

# Functional Neonatal Echocardiography: Indian Experience

ANILKUMAR MOHAN KHAMKAR<sup>1</sup>, PRADEEP B. SURYAWANSHI<sup>2</sup>, RAJESH MAHESHWARI<sup>3</sup>, SUPRABHA PATNAIK<sup>4</sup>, NANDINI MALSHI<sup>5</sup>, VIJAY KALRAO<sup>6</sup>, SANJAY LALWANI<sup>7</sup>, JITENDRA SURWADE<sup>8</sup>

## ABSTRACT

**Introduction:** Functional echocardiography, as opposed to echocardiography as performed by the cardiologist, is the bedside utilization of cardiac ultrasound to take after functional and haemodynamic changes longitudinally. Information reflecting cardiovascular capacity and systemic and pulmonary blood flow in sick preterm and term neonates can be observed utilizing this strategy. Information is lacking on its use in neonatal units in India.

**Aim:** To characterize the impact of Functional neonatal echocardiography (FnECHO) programme on decision making in a tertiary care centre in India by evaluating its frequency of use, patient characteristics, and indications.

**Materials and Methods:** Prospective observational study of neonates in a tertiary Neonatal Intensive Care Unit (NICU) in Pune (India) from February 2014 to January 2015. All the neonates undergoing FnECHO during this 12 month period based on clinical findings were included in the study. Data extracted from the review of the clinical notes included gestational age, birth-

weight, mode of delivery, Apgar scores, details of respiratory and cardiovascular support, timing of FnECHO and any other clinical diagnosis. The findings of echocardiography were recorded and correlated with the clinical and other laboratory or X-ray findings. If these findings indicated a change in management, it was instituted.

**Results:** A total of 348 echocardiographic studies were performed in 187 neonates (mean 1.86; SD 2.02). The most frequent indication was Patent Ductus Arteriosus (PDA) assessment (n=174, 50%), followed by haemodynamic instability (n=43, 12.36%). The results of FnECHO modified treatment in 148 cases (42.50%) in the form of addition and/or change in the treatment or avoidance of unnecessary intervention.

**Conclusion:** FnECHO is frequently used in the NICU setting and may be a useful tool to guide treatment. PDA assessment and haemodynamic instability are the most frequent indications. To validate its usefulness, well co-ordinated large prospective studies are needed.

**Keywords:** Neonate, Neonatal intensive care unit, Patent ductus arteriosus, Point of care

## INTRODUCTION

Boundless utilization of echocardiography in NICUs around the globe has been seen because of scaling down of the innovation and expanding accessibility of ultrasound scanners and gifted professionals [1]. Over the past few years, the role of echocardiography in the Neonatal Intensive Care Unit (NICU) has been changed. Beforehand, just Paediatric Cardiologists were performing the echocardiographic studies in the NICU for diagnosing and monitoring Congenital Heart Disease (CHD) and for the screening of Patent Ductus Arteriosus (PDA) in preterm neonates. All the more as of late, it is watched that neonatologists are likewise intrigued by the echocardiographic evaluation of haemodynamic instability in neonates. As an adjunct in neonatal clinical appraisal of the haemodynamic status, new terms, for example, functional echocardiography (FnECHO) and point of care echo cardiography have been presented [1-4].

The essential objective of FnECHO is to give non-invasive information on the fundamental cardiovascular pathophysiology bringing about haemodynamic unsteadiness. It additionally serves to study the response to treatment in an individual neonate over a period of time. It is difficult to define the most appropriate criteria for the FnECHO. The current indications used for FnECHO have been primarily established on the basis of clinical experience in a growing number of neonatal units and recent observational studies and not on the basis of large clinical studies [5]. It is vital to understand that FnECHO is not expected as a substitute for the assessment of a

neonate with suspected CHD by a qualified paediatric cardiologist. On the off chance that basic CHD or critical arrhythmia is clinically suspected in a neonate, the infant ought to be clinically evaluated by a paediatric cardiologist, and echocardiography should be performed by a person trained in paediatric echocardiography and reviewed by a paediatric cardiologist [6-8].

Currently there are no published data on the use of FnECHO in Indian NICUs. In our tertiary NICU, we have been using FnECHO for five years. The present study was undertaken to study the various indications for FnECHO and its usefulness in clinical decision making in a tertiary care centre in India. This is a prospective observational study on the use of FnECHO in an Indian NICU during a 12 month period, in which we sought to analyse frequency and indications of FnECHO use, and effects of FnECHO on the management of neonates.

