

Heart murmurs and echocardiography findings in the normal newborn nursery

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Abstract

Objective: To determine the clinical findings and management implications of echocardiograms performed on infants with murmurs in the nursery.

Design: Retrospective cohort study conducted from January 2008 through December 2015. Patients in the study were followed by chart review for up to 5 years. In addition, a survey of nursery providers was conducted in February 2016.

Setting: A single community hospital associated with a university.

Patients: All 26 573 infants who received care in the normal newborn nursery were eligible for inclusion in the study. Infants with echocardiograms were analyzed. The survey was sent by e-mail to all 135 physicians who work in the nursery.

Outcome Measures: The primary outcomes include the specific findings on echocardiogram and whether the findings required an acute change in management, outpatient follow up, or were incidental findings. The primary survey question was how physicians would manage an otherwise asymptomatic newborn with a heart murmur.

Results: Four hundred ninety-nine infants had echocardiograms, and over the study period the utilization of echocardiography increased from 1.02% to 2.56% ($P < .001$) of all infants. Three hundred fifty-four babies had echocardiography performed because of a heart murmur. One hundred sixty-three (46.0%) of these echocardiograms were normal and 160 (45.2%) had findings that did not require additional care. Twenty-three neonates (6.5%) had echocardiographic findings that necessitated outpatient follow-up and 8 neonates (2.3%) required neonatal intensive care due to the findings on their echocardiogram. In total, 14 infants (4%) would go on to require heart surgery or interventional cardiac catheterization. 63/135 (47%) physicians completed the survey, with wide variations in the management of newborns with heart murmurs.

Conclusions: The use of echocardiography in the normal newborn nursery has increased with time despite improved prenatal detection of heart disease and the use of pulse oximetry screening, and identifies significant heart disease in a small but important number of infants.

KEYWORDS

echocardiography, murmurs, newborn infant

1 | INTRODUCTION

Congenital heart disease (CHD) is an important cause of infant morbidity and mortality. While prenatal diagnosis of CHD is improving, almost half of cases are diagnosed after birth.¹ Clinicians use findings such as heart murmurs, peripheral pulses, and pulse oximetry screening to identify infants at risk, and echocardiography is the gold standard for diagnosis of CHD. However, echocardiograms are expensive and not readily available at all birthing centers.

Several international studies have examined the significance of heart murmurs in the newborn period and reached different conclusions. Singh et al² found that 74% of newborns with a heart murmur had CHD, and they recommended all newborns with murmur have echocardiograms before discharge from the hospital. Several other studies found CHD in 22%–86% of neonates with murmurs.^{3–12} The variation in these studies can be attributed to the populations studied and variable definition of CHD, but most authors recommended early echocardiograms in infants with murmurs. However, O'Reilly et al¹³ proposed an algorithm for management of murmurs and concluded that some asymptomatic infants could be safely discharged home without an echocardiogram based on an audit of 89 newborns with murmurs. Because of significant differences in health care delivery systems between countries, including rates of prenatal detection, typical lengths of stay, and locally available resources, it is difficult to generalize these findings.

To our knowledge, there are no similar studies on the significance or management of neonatal heart murmurs in the United States. In addition, improved prenatal detection of CHD and neonatal pulse oximetry screening may alter the implications of a heart murmur if a greater percentage of significant heart defects have been identified before the newborn examination. For these reasons, we investigated the use of echocardiograms in a population of term newborns with heart murmurs to evaluate the clinical findings and whether the echocardiogram changed medical management. Additionally, we conducted a survey to evaluate practice variation among physicians regarding the management of murmurs in the nursery.

2 | PATIENTS AND METHODS

The chart review was performed on all newborn echocardiograms performed at Meriter Hospital (Madison, Wisconsin) from January 2008 through December 2015. Congenital heart disease screening with single-site pulse oximetry was done from 2008 to 2010, and pre/postductal screening from 2011–2015. Any baby who was clinically unstable or with a saturation of less than 90% on pulse oximetry screening would have been transferred to the neonatal intensive care unit (NICU) before echocardiography was performed. Only the first echocardiogram done on each patient was assessed and studies performed after transfer to the NICU were excluded.

