

Targeted Neonatal Echocardiography Services

Need for Standardized Training and Quality Assurance

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Objectives—Targeted neonatal echocardiography refers to a focused assessment of myocardial performance and hemodynamics directed by a specific clinical question. It has become the standard of care in many parts of the world, but practice is variable, and there has been a lack of standardized training and evaluation to date. Targeted neonatal echocardiography was first introduced to Canada in 2006. The purpose of this study was to examine the characteristics of targeted neonatal echocardiography practice and training methods in Canadian neonatal intensive care units (NICUs).

Methods—A total of 142 Canadian neonatologists were invited to participate in an online survey, which was conducted in September 2010. The survey consisted of questions related to the availability of targeted neonatal echocardiography, clinical indications, benefits and risks, and training methods.

Results—The overall survey response rate was 65%. Forty-eight respondents (34%) indicated that targeted neonatal echocardiography was available in their units, and the program was introduced within the preceding 1 to 5 years. In centers where it was unavailable, lack of on-site echocardiography expertise was cited as the major barrier to implementation. The most common indications for targeted neonatal echocardiography included evaluation of a hemodynamically significant ductus arteriosus, systemic or pulmonary blood flow, and response to cardiovascular treatments. Only 27% of respondents, working in centers where targeted neonatal echocardiography existed, actually performed the studies themselves; most individuals completed 11 to 20 studies per month. Almost half of the respondents said that training was available in their institutions, but methods of training and evaluation were inconsistent. Eighty-seven percent of respondents reported no formalized process for assessment of ongoing competency after the initial training period.

Conclusions—Targeted neonatal echocardiography is becoming more widely available and is gaining acceptance in Canadian NICUs. Although training is provided in many institutions, the process is not well established, and formal evaluation is rarely performed. This study emphasizes the need for development of standards for formalized training, evaluation, and quality assurance.

Key Words—echocardiography; evaluation; neonatal; point-of-care ultrasound; targeted neonatal echocardiography; training

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Abbreviations

NICU, neonatal intensive care unit

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The care of the critically ill neonate with cardiovascular impairment may be challenging. Use of clinical judgment alone to define the nature of the disease process can lead to incorrect assumptions or inappropriate therapeutic interventions.

Historically, cardiovascular assessment and monitoring within the neonatal intensive care unit (NICU) comprised measurement of blood pressure and other poorly validated clinical signs, such as the heart rate and capillary refill time.¹ Within the immediate postnatal period, it is also difficult to determine whether hemodynamic instability is a result of intracardiac and extracardiac shunting, alterations in systemic and pulmonary vascular resistance, or a developmentally immature myocardium.²

Targeted neonatal echocardiography is the term used to describe “the bedside use of echocardiography to longitudinally assess myocardial function, systemic and pulmonary blood flow, intracardiac and extracardiac shunts, organ blood flow, and tissue perfusion.”¹ Targeted neonatal echocardiography is usually performed by a neonatologist, is directed by a specific clinical question, and may provide hemodynamic information that either complements clinical findings or provides novel physiologic insights. The availability of real-time physiologic data is thought to help the attending physician provide more focused and targeted cardiovascular care. Targeted neonatal echocardiography has now become the standard of care within many NICUs throughout the world, and there is increasing evidence of its benefit to neonates.^{3–6}

Although there is increasing awareness of the urgent need to train neonatologists, formalized training opportunities are limited. Moreover, there has been a lack of standardization of training and evaluation both on completion of training and as a measure of ongoing competency. Targeted neonatal echocardiography was first introduced to Canada in 2006 at a single site (Hospital for Sick Children), and the practice has spread to other centers. The service was introduced on the basis of the need to have enhanced access to real-time and longitudinal hemodynamic information to guide cardiovascular decision making. The clinical and training components of the service were operated exclusively within the Department of Neonatology. The purpose of this study was to characterize the extent of dissemination of targeted neonatal echocardiography practice in Canada, examine clinical indications for use, and determine the extent of training offered and quality assurance mechanisms.

