Effectivity of functional echocardiography in paediatric intensive care unit: An observational study

***Prashant Hari Bhadane**[1]

Sri Lanka Journal of Child Health, 2023; **52**(1)**:** 81-85
DOI: http://dx.doi.org/10.4038/sljch.v52i1.10478

Abstract

Introduction: Bedside echocardiography is an important screening tool for evaluating intravascular volume status and cardiac functions in the paediatric intensive care unit (PICU). It offers a good image of the heart and is a useful bedside imaging modality and an accurate diagnostic tool.

Objectives: To detect the role of echocardiography in PICUs in the management of critical patients.

Method: It was a descriptive, observational, prospective case control study in a tertiary care children's hospital from 1st August 2018 to 31st July 2019. Critically ill children were admitted from emergency paediatric department or directly from outpatient department; 83 of 100 critically ill PICU children fulfilling study criteria, were included. Initial echocardiogram was done within 48 hours of admission and repeated as and when indicated.

Results: During the study period, 100 children were admitted to the PICU, 83% being critical. Left ventricular hypertrophy (LVH) was noted in 22.9% and high left ventricular mass index (LVMI) was noted in children with abnormal renal profile, hypertension and hypocalcaemia. Left ventricular (LV) systolic dysfunction was significant in the sepsis group of patients and those who had a PICU stay of more than 10 days duration. Isolated LV diastolic dysfunction was found in 88.7%. Abnormal right ventricular (RV) function was noted in 68.7%. Inferior vena cava collapsibility index (IVC-CI) more than 55% was found in 26.5% and IVC-distensibility index (IVC-DI) more than 18% in 91.6%, suggestive of fluid responsive states. 2D-echocardiography evaluation warranted medical intervention in 69.9% patients in the PICU. Ten (12%) children expired during study period.

Conclusions: In the PICU, echocardiography is a very useful tool in the management of critical patients.

(Key words: Functional echocardiography, Paediatric intensive care unit, Paediatric cardiac functions)

Introduction

Many adult studies have demonstrated that echocardiography can help with medical decisions via early detection of heart dysfunction. Care for critically ill paediatric patients is a hard endeavour that necessitates good time management and appropriate prioritisation. The clinical picture is frequently made more difficult by multi-system illness with overlap of symptoms. Recently, haemodynamic evaluation has been given primary attention in the care of critically ill patients. Echocardiography is regarded as a practical, bedside, non-invasive imaging modality and an accurate diagnostic tool that investigates a key body system[1]. One advantage is that it is a risk-free, non-invasive technique that can be applied serially and in real time. Additionally, paediatric intensivists are observing it alongside clinical data and correlating with practical aspects of management. According to many studies, the use of echocardiography in the treatment of critically ill patients has a good effect and alters the course of disease and their care in 30% to 60% of instances after the test[2-5].

Objectives

The purpose of this study was to evaluate the cardiac functions by bedside 2D-echocardiogram / Colour Doppler in critically ill children in the paediatric intensive care unit (PICU).

Method

It is a descriptive, observational, prospective case control study in a children's hospital with tertiary care.

[1]*Associate Professor, Consultant Paediatric and Fetal Cardiologist, Department of Paediatrics, Dr. Vasantrao Pawar Medical College, Nashik, Maharashtra, India*
**Correspondence:* drprashantbhadane@gmail.com
https//orcid.org/0000-0002-1034-9287

(Received on 27 September 2022: Accepted after revision on 18 November 2022)
The authors declare that there are no conflicts of interest
Personal funding was used for the project.

Open Access Article published under the Creative Commons Attribution CC-BY License

Patients admitted to the PICU of Dr. Vasantrao Pawar Medical College, Nashik, India, from 1st August 2021 to 31st January 2022 were assessed. Basic patient information was gathered, including clinical history, physical examination results, reasons for an echocardiogram, the results of the echocardiogram, and changes in management following the echocardiogram. Portable and advanced transthoracic echocardiography was used. All the critical paediatric patients without congenital heart disease (CHD) diagnosis were found eligible.

Eighty three of 100 critically ill PICU children, who fulfilled the study criteria, were included. Initial echocardiogram was done within 48 hours of admission and repeat echocardiograms as and when indicated. Paediatric cardiac dimensions, cardiac functions and cardiac output were assessed by standard methods and compared to paediatric age norms and body surface area (BSA). Volume status was assessed by inferior vena cava collapsing index (IVC-CI) and IVC distensibility index (IVC-DI).