The date of birth, date of study, indication for echocardiography, and results were recorded. This information was obtained from the written echocardiogram report. In a number of cases, the indication for the echocardiogram was unclear from the report, and the infant's electronic medical record was reviewed. Only echocardiograms performed for heart murmurs were included in the study. If an infant had multiple indications, such as Down syndrome and a heart murmur, they were not included.

The echocardiogram results were divided into four categories: normal, incidental findings, findings necessitating outpatient cardiology follow-up, and those that triggered a change in management before hospital discharge. Small patent foramen ovale, small patent ductus arteriosus (PDA), and mild peripheral pulmonary stenosis were considered normal findings. Small muscular ventricular septal defects (VSD), small secundum atrial septal defects, and mild valvar insufficiency were considered incidental findings. The medical records of those babies who required outpatient follow-up or a change in their neonatal care were reviewed to determine their clinical outcome.

An online survey was sent in February 2016 to all attending physicians who work in the normal newborn nursery (NNN). Providers were asked about their practice, including years of experience, specialty, and volume of patients seen in the nursery. In addition, they were asked if their evaluation of murmurs has changed since graduation from residency and whether or not pulse oximetry screening has affected their practice in the nursery. Finally, they were asked "How would you typically manage an asymptomatic, nonsyndromic term infant with an unremarkable family history, a 2/6 systolic murmur, normal pulses, and normal pulse oximetry?" Response options included routine follow-up, early outpatient visit with primary provider, echocardiogram before discharge, outpatient echocardiogram, referral to cardiology, or free response.

Study outcomes were summarized in tabular format in terms of frequencies and percentages. Changes in the percentage of infants with echocardiography for any indication across time points were evaluated using the Cochran-Armitage trend test. The comparisons of survey responses between pediatricians and family physicians were conducted using a chi-square test or Fisher's exact test. All reported *P* values are two-sided and *P* < .05 was used to define statistical significance. Data analysis was conducted using Excel (Microsoft Corporation, Redmond, Washington) and SAS software (SAS Institute Inc, Cary, North Carolina), version 9.4.

This study was approved by the Meriter Institutional Review Board and the University of Wisconsin Health Sciences Institutional Review Board.

3 | RESULTS

From 2008 to 2015, there were 30 430 infants born at Meriter Hospital and 26 565 received their care exclusively in the NNN and 8 asymptomatic neonates were transferred to the neonatal intensive care based on the results of their NNN echocardiogram. Of these

26 573 infants, 499 (1.88%) had echocardiograms for any cause, and 354 of these were performed solely because of a heart murmur. The percentage of infants in the NNN with echocardiography increased from 1.02% to 2.56% ($P < .001$) during this time period (Figure 1). Studies were performed on day of life 0 through day of life 4, with a median age of 2 days at the time of echocardiogram.

One hundred sixty-three (46.0%) of the echocardiograms were normal or had normal neonatal variants, including studies with small PDAs, patent foramen ovale, or mild peripheral pulmonary stenosis (Figure 2). 160 (45.2%) of the echocardiograms showed incidental findings which did not necessitate further care. The most common of these findings were small muscular VSDs.

There were 23 infants (6.5%) with findings that would need follow-up as an outpatient, but their care was not altered during the nursery hospitalization. 10/23 of these infants would go on to surgery or interventional catheterization (3 VSD, 2 coarctation of the aorta, atrioventricular canal, pulmonary valve stenosis, aortic valve stenosis, Ebstein’s anomaly with partial anomalous pulmonary

venous return, tetralogy of Fallot). 2/23 patients have had 1–4 years of ongoing follow-up but have not needed intervention (aortic stenosis, PAPVR). An additional 11/23 infants had normal follow-up studies or significant improvement without intervention and were discharged after 1 week to 5 years of follow-up.

Eight (2.3%) were transferred to the NICU based at least to some degree on their echocardiogram. Two infants had neonatal heart surgery for aortic stenosis and had harsh, loud (3–4/6) systolic murmurs on exam. One patient had pulmonary hypertension that was monitored in the NICU, improved with oxygen treatment, and had a normal follow-up echocardiogram. Two more infants had close monitoring in the NICU without further interventions, and had normal echocardiograms either in the NICU or in outpatient follow-up. Two patients had procedures after discharge, one for VSD closure and the second had a balloon pulmonary valvuloplasty due to valvar pulmonic stenosis. One patient had outpatient follow-up for a PDA and is scheduled for closure at 3 years of age, with no prior interventions.