## MATERIALS AND METHODS

This prospective study was conducted in the Department of Neonatology of tertiary care University Medical College and Hospital, Pune. This is a 40 bedded NICU with annual admission of about 1250 neonates. The study was done over a period of 12 months from February 2014 to January 2015. Every examination was performed at the request of the physicians in charge according to need. Each and every study of FnECHO was performed by neonatologist who bears more than five years experience in neonatal FnECHO. When an ultrasound was done, the results were discussed with the physicians in charge to decide on the therapeutic approach.

### Inclusion criteria

- All the neonates undergoing FnECHO (as per request of physician in charge) during this 12 month period based on clinical findings.

### Exclusion criteria

- Prior diagnosed cases of structural cardiac defects by Paediatric Cardiologist.
- FnECHO performed on neonates out of the study duration.

Data extracted from the review of the clinical notes included gestational age, birth-weight, mode of delivery, Apgar scores, details of respiratory and cardiovascular support, timing of FnECHO and any other clinical diagnosis. The echocardiographic examination was performed by single user by echocardiographic machines with a neonatal probe (Acuson X 300, Siemens Medical Solutions USA, Inc. Probe: P8-4 Transducer Frequency Bandwidth: 8–4 MHz). Infection control precautions were followed while performing the scans. The first scan included all the standard views (long axis, short axis etc). Follow-up scans included the views as required for the particular indication. The findings of echocardiography were recorded and correlated with the clinical and other laboratory or X-ray findings. If these findings indicated a change in management, it was instituted. The collected data was entered in Microsoft Excel (Microsoft Corp, Redmond, WA, USA) spreadsheet and descriptive statistics were used. The study was approved by the hospital ethics committee.

## RESULTS

During the study period, a total of 187 neonates were enrolled in the study on whom FnECHO was performed for various indications. Some neonates required more than one FnECHO study either to monitor response and/or as per need warranted by clinical situation. Thus total of 348 echocardiographic studies were performed in these 187 neonates (mean 1.86, SD 2.02).

[Table/Fig-1] gives the details of the enrolled neonates. More than half of the neonates (67.4%) were male and majority were preterm. The mean gestational age of the neonates in the study was 34.9 weeks (SD±4.8 weeks). The mean birth weight of neonates in the study was 1.90 kg (SD±0.7kg). [Table/Fig-2] describes the distribution of study subjects according to indication of FnECHO. [Table/Fig-3] shows the details of respiratory support that the neonates were receiving at the time of FnECHO scans. [Table/Fig-4] depict the timing of first scan from hospitalization. In 55.4% cases echocardiography was done within 24 hours of admission whereas in only 16.6% cases it was done after 72 hours of admission.

When the impact of FnECHO on patient management was considered, following results were noted. A total of 348 echocardiographic studies were performed in 187 neonates (mean

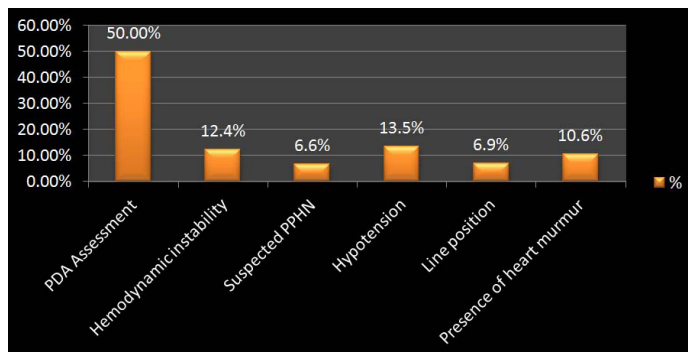
Variable	No. (n=187)	%	
Sex	Male	126	67.4
	Female	61	32.6
Gestational age	< 28 weeks	24	12.8
	28-31.9 weeks	41	21.9
	32-36.9 weeks	48	25.7
	Term (37 – 41.9)	71	38
	Post term (≥ 42 weeks)	03	1.6
Birth weight	< 1 kg	20	10.7
	1-1.499 kg	51	27.3
	1.5-2.499 kg	70	37.4
	2.5 -3.499 kg	44	23.5
	≥3.5 kg	02	1.1

[Table/Fig-1]: Neonatal details

1.86, SD 2.02). Some neonates required more than one FnECHO study either to monitor response and/or as per need warranted by clinical situation. FnECHO results led to treatment modification after 148 echo studies (42.5%). The most common modifications in the management were done in PDA patients. Haemodynamically significant PDA was diagnosed in 26.4% FnECHO. And these cases were managed by ibuprofen.