Ethical issues: Approval for the study was obtained from the Institutional Ethics Committee of Dr. Vasantrao Pawar Medical College, Hospital & Research Centre, Nashik, India (No. IEC- 03/2021-22 dated 27/04/2021). Informed written consent was obtained from the parents of the study participants.

Statistical analysis: Data were analysed using Statistical Package for the Social Sciences version 19. Means, medians, standard deviations and ranges were used to depict quantitative data. Chi-square test or Fisher exact test was used to compare qualitative data that were given as numbers and percentages. p-value <0.05 was deemed significant.

Results

One hundred patients were admitted to the PICU during the study period and 83 echocardiograms were completed. With the exception of congenital heart disorders, critically unwell children hospitalised from the emergency paediatric department or immediately from the outpatient department were included. The children that were included in the study ranged in age from one month to thirteen years and comprised 24 (28.9%) infants and 59 (71.1%) children. Of the 83 patients 43 (51.8%) were male. Indications for echocardiography are shown in Table 1.

Various echocardiographic parameters helped in qualitative and quantitative assessment of the severity of disease (Table 2).

Table 1: ***Indications for echocardiography*** **-**

Indication for echocardiography	Number (%)
Normal heart	62 (74.7)
Pulmonary hypertension secondary to lung disease	11 (13.3)
Dilated cardiomyopathy	04 (04.8)
Pericardial effusion	02 (02.4)
Infective endocarditis	03 (03.6)
Rheumatic heart disease	01 (01.2)

Table 2: ***Echocardiographic parameters in study subjects***

Parameter	Variable	Number (%)
Left ventricular internal dimension in diastole (LVIDD)	Low	18 (21.7)
	Normal	60 (72.3)
	High	05 (06.0)
Left ventricular systolic functions	Dysfunction	16 (19.2)
	Hypercontractile	05 (06.0)
	Normal	62 (74.7)
Left ventricular mass index (LVMI)	Increased	19 (22.9)
	Normal	64 (77.1)
Diastolic functions	Impaired relaxation	12 (14.5)
	Pseudo-normalization	37 (44.6)
	Restrictive pattern	19 (22.9)
	Normal	15 (39.7)
Right ventricular functions	Abnormal	57 (68.7)
	Normal	26 (31.3)

Left ventricular hypertrophy (LVH) was noted in 22.9% and high left ventricular mass index (LVMI) was noted in children with abnormal renal profile, hypertension and hypocalcaemia ($p<0.05$).
LV systolic dysfunction was significant in sepsis group patients (32.5%) ($p=0.0063$) and those who had a PICU stay more than 10 days duration ($p=0.013$).

Isolated LV diastolic dysfunction was found in 88.7% with 61.9% having preserved LV systolic function ($p=0.0058$). Abnormal RV function was noted in 57 (68.7%) patients (Table 2).

Other echocardiographic parameters in study subjects are shown in Table 3. Low LVCO-index was noted in 47.0% and high in 21.7%.

IVC-CI more than 55% was found in 26.5% and IVC-DI more than 18% was found in 91.6% suggestive of fluid responsive states (Table 3).

2D- echocardiography evaluation warranted medical intervention in 69.9% patients (n= 58/83) in PICU ($p <0.05$).

Ten (12%) children expired during study period.

Table 3: ***Other echocardiographic parameters in study subjects***

Parameter	Variable	Number (%)
LV CO-index	Low	39 (47.0)
	Normal	26 (31.3)
	High	18 (21.7)
RV CO-index	Low	38 (45.8)
	Normal	23 (27.7)
	High	22 (26.5)
Inferior vena cava collapsibility index (IVC-CI)	Decreased	61 (73.5)
	Increased	22 (26.5)
Inferior vena cava distensibility index (IVC-DI)	Decreased	07 (08.4)
	Increased	76 (91.6)
Functional echocardiography	Systolic dysfunction	05 (06.9)
	Normal	69 (93.2)

Discussion

Portable echocardiography is an essential screening tool in monitoring of disease. Several studies have detected the valuable effect of the use of echocardiography in the management of critically ill patients, changing their treatment in 30%–60% of cases after echocardiography[6,7]. Several studies were done to evaluate the role of echocardiography in PICU like the study conducted by Şahin S, *et al*[8], where echocardiograms were done for 140 out of 186 patients (75.2%) admitted in the PICU over a period of 6 months, and in the study done at the Child Health Department, Sultan Qaboos University Hospital, Muscat, Oman by Rabah F, *et al*[9] where 82 patients had echocardiography out of 424 patients were admitted in this PICU over a-24-month period. In this research, we have studied 83 patients from a total of 100 patients who were admitted to the PICU.

