sonuç: Hedefe yönelik ekokardiografi, sıklıkla kullanılır ve tedaviyi yönlendirmede faydalı bir araç olabilir. Patent Duktus Arteriozus, miyokard performansı ve sistemik kan akımı değerlendirmesi en sık kullanım endikasyonlarıdır. Yararlılığını doğrulamak için iyi koordine edilmiş büyük prospektif çalışmalara ihtiyaç vardır.

Anahtar kelimeler: Ekokardiografi, yenidoğan, yoğun bakım

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INTRODUCTION

Tissue perfusion is difficult to evaluate in neonatal patients with clinical and laboratory findings. Contrary to common knowledge, systemic blood pressure does not directly indicate cardiac functions. But blood pressure is a poor predictor of systemic flow and there is no reliable evidence from which to identify a blood pressure threshold for intervention or that such intervention improves outcome¹. Again, although there is no linear relationship between systemic blood pressure and blood flow, there is a blood pressure threshold for the maintenance of systemic blood flow^{1,2}. In newborn infants, especially in extremely low birth weight (ELBW) preterm infants, arterial blood pressure below 30 mmHg is considered a threshold for disruption of cerebral autoregulation, and below this threshold, the neurodevelopmental outcome is poor². Therefore, it is important to diagnose and appropriately treat cardiovascular dysfunction before it irreversibly affects the clinical status of preterm infants. Also complex hemodynamic changes occur during the transition to postnatal life and also being of patency of ductus arteriosus and hypotension status in neonatal intensive care unit (NICU) stay. Complex hemodynamic changes are observed in neonatal infants due to the presence of Patent Ductus Arteriosus (PDA) and especially hypotensive status in ELBW infants during the postnatal transition period³.

Echocardiography is used for accurate evaluation of hemodynamic status and providing appropriate clinical support in ICU patients. In recent years, the role of echocardiography in neonatal intensive care units (NICU) has changed and improved. Previously, it was only used by cardiologists in neonatal intensive care units to evaluate the structural and functional status of the heart and to determine the patency of ductus arteriosus. Especially in the last decade, the interest of neonatologists in echocardiography has increased. Longitudinal and real time evaluation of hemodynamic changes at the bedside has become widespread. Targeted Neonatal Echocardiography (TnECHO) is the evaluation of the hemodynamic status of neonatal infants using echocardiography, along with clinical and laboratory findings^{3,4}.

TnECHO aims to obtain noninvasive and real time information about cardiovascular pathophysiology which causes complex hemodynamic changes and uncertainties. The functional assessment of the heart

performed by neonatologists should not be confused with cardiologists' structural and functional evaluations of the heart. The first echocardiographic evaluation should be performed by pediatric cardiologists for a comprehensive structural evaluation of the heart, in order to evaluate the cardiac structure, cardiac anatomy and global cardiac function in newborns⁵. Functional echocardiography should focus on identifying the causes of cardiac-induced hemodynamic changes in the structurally normal heart. Neonatologists performs echocardiography to define the bedside use of echocardiography to longitudinally assess myocardial function, pulmonary and systemic blood flow, extracardiac and intracardiac shunts, organ blood flow and tissue perfusion^{5,6}.

TnECHO is widely and effectively practiced by neonatologists across Europe, North America and Australia. Questions related to the TnECHO application remain current due to uncertainty and the absence of a formal and accredited training program worldwide⁷.

To our knowledge, there are no published data on TnECHO applications from Turkey. We have been using TnECHO for four years in our tertiary NICU. In this study, we presented retrospectively the data of our targeted echocardiographic evaluations applied to newborn babies in our 3rd level NICU for a two year period.

MATERIALS AND METHODS

This retrospective cohort study included the neonates who had circulatory collaps, hypotension, required respiratory support (mechanical ventilation) and a central catheter insertion while admitted to the NICU of tertiary care Hospital in Adana, Turkey. This is a 35-bed NICU with an admission rate of about 800 neonates per year. This study was conducted as a result of data collection of patients who underwent echocardiographic evaluations for different reasons between 1 September 2016 and 1 September 2018 for 24 months. In this study period, echocardiography was performed in every patient who had circulatory collaps, hypotension, respiratory support (mechanical ventilation) and a central catheter insertion. The first cardiac full structural evaluation of all patients included in the study was performed by a pediatric cardiologists (Çilsal E, Sönmez H). Echocardiographic evaluations of the patients included in the study were performed by a

single neonatologist (Mert MK) with targeted echocardiographic experience and training.

feeding intolerance, transient tachypnea of newborn, etc) were excluded from the study.

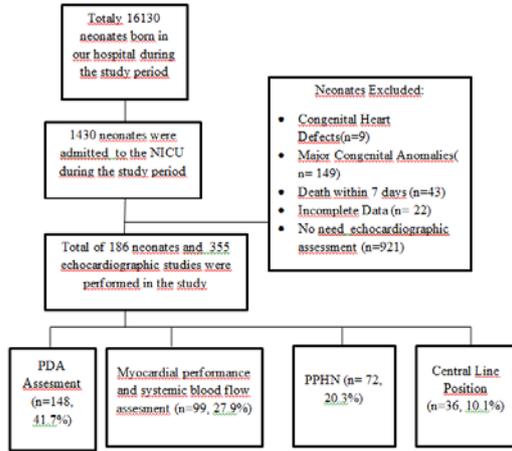


Figure 1. Distribution of study subjects according to indication of TnECHO.