In 4% FnECHO ibuprofen was stopped before completion of full course or was not started as FnECHO was not suggestive of either haemodynamically significant PDA or it was closed.

Regarding haemodynamic instability, FnECHO led to changes in the management of 8.6% of studies. The changes involved volume expansion therapy (3.4%) and initiation or modification of inotropic therapy (5.2%). Line position was modified after 3.4% of FnECHO studies.



[Table/Fig-2]: Distribution according to indication for FnECHO  
\*Persistent Pulmonary Hypertension of Newborn (PPHN)

Respiratory support	No. (n=187)	%
No Support	52	27.8
Hood O <sub>2</sub> *	05	2.7
CPAP†	72	38.5
SIMV/PSV‡	56	30
A/C MODE§	02	1.1

[Table/Fig-3]: Distribution according to respiratory support.  
(\*O<sub>2</sub>: Oxygen; † CPAP: Continuous Positive Airway Pressure; ‡ SIMV/PSV: Synchronized Intermittent Mandatory Ventilation; § A/C: Assist Control)

Timing of echo	No	%
Within 12 h	28	14.8
13 to 24 h	76	40.6
25 to 48 h	35	18.7
49 to 72 h	17	9.1
> 72 h	31	16.6

[Table/Fig-4]: Timing of first scan from hospitalization

## DISCUSSION

The present study was conducted with the objective to study the various indications for FnECHO in a tertiary neonatal unit in India. It was also observed that the incidence of the neonates undergoing echocardiography was more in preterm (60.43%) and in low birth weight (75.4%) neonates [Table/Fig-1]. In a study conducted by AM Groves et al., the author observed that majority of the neonates undergoing echocardiography were low birth weight and preterm [9]. Thus the findings correlate with our study. In 55.61% cases echocardiography was done within 24 hours of admission [Table/Fig-4]. Echocardiography is being utilized progressively on the neonatal unit, and has been indicated to have a high return for both structural and functional cardiac abnormalities [10]. Repeated clinical examinations in the preterm newborn child give data on haemodynamic status which is of pragmatic clinical value [11]. However, such examinations include repeated handling which clashes with the broadly suggested principles of minimal handling of

preterm infants [12]. Handling scenes, for example, care procedures and chest radiographs have been demonstrated to affect on both oxygen saturation and blood pressure [12,13].

It was seen that majority of the neonates in the present study undergone echocardiography were on respiratory support [Table/Fig-3]. A total of 38.50% neonates were on continuous positive airway pressure whereas 29.95% neonates were on synchronized intermittent mandatory ventilation plus pressure support ventilation.

In the present study it was observed that most common indication for echocardiography was PDA assessment (50%) [Table/Fig-2]. Following to the PDA assessment, haemodynamic instability (12.4%) and hypotension (13.5%) were the common indications. Various other indications include presence of heart murmur (10.6%), suspected PPHN (6.6%) and line position (6.9%). El-Khuffash et al., in their study noted PDA assessment (51%) as the commonest indication of ECHO [14].

Among the PDA cases majority of the neonates were low birth weight and preterm. According Koch et al., and Furzan JA et al., the incidence of a persistent PDA increases with decreasing Estimated Gestational Age (EGA) and birth weight [15,16]. FG Ramos et al., also observed echocardiography as a sensitive and specific investigation for diagnosing PDA [17].

Premature and Low Birth Weight (LBW) infants additionally constitute a critical gathering of paediatric patients with CHD, in whom remedial cardiovascular surgery is progressively performed early in life [18-20]. Echocardiography is especially imperative for preoperative determination in these patients in light of the fact that indicative heart catheterization in premature and LBW infants is connected with generally high rates of morbidity and mortality [21,22].

In the present study changes in the management was done in 39.6% patients after FnECHO, and the findings were very close to the findings reported by A. Corredera et al., and El-Kuffash with a rate of 36.89% and 41% management changes following the ultrasound examination respectively [14,23]. In our series echocardiography had helped us to confirm the clinical diagnosis and decision making of further treatment line.

Echocardiographic assessment can be broadly divided into functional and structural assessment. Functional echocardiography in the hands of an appropriately trained neonatologist is an open and valuable methodology in the neonatal intensive care unit. This tool permits the neonatologist to evaluate different parameters, e.g. ventricular outputs and SVC flow, ventricular function, pulmonary pressures and ductus arteriosus and execute prompt management as a result. It is the key that there is backing from the Paediatric Cardiologist to counteract misdiagnosis of congenital heart disease and execute further management [24].