Materials and Methods

All Canadian neonatologists ($n = 142$) were invited to participate in an online survey in September 2010, before publication of the 2011 expert consensus statement on the use of targeted neonatal echocardiography in the NICU.⁷

The e-mail addresses of all neonatologists practicing in Canada were obtained through the Canadian Paediatric Society and Canadian Neonatal Network directories. A letter of invitation was sent to the division head at each neonatal site, requesting permission to disseminate the study survey to all neonatologists at their center. An initial e-mail was sent to all neonatologists, introducing the study and inviting them to take part. The survey questionnaire link was made available in the body of the e-mail, and consent was implied by participation in the survey. Physician and site identifiers were kept confidential throughout the data collection, analysis, and presentation of results. The survey was kept open for 4 weeks, and weekly reminders were sent. In addition to collecting information from individual neonatologists, site-specific data were collected from lead neonatologists at 8 major neonatal centers across Canada. No financial incentives or rewards were offered for taking part in the survey. Institutional Research Ethics Board approval was obtained.

Survey Tool

A 43-item questionnaire (Appendix) was designed to capture information related to the availability of targeted neonatal echocardiography, clinical indications for its use, and methods of training and evaluation. The content was modified after receiving feedback from 2 neonatologists with expertise in targeted neonatal echocardiography. A pilot survey was completed by 2 fellows and 2 attending neonatologists at another NICU to assess content validity, ease of completion, and interest among responders. The survey was then further modified to incorporate these suggestions and uploaded to an online survey tool (www.surveymonkey.com) for dissemination.

Sample Size and Analysis

A total of 142 practicing neonatologists were identified from the aforementioned physician directories. Our goal was to recruit at least 60% ($n = 85$) to ensure a representative sample size. Descriptive statistics were used to present the data.

Results

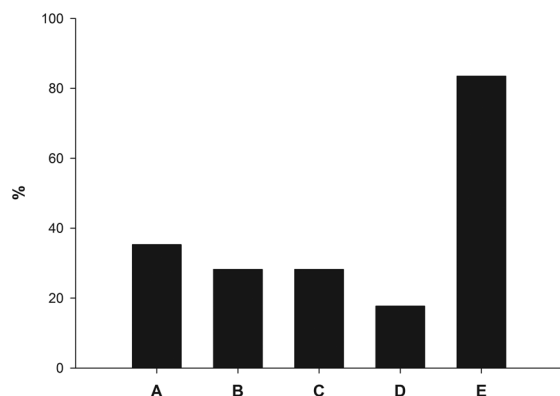
The overall survey response rate was 65% ($n = 93$ neonatologists). Most respondents worked in units serving both inborn and outborn neonates with an average range of deliveries annually between 2000 and 6000. The respondents had varying levels of experience, with 39% having less than 10 years, 26% having 10 to 20 years, and 36% having greater than 20 years of experience as a neonatologist.

Echocardiography Services

Thirty-four percent of respondents indicated that they had access to targeted neonatal echocardiography in their units, and in most cases (71%), the service was introduced within the preceding 1 to 5 years. In the remainder of units where targeted neonatal echocardiography was available, it had been introduced within the preceding year. Where it was not available, 80% of individuals reported an interest in introducing this service; however, lack of expertise in echocardiography among the neonatologists was the major barrier to implementation (53%). Other factors reported were ready access to pediatric echocardiography laboratory services, which obviated the need for a targeted neonatal echocardiography service, the cost-prohibitive nature of the equipment, and an opinion that there is insufficient evidence of the benefits of targeted neonatal echocardiography.

More than 60% of respondents reported having access to on-site pediatric echocardiography laboratory services. More than 70% of these respondents reported access to evening and weekend service. Urgent studies were usually reported within 6 hours of completion (62%). The official report for nonurgent scans took between 24 and 72 hours, which was a major concern for respondents. Data were not available, however, on informal methods of reporting, such as verbal reports.

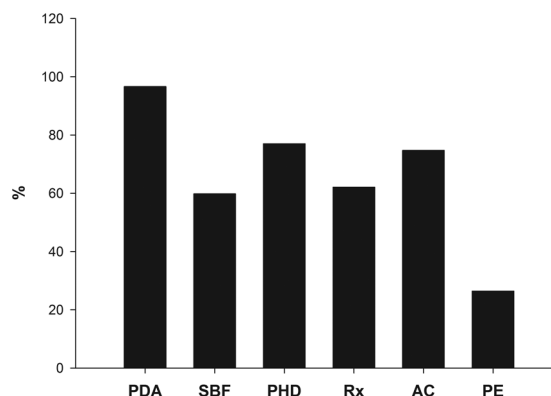
Figure 1. Factors influencing the decision to introduce targeted neonatal echocardiography at centers where the practice has been adopted. A indicates literature suggested it contributes to improved patient outcomes; B, worked in units where targeted neonatal echocardiography was routinely practiced; C, pediatric cardiology services were not readily accessible; D, hemodynamic information was not readily available on routine echocardiography; and E, need to integrate clinical and targeted neonatal echocardiographically derived hemodynamic data.