The two most frequent indications for echocardiography in the current study were critical normal study, which occurred in 62 (74.7%) patients, and pulmonary hypertension secondary to lung disease, which occurred in 11 (13.3%) patients, whereas the study by Rabah F, *et al*[9] shows that 27 (26.7%) examinations were performed to evaluate left ventricular function in haemodynamically unstable patients and the second frequent indication was suspicion of congenital heart disease (18.8%). Due to the great sensitivity and specificity of echocardiography, its value extends to the detection of peripheral lung pathology[10].

In both the neonatal intensive care unit and the PICU, bedside echocardiography has statistically significantly increased the accuracy of the detection of structural cardiac abnormalities, decreased cardiac contractile functions, and pulmonary hypertension. To increase clinical examination accuracy and decision-making, a more thorough clinical examination and search for symptoms is considered necessary. Once more, bedside echocardiogram skills training is required for physicians caring for PICU patients[11]. Another critical issue that needs to be addressed in the PICU settings is the ambulation of the echocardiography equipment, according to a previous study[12].

Left ventricular hypertrophy (LVH) was noted in 22.9% and high LVMI was noted in children with abnormal renal profile, hypertension and hypocalcaemia ($p<0.05$). Mitsnefes MM, *et al*[13] reported LVH in 11%. LV systolic dysfunction was significant in severe sepsis group patients (32.5%)

(p=0.0063) which was less compared to LV systolic dysfunction in paediatric sepsis which was 26 (52%) depicted by Li J, *et al*[14].

Because the p-value of the data for 58 (69.9%) patients, was significant, there was a strong positive connection between the echocardiographic results and the clinical intervention or choice in this investigation. Every result in the study by Rabah F, *et al*[9] had a significant p-value. Şahin S, *et al*[8] also suggested that echocardiographic evaluation was necessary in mechanically ventilated (MV) children and there was a positive correlation between the Paediatric Risk of Mortality (PRISM) III score and the requirement of echocardiographic assessment ($p<0.001$)[15]. These results are consistent with those of Rabah F, *et al*[9] in which 79.2% of the patients were discharged and 20.8% of them died. In this study, 88% of the investigated patients were discharged from the hospital, while 12% of them died. The numerous requests should not be interpreted as a misuse of resources, but rather as a sign that a critically ill infant or child needs to have bedside echocardiogram performed as an additional component of physical examination instead[16].

Conclusions

In the PICU, echocardiography is a very useful tool in the management of critical patients.

Acknowledgments

Author thanks colleagues in the Paediatric Department, Faculty of Pediatrics, Dr. Vasantrao Pawar Medical College, Nashik (India) for their assistance, the children and their parents who participated in this study

References

1. Adeboye A, Alkhatib D, Butt A, Yedlapati N, Garg N. A review of the role of imaging modalities in the evaluation of viral myocarditis with a special focus on Covid-19-related myocarditis. *Diagnostics* 2022; **12**(2): 549. https://doi.org/10.3390/diagnostics12020549 PMid: 35204637 PMCid: PMC8870822

2. Vieillard-Baron A, Prin S, Chergui K, Dubourg O, Jardin F. Haemodynamic instability in sepsis: bedside assessment by Doppler echocardiography. *American Journal of Respiratory and Critical Care Medicine* 2003; **168**(11): 1270-6. https://doi.org/10.1164/rccm.200306-816CC PMid: 14644922

3. Spencer KT. Focused cardiac ultrasound: where do we stand? *Current Cardiology Reports* 2015; **17**(3): 1-8. https://doi.org/10.1007/s11886-015-0567-y PMid: 25676829