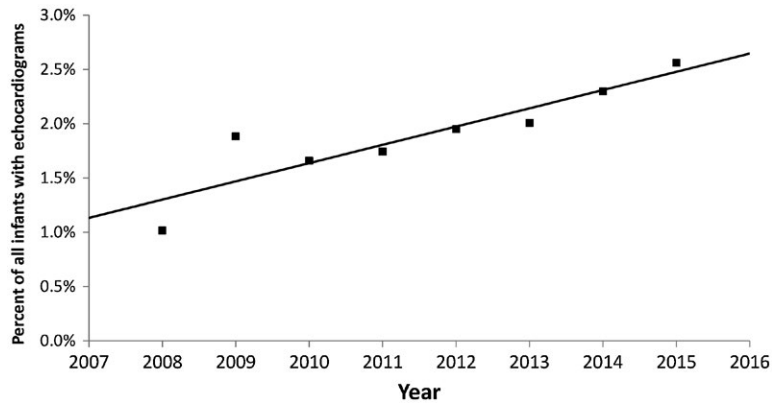


FIGURE 1 The percent of infants in the NNN who had echocardiograms for any indication before discharge

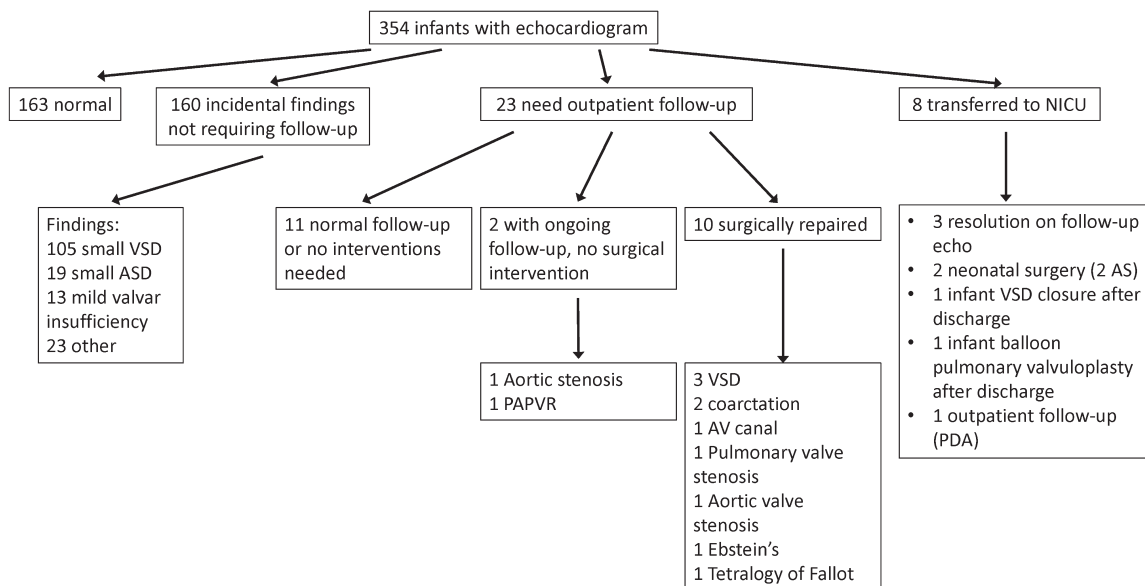


FIGURE 2 Flow sheet depicting results from all echocardiograms for heart murmurs in the NNN

In total, 31/354 (8.8%) babies had echocardiographic findings in the NNN that necessitated additional care. Fourteen (4.0%) of these neonates required surgery or interventional catheterization, one was treated for neonatal pulmonary hypertension, three have required ongoing cardiology follow-up, and 13 had spontaneous resolution of the issues identified at neonatal echocardiography.

3.1 | Survey results

Sixty-three of 135 (47%) physicians completed the survey (Table 1). Physicians were in practice for an average of 17 years prior to the survey (range 1-39 years) with only two pediatricians and five family physicians in practice for fewer than five years. Half of responders saw five or fewer newborns per month. The advent of pulse oximetry screening did not change practice patterns overall, with 37% of responders reporting no change in practice and roughly equal numbers reporting more and less likely to refer to cardiology or order echocardiograms. However, those in practice over 15 years reported increased frequency of ordering echocardiograms since the start of pulse oximetry screening compared to those in practice < 15 years ($P = .04$). Pediatricians indicated that they had become more likely to order echocardiograms with time ($P = .002$), whereas family physicians reported they were less likely ($P = .04$). There were no other significant differences between the responses of pediatricians and family physicians.