Targeted Neonatal Echocardiography Services

The main factor influencing the decision to introduce targeted neonatal echocardiography to the NICU was the need to have timely and longitudinal echocardiographically derived hemodynamic information to guide cardiovascular therapy. Other reasons cited included concern regarding the extent of the hemodynamic information provided by traditional echocardiographic studies and literature suggesting improved short-term clinical outcomes with targeted neonatal echocardiography use (Figure 1). The most commonly reported indications for targeted neonatal echocardiography included evaluation of pulmonary and systemic hemodynamics, assessment of a hemodynamically significant ductus arteriosus, and evaluation of the response to therapy (Figure 2). Fifty-nine percent of respondents reported that a comprehensive pediatric cardiology anatomic scan was always performed before a targeted neonatal echocardiographic evaluation was requested. Only 11 respondents (7.7%) actually performed and interpreted targeted neonatal echocardiography studies themselves. This equates to 27% of neonatologists at centers where a targeted neonatal echocardiography program was in place. Of these, most specialists in targeted neonatal echocardiography (60%) performed, on average, 11 to 20 echocardiographic examinations per month. Most (74%) had access to a dedicated echocardiography machine within the NICU. Images were most commonly archived in the NICU on the machine itself (58%) or a dedicated computer with sufficient hard drive space (48%). Only 10% of centers reported permanent archiving to the pediatric echocardiography labora-

Figure 2. Common indications for targeted neonatal echocardiography. AC indicates acute collapse; PDA, patent ductus arteriosus; PE, pericardial effusion; PHD, pulmonary hemodynamics; Rx, treatment response after targeted neonatal echocardiography; and SBF, systemic blood flow.



tory archive on a hospital-based server. The most common method of reporting was a structured note in the electronic or paper health record. Sixteen respondents stated that they used targeted neonatal echocardiography as a component of their clinical research programs. Only 3 respondents reported its use for basic/translational research.

Targeted Neonatal Echocardiography Training

Just less than half of respondents reported that some form of targeted neonatal echocardiography teaching/training program was offered at their institutions for staff neonatologists and neonatal fellows. The composition of the training programs was highly variable between centers and consisted of a mixture of formal and self-directed learning (Table 1). The teaching was directed by neonatologists, cardiologists, and sonographers. Although there was no formal curriculum, in general, 2 to 5 hours per week of teaching was consistently provided in most centers. The duration of the training period was highly variable, ranging from less than 8 weeks (14%) in some centers to more than 16 weeks (29%).

Targeted Neonatal Echocardiography Skill Evaluation

There is no formal accredited evaluation method in Canada. For centers offering targeted neonatal echocardiography training, respondents reported the provision of a local certificate of successful completion of training, a certificate of attendance, or a letter outlining activities completed in the program. Only 6 respondents reported a formal process of evaluation on completion of training; the most common method was assessment of a logbook ($n = 3$). The logbook-based evaluation was highly variable, with the number of studies ranging from less than 25 to 100. Most respondents (87%) reported no assessment of ongoing competency after completion of initial training. In centers where an assessment process existed, it typically was ad hoc, took place annually, and involved assessment of a logbook. The number of mandatory studies per year required to maintain competency varied from 10 to 50.

Table 1. Targeted Neonatal Echocardiography Training Methods

Educational Modality	%
Didactic component	80
Hands-on component	100
Logbook	55
Teaching aids (online tools, DVDs)	70
Pediatric echocardiography laboratory rotation	50
Program taught by neonatology staff	30
Joint neonatology–pediatric cardiology program	40

To further validate our data, we requested site-specific data from lead neonatologists at 8 major centers in Canada. Four centers reported access to a neonatology-led targeted neonatal echocardiography service, with 5 centers having a dedicated echocardiography machine in the NICU. Most ($n = 6$) reported onsite access to pediatric cardiology services; however, 24/7 access was only available in 4 centers. Only 2 sites had a dedicated targeted neonatal echocardiography training program, which was led by targeted neonatal echocardiography specialists in collaboration with pediatric echocardiography staff.