*NICU: Neonatal Intensive Care Unit *PDA: Patent Ductus Arteriosus **PPHN: Persistent Pulmoner Hypertension

Patients diagnosed with major structural heart disease by the pediatric cardiologist, neonates with major congenital anomalies (congenital diaphragmatic hernia, gastrointestinal anomalies, congenital hydrocephaly, spina bifida, etc) and neonates admitted to NICU with indications that don't need hemodynamic evaluation (Hyperbilirubinemia,

The data of sex, gestational age, birth-weight, timing of TnECHO and respiratory and cardiovascular support of the patients included in the study were compiled from the patient notes in the files. Echocardiographic examination was performed by a single user with the Vivid 7® echocardiography machine with a 6S and 10RS neonatal probe (GE, Waukesha, WI, USA). All of the ecocardiographic studies were archived on an expandable storage off the machines. Infection control precautions were followed while performing the scans. The first scan included all the standard views (short axis, long axis, apical axis etc) and also required views for the particular indication. All of the ecocardiographic studies were archived on an expandable storage off the machines. The studies were then downloaded and documented in the patient chart.

Statistical analysis

Descriptive statistics were used to summarize the collected data using SPSS (version 20, IBM, Armonk, NY, USA). Ethics committee approval was obtained for the study in the meeting of Adana Şehir Training and Research Hospital Clinical Research Ethics Committee with the decision No. 513 on June 24, 2019. Since this was a retrospective study, volunteer/ patient consent was not required.

Table 1. Clinical and demographic features of the study

Variable		n (186)	%
Sex	Male	106	57.0
	Female	80	43.0
Gestational Age	<28 weeks	39	20.9
	28 ⁰ -31 ⁶ weeks	51	27.4
	32 ⁰ -37 ⁶ weeks	34	18.4
	38 ⁰ -41 ⁶ weeks	62	33.3
Birth Weight	<1000 gr	41	22.1
	1001-1500 gr	69	37.1
	1501-2500 gr	36	19.3
	> 2500 gr	40	21.5
Timing of ECHO	<12 h	32	17.2
	13-24 h	42	22.6
	25-72 h	69	37.1
	>72 h	43	23.1
Respiratory Support	No Support	29	15.6
	Hood O ₂	46	24.7
	CPAP	39	21.0
	Conventional MV	51	27.4
	HFOV	21	11.3

*CPAP: Continuous positive airway pressure **HFOV: High frequency ossilatory ventilation ¶MV: Mechanical ventilation

RESULTS

During the study period, a total of 355 TnECHO studies were performed on 186 neonates for various indications. The indications for TnECHO included assessment of myocardial performance, systemic blood flow, patent ductus arteriosus (PDA), pulmonary hypertension (PPHN) and central or peripherally inserted central catheters tip position (Figure 1). Some neonates required more than one TnECHO study either to monitor response and/or as per need warranted by clinical situation.

The most infants underwent an echocardiogram for assessment of PDA significance (41.7%). TnECHO resulted in a change in PDA management; the most common of decisions related to choice of PDA care and inotrope therapy. Mostly the purpose of repeated TnECHO evaluations were to monitor treatment response. More than half of the neonates (67.4%) were male and majority of infants were preterm (81.6%). The mean birth weight and gestational age of the neonates in the study was 1.46 kg (SD±0.6 kg) and 33.1 weeks (SD±4.1), respectively. The echocardiography assessments were performed at a median time of 22 (1 to 178) hours. Majority of infants' (n= 143, 76.8%) echocardiography was done within 72 hours, however in 23.2% (n= 43) patients echocardiography was done after 72 hours of NICU admission. More than half of the neonates (59.7%) had respiratory support (continuous positive airway pressure (CPAP) 21%, conventional mechanical ventilation 27.4% and high frequency oscillatory ventilation (HFOV) 11.3%, respectively) (Table 1). Initial diagnosis of patients are prematurity (66.6%), sepsis (5.4%), systemic hypotension/shock (14%) and PPHN (7.5%) and others (%6.5), respectively.

DISCUSSION

In this study, indications of targeted neonatal echocardiography performed in our neonatal intensive care unit were examined. Even though TnECHO application has only begun to spread in Turkey in recent years, it has been applied in NICUs, particularly in North America, Australia and Europe in the last 10 years⁸. There are few retrospective studies in the literature regarding the application of TnECHO in neonates. The impact of the use of functional echocardiography on outcomes is not fully demonstrated, nevertheless many neonatologists have adopted its value in assessing rapidly changing