In the scenario of an asymptomatic infant with a 2/6 systolic murmur, normal pulses, and normal pulse oximetry, 30% of respondents would order an echocardiogram before discharge, 25% would provide routine follow-up with the primary care provider, 23% would schedule early outpatient follow-up, 8% would order an outpatient echocardiogram, 3% would refer to cardiology, and 11% entered free responses. The free responses all offered management plans that depended on other factors, such as location and quality of the murmur and availability of follow up. There were no significant differences

TABLE 1 Characteristics of survey responders

Specialty	Number of responses (%)
Pediatrician	29 (46)
Family medicine	29 (46)
Newborn hospitalist	5 (8)
Years in practice	
≤5	11 (17)
6-15	20 (32)
16-25	20 (32)
>25	12 (19)
Number of newborns seen per month	
≤5	32 (51)
6-15	24 (38)
16-25	3 (5)
>25	4 (6)

between the responses of family physicians and pediatricians or between those in practice more than or less than 15 years.

4 | DISCUSSION

Numerous studies have evaluated the prevalence and significance of murmurs in neonates, in a variety of settings with both prospective and retrospective methods. Ours is the largest study to date evaluating echocardiograms from a normal newborn nursery and the first to assess the evaluation of neonatal heart murmurs in the United States or to include the influence of neonatal pulse oximetry screening for critical congenital heart disease. Although the proportion of infants receiving echocardiograms increased throughout our study period, the overall rate of 1.88% was similar to the 1.6% noted in a previous study from the United Kingdom.² Few critical heart lesions were identified by these echocardiograms, and most of those were suspected by loud murmurs on exam. We also identified considerable practice variation among experienced nursery clinicians with respect to the management of murmurs in newborns.

Previous research has found a high prevalence of CHD in neonates with murmurs; with positive predictive values (PPV) ranging from 22% to 86%²⁻¹² but this literature is clouded by inconsistencies in the definition of CHD. We found a PPV of 54% for newborns with murmurs having any form of CHD, excluding PDAs, which is in line with the previously reported figures, however only 8.8% of newborns with murmurs in our study required an alteration in their care.

4.1 | Protocols for the assessment of murmurs

The practice variation in our survey data may reflect the lack of consensus among published studies on newborn murmurs. A recent literature review concluded that routine chest x-ray, electrocardiogram, and 4-limb blood pressure measurements were not helpful in evaluating infants with murmurs.¹⁴ The authors proposed an algorithm for evaluating asymptomatic murmurs in newborns in which the infant was evaluated by a senior clinician and pulse oximetry was obtained. They also recommended echocardiography, if available, before discharge. O'Reilly et al described a similar hospital protocol for evaluating murmurs in newborns, but did not recommend routine echocardiography. Concerning findings, such as a murmur > 2/6 or an unusual location for the murmur, would require inpatient cardiology evaluation while infants with innocent murmurs would have routine outpatient care.¹³ However, this algorithm requires the examiner to determine which murmurs are or are not consistent with an innocent murmur and in their audit of only 89 babies with murmurs, one child with hypoplastic left heart syndrome was discharged home prior to diagnosis.

Despite continuing progress in prenatal diagnosis and the widespread use of neonatal pulse oximetry screening, a heart murmur in the NNN will be the first indication of an important heart problem in a small but important number of babies. In our sample of 354 patients with heart murmurs in the NNN, 31 babies (8.8%) had a

finding on echocardiography that necessitated a change in their care. In 14 (4%), heart disease that would ultimately require surgery or interventional catheterization was first identified by a heart murmur in the NNN.

4.2 | Value of diagnosis

When heart disease significant enough to alter a newborn's care is identified by echocardiography, few providers would question the value of that echocardiogram. The value of an echocardiogram that excludes significant heart disease is much more difficult to ascertain. It is even more difficult to determine the costs and benefits of a neonatal echocardiogram that identifies an incidental finding and the potential risks of over diagnosis¹⁵ cannot be entirely overlooked.