Discussion

This survey demonstrates that targeted neonatal echocardiography is recognized by most Canadian neonatologists as a priority for clinical care; however, the approach to training is not well standardized, and the infrastructure to support targeted neonatal echocardiography programs is limited. The evolution of targeted neonatal echocardiography as a component of neonatal intensive care has occurred in response to the need for timely and longitudinal hemodynamic information, which is due in part to the lack of reliable clinical markers of hemodynamic instability. Many neonatologists reported that the information provided on routine echocardiograms obtained by a pediatric echocardiography laboratory service was sometimes not useful for day-to-day hemodynamic management. Delays in obtaining echocardiographic results, which extended up to 72 hours in some situations, do not align with the needs of the neonatal intensivist. These issues, in association with increasing evidence of the benefits of point-of-care echocardiography and growing endorsement by pediatric bodies worldwide, have led to an increased demand for training in this skill. It is imperative, however, that the use of targeted neonatal echocardiography is closely regulated, and standards for practice and training are established before mass dissemination of this tool.

Clinical Impact of Targeted Neonatal Echocardiography

There is growing evidence of the value of targeted neonatal echocardiography in aiding diagnosis and guiding hemodynamic therapy in the NICU. Carmo et al⁸ showed the benefit of serial echocardiography in directing the duration of indomethacin treatment in infants with a patent ductus arteriosus. There is increased evidence of the use of targeted neonatal echocardiography as an aid to earlier diagnosis and enhanced treatment of infants with persistent pulmonary hypertension.⁶ Jain et al^{4,5} showed the benefits of targeted neonatal echocardiography in preventing

postoperative cardiorespiratory instability following patent ductus arteriosus ligation and in aiding in the confirmation of central line placement. Neonatologists who wish to develop expertise in targeted neonatal echocardiography must undergo formalized and structured training and evaluation to ensure competency. Specifically, it is imperative they are able to obtain high-quality images and have the necessary knowledge of cardiovascular physiology and therapeutics to ensure that their medical recommendations are rational and scientifically valid.

A major concern regarding the application of targeted neonatal echocardiography in the setting of a neonate with hemodynamic instability is the fact that a small proportion of these neonates may represent undiagnosed congenital heart disease.⁷ There is also the potential that, in the hands of an inexperienced operator, the use of targeted neonatal echocardiography could result in the generation of diagnoses that are aberrant from the clinical picture, leading the clinician to institute inappropriate therapies.⁹ These issues further emphasize the need for close collaboration between neonatologists performing these evaluations and a pediatric cardiologist or echocardiography laboratory and, wherever possible, integration of aspects of the targeted neonatal echocardiography service within the infrastructure of a pediatric echocardiography laboratory. These steps will facilitate enhanced quality assurance and improved efficiency and may cultivate interdisciplinary research initiatives.

Standards for Clinical Practice and Training

The need for standardization of training and quality assurance is recognized by neonatologists with expertise in the field.³ In Australasia establishment of the Certificate of Clinician-Performed Ultrasound was the first step toward a structured curriculum and an enhanced training program with formal evaluation.³ Recently, a writing group of the American Society of Echocardiography in collaboration with the European Association of Echocardiography and the Association for European Paediatric Cardiologists was convened to address issues related to the use of targeted neonatal echocardiography, including indications for its use and recommendations with regard to training and accreditation.⁷ This group recommends that infants who have suspected congenital heart disease or a cardiac arrhythmia should always have an evaluation by a pediatric cardiologist. In situations in which there is hemodynamic instability and congenital heart disease is not suspected clinically, a comprehensive echocardiographic examination should always be performed initially; although the study may be performed by an individual trained in tar-

geted neonatal echocardiography, it is advised that it should be reviewed by a pediatric cardiologist “within a reasonable time period”.⁷ Recommended indications for targeted neonatal echocardiography are similar to the common indications cited by respondents within our study and include assessment of a suspected patent ductus arteriosus, myocardial dysfunction in perinatal asphyxia, and determination of the etiology and assessment of the response to therapy in neonatal hypotension.⁷ Targeted neonatal echocardiography may also be useful for diagnosis of pericardial and pleural effusions, identification of the catheter tip position following insertion of central lines, and diagnosis of complications such as thrombosis or infection.⁷