The principle debate encompassing execution of echocardiography by a neonatologist is taking into account the potential threat of missing a Congenital Cardiopathy (CC) or making incorrect diagnosis and beginning the wrong treatment in a patient with CC. On the other hand, while this is a genuine peril, as a rule an existing structural cardiopathy is recognized by FnECHO, regardless of the fact that a complete diagnostic assessment is not made [25,26]. Either way, cardiologists and neonatologists must work in close collaboration effort, or a cardiology counsel must be asked for at whatever point there are questions. Adequate training in FnECHO is essential to minimize these risks [26].

According to Maliheh Kadivar et al., echocardiography is an important tool for diagnosis of cardiac abnormalities that can impact the management and outcome of the sick newborn in the intensive care unit. A preliminary echocardiogram performed by the neonatologist under the supervision of a paediatric cardiologist

for interpretation and review is an alternate when there is not a cardiologist "in house" [27].

## LIMITATIONS

There are several limitations to this study, for occurrence, small sample size. This study can't figure out if restorative decisions would have been distinctive if FnECHO had not been accessible. Then again, besides, the very choice of performing the ultrasound test, or not, also rested with the physician in charge rather than being determined by a study protocol, which could have a considerable impact on the observed frequency of use.

## CONCLUSION

Thus from the above discussion we could conclude that FnECHO is a useful investigation in NICU to diagnose various conditions such as PDA especially in LBW and premature neonates. Though it is not a substitute for thorough clinical examination, it has major impact on decision making in the management of various clinical conditions. However, to validate its usefulness well coordinated large prospective studies are needed.

## REFERENCES

- [1] Kluckow M, Seri I, Evans N. Functional echocardiography: an emerging clinical tool for the neonatologist. *J Paediatr.* 2007;150:125-30.
- [2] Kluckow M, Seri I, Evans N. Echocardiography and the neonatologist. *Paediatr Cardiol.* 2008;29:1043-47.
- [3] Sehgal A, McNamara PJ. Does point-of-care functional echocardiography enhance cardiovascular care in the NICU? *J Perinatol.* 2008;28:729-35.
- [4] Sehgal A, McNamara PJ. Does echocardiography facilitate determination of haemodynamic significance attributable to the ductus arteriosus? *Eur J Paediatr.* 2009;168:907-14.
- [5] Evans N, Gournay V, Cabanas F, Kluckow M, Leone T, Groves A, et al. Point-of-care ultrasound in the neonatal intensive care unit: inter-national perspectives. *Seminars in Fetal & Neonatal Medicine.* 2011;16:61-68.
- [6] Mertens L, Seri I, Marek J, Arlettaz R, Barker P, McNamara P, et al. Functional neonatal echocardiography in the neonatal intensive care unit: practice guidelines and recommendations for training. *European Journal of Echocardiography.* 2011;12:715-36.
- [7] Mertens L, Helbing W, Sieverding L, Daniels O. Guidelines from the Association for european paediatric cardiology: standards for training in paediatric echocardiography. *Cardiol Young.* 2005;15:441-42.
- [8] Sanders SP, Colan SD, Cordes TM, Donofrio MT, Ensing GJ, Geva T, et al. ACCF/ AHA/AAP recommendations for training in paediatric cardiology. Task Force 2: paediatric training guidelines for noninvasive cardiac imaging endorsed by the American Society of Echocardiography and the Society of Paediatric Echocardiography. *J Am Coll Cardiol.* 2005;46:1384-8.
- [9] Groves AM, Kuschel CA, Knight DB, Skinner JR. Cardiorespiratory stability during echocardiography in preterm infants. *Arch Dis Child.* 2005;90:86-87.
- [10] Moss S, Kitchiner DJ, Yoxall CW, et al. Evaluation of echocardiography on the neonatal unit. *Arch Dis Child Fetal Neonatal Ed.* 2003;88:F287-91.
- [11] Kluckow M, Evans N. Relationship between blood pressure and cardiac output in preterm infants requiring mechanical ventilation. *J Paediatr.* 1996;129:506-12.
- [12] Murdoch DR, Darlow BA. Handling during neonatal intensive care. *Arch Dis Child.* 1984;59:957-61.
- [13] Omar SY, Greisen G, Ibrahim MM, et al. Blood pressure responses to care procedures in ventilated preterm infants. *Acta Paediatr Scand.* 1985;74:920-24.
- [14] El-Khuffash A, Herbozo C, Jain A, Lapointe A, McNamara PJ. Functional neonatal echocardiography (FnECHO) service in a Canadian neonatal intensive care unit: a 4-year experience. *J Perinatol.* 2013;33:687-90.
- [15] Koch J, Hensley G, Roy L, Brown S, Ramaciotti C, Rosenfeld CR. Prevalence of spontaneous closure of the ductus arteriosus in neonates at a birth weight of 1000 grams or less. *Paediatrics.* 2006;117:1113-21.
- [16] Furzan JA, Reisch J, Tyson JE, Laird P, Rosenfeld CR. Incidence and risk factors for symptomatic patent ductus arteriosus among inborn very-low-birth-weight infants. *Early Hum Dev.* 1985;12:39-48.
- [17] FG Ramos, CR Rosenfeld, L Roy, J Koch, C Ramaciotti. Echocardiographic predictors of symptomatic patent ductus arteriosus in extremely-low-birth-weight preterm neonates. *Journal of Perinatology.* 2010;30:535-39.
- [18] Reddy VM, Hanley FL. Cardiac surgery in infants with very low birth weight. *Semin Paediatr Surg.* 2000;9:91-95.
- [19] Bacha EA, Almodovar MA, Wessel DL, et al. Surgery for coarctation of the aorta in infants weighing less than 2 kg. *Ann Thorac Surg.* 2001;71:1260-64.