4.3 | Limitations

As with previous studies, our study is limited in that it is retrospective in nature and the clinical decision process behind ordering each echocardiogram may not be ideally reflected in the medical documentation. We hope to have sharpened the focus of this study by including only those infants where a heart murmur appeared to be the only indication for echocardiography and excluding those who required an increased level of care before echocardiography was performed. In addition, this study reflects the disease incidence, practice patterns, and resource availability of a single community.

5 | CONCLUSION

Despite advances in prenatal detection of CHD and the introduction of neonatal pulse oximetry screening, physical examination, and newborn echocardiography continue to serve a role in the diagnosis of heart disease in the normal newborn nursery. Although additional care was needed for only 8.8% of the infants evaluated with echocardiography in the normal newborn nursery for a heart murmur, the value to that subset of infants was significant.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest relevant to this article to disclose.

AUTHOR CONTRIBUTIONS

Fenster designed and implemented the survey instrument, collected the data, carried out the data analysis, drafted the initial manuscript, and reviewed the final manuscript as submitted.

Hokanson conceptualized the study, supervised the data collection and analysis, revised the manuscript, and reviewed the final manuscript as submitted.

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REFERENCES

- Hill GD, Block JR, Tanem JB, Frommelt MA. Disparities in the prenatal detection of critical congenital heart disease. *Prenat Diagn.* 2015;35:859–863.
- Singh A, Desai T, Miller P, Rasiah SV. Benefits of pre-discharge echocardiography service for postnatal heart murmurs. *Acta Paediatr.* 2012;101:e333–e336.
- Ainsworth S, Wyllie JP, Wren C. Prevalence and clinical significance of cardiac murmurs in neonates. *Arch Dis Child Fetal Neonatal Ed.* 1999;80:F43–F45.
- Azhar AS, Habib HS. Accuracy of the initial evaluation of heart murmurs in neonates: do we need an echocardiogram? *Pediatr Cardiol.* 2006;27:234–237.
- Brunetti ND, Rosania S, D'Antuono C, D'Antuono A, De Gennaro L, Zuppa AA, et al. Diagnostic accuracy of heart murmur in newborns with suspected congenital heart disease. *J Cardiovasc Med.* 2015;16:556–561.
- Du ZD, Roguin N, Barak M. Clinical and echocardiographic evaluation of neonates with heart murmurs. *Acta Paediatr.* 1997;86:752–756.
- Karatza AA, Fouzas S, Tzifas S, Mermiga A, Dimitriou G, Mantagos S. Accuracy of cardiac auscultation in asymptomatic neonates with heart murmurs: comparison between pediatric trainees and neonatologists. *Pediatr Cardiol.* 2011;32:473–477.
- Lardhi AA. Prevalence and clinical significance of heart murmurs detected in routine neonatal examination. *J Saudi Heart Assoc.* 2010;22:25–27.
- Mackie AS, Jutras LC, Dancea AB, Rohlicek CV, Platt R, Beland MJ. Can cardiologists distinguish innocent from pathologic murmurs in neonates? *J Pediatr.* 2009;154:50–54.
- Mirzarahimi M, Saadati H, Doustkani H, Alipoor R, Isazadehfar K, Enteshari A. Heart murmur in neonates: how often is it caused by congenital heart disease? *Iran J Pediatr.* 2011;21:103–106.
- Rein AJ, Omokhodion SI, Nir A. Significance of a cardiac murmur as the sole clinical sign in the newborn. *Clin Pediatr (Phila).* 2000;39:511–520.
- Al-Ammouri I, Ayoub F, Dababneh R. Is pre-discharge echocardiography indicated for asymptomatic neonates with a heart murmur? A retrospective analysis. *Cardiol Young.* 2016;26:1056–1059.
- O'Reilly KM, Hall FM, Richens T, Cunningham C, Simpson JH. An audit of the management of heart murmurs on the postnatal wards. *Scott Med J.* 2013;58:e11–e14.
- Shenvi A, Kapur J, Rasiah SV. Management of asymptomatic cardiac murmurs in term neonates. *Pediatr Cardiol.* 2013;34:1438–1446.
- Coon ER, Quinonez RA, Moyer VA, Schroeder AR. Overdiagnosis: how our compulsion for diagnosis may be harming children. *Pediatrics.* 2014;134:1013–1023.

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