4. Colreavy FB, Donovan K, Lee KY, Weekes J, Transesophageal echocardiography in critically ill patients. *Critical Care Medicine* 2002; **30**(5): 989-96. https://doi.org/10.1097/00003246200205000-00007 PMid: 12006793

5. Croft LB, Duvall WL, Goldman ME. A pilot study of the clinical impact of hand-carried cardiac ultrasound in the medical clinic. *Echocardiography* 2006; **23**(6): 439-46. https://doi.org/10.1111/j.15408175.2006.00240.x PMid: 16839380

6. Manasia AR, Nagaraj HM, Kodali RB, Croft LB, Oropello JM, Kohli-Seth R, *et al.* Feasibility and potential clinical utility of goal-directed transthoracic echocardiography performed by non-cardiologist intensivists using a small hand-carried device (SonoHeart) in critically ill patients. *Journal of Cardiothoracic and Vascular Anesthesia* 2005; **19**(2): 155-9. https://doi.org/10.1053/j.jvca.2005.01.023 PMid: 15868520

7. Sehgal A, McNamara PJ. Does point-of-care functional echocardiography enhance cardiovascular care in the NICU? *Journal of Perinatology* 2008; **28**(11): 729-35. https://doi.org/10.1038/jp.2008.100 PMid: 18633423

8. Sahin S, Yazici M, Ayar G, Koksal T, Cetin I, Ekici F, *et al.* Clinical impact and efficacy of bedside echocardiography on patient management in pediatric intensive care units (PICUs): A prospective study. *Anatolian Journal of Cardiology* 2017; **18**(2). https://doi.org/10.14744/AnatolJCardiol.2017.7659 PMCid: PMC5731263.

9. Rabah F, Al-Senaidi K, Beshlawi I, Alnair A, Abdelmogheth AA. Echocardiography in PICU: When the heart sees what is invisible to the eye. *Jornal de Pediatria* 2016; **92**: 96-

100.
https://doi.org/10.1016/j.jped.2015.04.011
PMid: 26569341.

10. Basanti C, Kotb MA, Seif HM, Farag FI, Abdelmegeid AK. Paediatric chest ultrasound for bedside diagnosis of pneumonia: A validation study for diagnostic options in developing countries. *Pediatric Sciences Journal* 2021; **1**(1): 15-24.
https://doi.org/10.21608/cupsj.2020.34773.1002

11. Srivastava S, Printz BF, Geva T, Shirali GS, Weinberg PM, Wong PC, et al. Task force 2: paediatric cardiology fellowship training in noninvasive cardiac imaging. *Circulation* 2015; **132**(6): e57-67.
https://doi.org/10.1161/CIR.0000000000000193

12. Tissot C, Muehlethaler V, Sekarski N. Basics of functional echocardiography in children and neonates. *Frontiers in Pediatrics* 2017; **5**: 235.
https://doi.org/10.3389/fped.2017.00235
PMid: 29250515 PMCid: PMC5716984.

13. Mitsnefes MM, Betoko A, Schneider MF, Salusky IB, Wolf MS, Jüppner H, *et al*. FGF23 and left ventricular hypertrophy in children with CKD. *Clinical Journal of the American Society of Nephrology*. 2018; **13**(1): 45-52.
https://doi.org/10.2215/CJN.02110217
PMid: 29025789 PMCid: PMC5753303.

14. Li J, Ning B, Wang Y, Li B, Qian J, Ren H, *et al.* The prognostic value of left ventricular systolic function and cardiac biomarkers in pediatric severe sepsis. *Medicine* 2019; **98**(13).
https://doi.org/10.1097/MD.0000000000015070
PMid: 30921240 PMCid: PMC6456134

15. Şahin S. Yazıcı MU, Ayar G, Köksal T, Çetin İİ, Ekici F, *et al.* Clinical impact and efficacy of bedside echocardiography on patient management in paediatric intensive care units (PICUs): A prospective study. *Anatolian Journal of Cardiology* 2017; **18**: 136-41.
https://doi.org/10.14744/AnatolJCardiol.2017.7659
PMCid: PMC5731263

16. Spencer KT, Flachskampf FA. Focused cardiac ultrasonography. *JACC: Cardiovascular Imaging* 2019; **12**(7 Part 1): 1243-53.
https://doi.org/10.1016/j.jcmg.2018.12.036
PMid: 31272607