- [20] Reddy VM, McElhinney DB, Sagrado T, Parry AJ, Teitel DF, Hanley FL. Results of 102 cases of complete repair of congenital heart defects in patients weighing 700 to 2500 grams. *J Thorac Cardiovasc Surg.* 1999;117:324-31.
- [21] Simpson JM, Moore P, Teitel DF. Cardiac catheterization of low birth weight infants. *Am J Cardiol.* 2003;87:1372-77.
- [22] Rhodes JF, Asnes JD, Blaufox AD, Sommer RJ. Impact of low body weight on frequency of paediatric cardiac catheterization complications. *Am J Cardiol.* 2000;86:1275-78.
- [23] Corredera A, Rodríguez MJ, Arévalo P, Llorente B, Moro M, Arruza L. Functional echocardiography in neonatal intensive care: 1-Year experience in a unit in Spain. *An Paediatr (Barc).* 2014;81(3):167-73.
- [24] Hunter L, Patel N. Echocardiography and the neonatologist. *Paediatrics and child health.* 2011;21(6):254-57.
- [25] Skinner JR. Echocardiography on the neonatal unit: a job for the neonatologist or the cardiologist? *Arch Dis Child.* 1998;78:401-02.
- [26] Whitehall J. Echocardiography by a neonatologist. *Arch Dis Child.* 1999;80:580-81.
- [27] Kadivar M, Kiani A, Kocharian A, Shabaniyan R, Nasehi L, Ghajarzadeh M. Echocardiography and Management of Sick Neonates in the Intensive Care Unit. *Congenit Heart Dis.* 2008;3:325-29.

**PARTICULARS OF CONTRIBUTORS:**

1. Assistant Professor, Department of Neonatology, BVU Medical College, Pune, Maharashtra, India.
2. Professor and Head, Department of Neonatology, BVU Medical College, Pune, Maharashtra, India.
3. Consultant Neonatologist, Westmead Hospital, Westmead, NSW, Australia.
4. Assistant Professor, Department of Neonatology, BVU Medical College, Pune, Maharashtra, India.
5. Associate Professor, Department of Neonatology, BVU Medical College, Pune, Maharashtra, India.
6. Professor, Department of Paediatrics, BVU Medical College, Pune, Maharashtra, India.
7. Professor and Head, Department of Pediatrics, BVU Medical College, Pune, Maharashtra, India.
8. Assistant Professor, Department of PSM, MNR Medical college and Hospital, Sangareddy, Andhra Pradesh, India.

**NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:**

Dr. Anilkumar Mohan Khamkar,  
402, A Wing, Anandibaug Phase II, Near Podar International School, Kharalwadi, Pimpri, Pune-411018, India.  
E-mail: Shreyas2138@gmail.com

Date of Submission: **Apr 25, 2015**Date of Peer Review: **Jul 07, 2015**Date of Acceptance: **Oct 12, 2015**Date of Publishing: **Dec 01, 2015****FINANCIAL OR OTHER COMPETING INTERESTS:** None.