hemodynamic status⁹. Although there are not enough reports about its efficacy, the use of TnECHO in unwell newborn infants, where sudden hemodynamic changes are common, attracts the attention of neonatologists. The most frequent indication for use of TnECHO in neonatal wards by neonatologists was the evaluation of PDA in preterm infants (51%), and this was followed by pulmonary hypertension and systemic hypotension^{3,10}. In fact, the use of echocardiography by neonatologists who have extensive clinical data in critically ill patients leads to early and effective intervention in hemodynamic instability as a result of serial and longitudinal evaluation. The incidence of a PDA in babies born <1500 g varies between 18 to 77%⁴. The clinical condition leading to early hemodynamic instability in preterm infants is PDA. The incidence of PDA in infants born below 1500 grams is between 18 and 77%⁶. Early detection and early treatment of PDA, which is a major cause of morbidity in preterm infants, has been shown to reduce morbidity in infants⁸. It has been shown that the risk of advanced stage intraventricular haemorrhage is reduced in infants with ductal patency followed by serial echocardiographic evaluation compared to those without serial echocardiographic evaluation^{8,9}. A more recent randomized trial of early targeted PDA treatment trial showed that earlier treatment, based on PDA diameter, reduces pulmonary hemorrhage and the need for late PDA treatment¹⁰. In another study in which hemodynamically significant PDA was determined based on PDA diameter, it was shown that early treatment of PDA reduces the incidence of bleeding in the lungs and the need for late PDA treatment¹¹. In our study, PDA evaluation was the most common indication for TnECHO (41.7%). In addition, the majority of patients who underwent echocardiography were preterm (66.6%) and low birth weight infants (59.2%). This finding correlates with the data which was reported in the study by AM Groves et al., showing that preterm and low birth weight is an important part of the indications of echocardiography¹². In the present study myocardial performance and systemic blood flow assessment (27.9%) and suspected PPHN (20.3%) were the common indications. Various other indication include central line position (10.1%).

In our study, echocardiography was performed in 55.61% of the cases in the first 24 hours. Especially for low birth weight preterm babies, the transitional period in the first hours of life is the most critical period for circulation. In this period, it is seen that

especially ELBW babies are prone to hypotension and their systemic blood flow is low. It may be seen that the immature heart fails to provide systemic blood flow in this patient group even if arterial blood pressure is normal against their increased peripheral resistance¹. During this transition period, arterial blood pressure is not a clear and definitive indicator of low blood flow and low blood flow causes short and long term adverse outcomes⁵. Therefore, especially in preterm infants, the serial and longitudinal evaluation of hemodynamic status by targeted echocardiography gives more accurate and sufficient information about the clinical status^{4,13}.

In our study, 66.1% of the patients on whom ecocardiography was performed received respiratory support. The majority (38.7%) of the babies who received respiratory support received invasive mechanical ventilation and 27.4% of them received noninvasive mechanical ventilation (CPAP) support.

Echocardiography performed by a neonatologist trained in targeted echocardiography will allow real-time and longitudinal hemodynamic evaluation in neonatal clinical practice⁴. It enables evaluation of many parameters such as biventricular output, pulmonary arterial pressure, ductal patency, superior vena cava flow, especially in critical NICU patients, and aids rapid and effective decision making in patient management^{3,5}. The neonatologist's experience with echocardiography, which is different from the cardiologist, allows early detection of cardiac-induced physiological changes that may develop in the normal heart and affect hemodynamics. This enables TnECHO's application area to be activated and improved. In clinical practice, neonatologists need hemodynamically close, serial and longitudinal evaluation of these critical infants³. Continuous monitoring by neonatologists experienced in echocardiography would be more beneficial than intermittent cardiologist consultations in terms of improving and developing patient care⁹. Because a clinician working continuously in the ICU and following up on the patient has more time and motivation for longitudinal hemodynamic assesment compared to cardiologists³. Two recent studies showed that close echocardiographic evaluation in critical patients changed the clinical decision in disease management by 36.89% and 41%^{9,14}. In our patients, echocardiography was also helpful in confirming and modifying the clinical decision and treatment.

There are some limitations in this study. The study

design is retrospective and the sample size of the study is small. There is not any comparative data before and after the period of neonatologist TnECHO application.

The use of echocardiography has changed dramatically within the last decade. With the increasing interest and experience of TnECHO by neonatologists, echocardiography has become more involved in clinical practice. It should be known that echocardiography alone is not sufficient to determine hemodynamic changes in newborn infants. In intensive care practice, echocardiography is one of the main parameters in the comprehensive evaluation of a patient with hemodynamic instability and can only be effective and accurate if used with other parameters. A detailed clinical evaluation together with echocardiography will provide the right clinical decision and treatment. At present, the most important problem with TnECHO is that a standardized and accredited training program is not available worldwide. It is essential that pediatric cardiologists form an important part of this training. A standardized training program prepared with cardiologists for TnECHO, which is showing progress in Turkey with baby steps, and is rapidly gaining attention among neonatologists, is needed.

Yazar Katkıları: Çalışma konsepti/Tasanımı: MKM; Veri toplama: MKM; Veri analizi ve yorumlama: MKM; Yazı taslağı: MKM İçeriğin eleştirel incelenmesi: MKM; Son onay ve sorumluluk: MKM; Teknik ve malzeme desteği: MKM; Süpervizyon: MKM; Fon sağlama (mevcut ise): yok.

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