Standards for targeted neonatal echocardiography training have also been developed based on published US and European pediatric echocardiography guidelines.^{7,10,11} Development of “core” competency requires the completion of 4 to 6 months training in pediatric echocardiography, enabling the performance of a minimum of 150 studies and the interpretation of a further 150 studies.⁷ A formal evaluation of image acquisition competency is recommended on completion. “Advanced” training should enable the independent performance and interpretation of targeted neonatal echocardiography for the previously mentioned indications. This training requires the performance of a further 150 studies and the review of an additional 150 studies, and on completion, the trainee should be able to reliably exclude congenital heart disease.⁷ The suggested timeline for this training is again 4 to 6 months, but it is recommended that it take place mainly within the setting of an NICU. On completion of advanced training, it is recommended that trainees perform a minimum of 100 targeted neonatal echocardiographic studies per year to maintain competency.⁷ Although the training, at first glance, may appear challenging, it will ensure that trained individuals function at a high level and that excellence in cardiovascular decision making is achieved. It will also lay the platform for enhanced collaboration between neonatologists and pediatric cardiologists.

This study highlights many issues related to training and assessment of competency in the performance of targeted neonatal echocardiography. Access to training is limited, and, where available, methods are inconsistent, with only a very small proportion of respondents reporting a formal assessment process on completion of training. For centers that do incorporate assessment through a logbook review, the required number of echocardiographic examinations is highly variable, ranging from less than 25 to 100. It must be acknowledged, however, that in the context of

recent targeted neonatal echocardiography training recommendations, these numbers fall far short of even those suggested to achieve core competency. It equally must be recognized that the recommended number of echocardiographic studies is based on expert opinion and has not been subjected to rigorous scientific scrutiny. As there are likely to be individuals who reach competency after fewer studies and others who require a greater volume of exposure, a prospective evaluation of the training needs of the targeted neonatal echocardiography specialist is worthy of future consideration. Notably, within this study, only 2 respondents reported a process of ongoing competency assessment. In cases in which such an assessment process exists, the number of echocardiographic examinations required for annual review ranges from 10 to 50, again falling substantially short of the recommended 100 studies necessary to maintain competency in this skill.

Limitations

This study did not address the merits of, or potential harms of, targeted neonatal echocardiographically guided practice. Also, as with any survey, these data were self-reported and as such may be open to respondent biases. To minimize individual biases, we conducted a site-specific appraisal of 8 sites, as outlined above, which demonstrated that the data were consistent with individual respondents.

Conclusions

Targeted neonatal echocardiography is becoming more widely available and is gaining acceptance in Canadian NICUs. Although training is provided in many institutions, the process is not well established, with inconsistent training methods and a lack of formal evaluative processes. In light of recent targeted neonatal echocardiography working group guidelines, this study highlights deficiencies in current training methods and the need for formalized training and evaluation to maintain quality assurance.

Appendix

Use of Targeted Neonatal Echocardiography

1. Is targeted neonatal echocardiography performed by a neonatologist available in your unit? (If no, please go to question 31.)
 - Yes
 - No
2. If yes, how long has this service been provided in your unit?
 - <1 year
 - 1–5 years
 - 5–10 years
 - >10 years
3. Do you have a dedicated echocardiographic machine for the NICU or share with cardiology department?
 - Dedicated
 - Shared
4. How are the echocardiograms acquired by the neonatologist archived? (Check all that apply.)
 - Archived in the unit on the machine
 - Archived in the unit on storage hard drive
 - Archived in cardiology department hard drive
 - Archived as hard copy printouts
 - Not archived
5. How are the echocardiograms acquired by the neonatologist reported? (Check all that apply.)
 - By neonatologists as a written note
 - By neonatologists as an electronic report
 - By cardiologists as a written note
 - By cardiologists as an electronic report
6. If neonatologist-performed targeted neonatal echocardiography is practiced in your NICU, what factors influenced your decision? (Check all that apply.)
 - Literature suggests it contributes to improved patient outcomes
 - Worked in units where it is routinely practiced
 - Pediatric cardiology services not readily accessible
 - Information available from pediatric cardiology echocardiograms not very useful for hemodynamics
 - Prefer using echocardiographic information in conjunction with clinical information to tailor appropriate therapy
7. What are the indications for which neonatologist-performed targeted neonatal echocardiography is done in your unit? (Check all that apply.)
 - Evaluation of a hemodynamically significant ductus arteriosus
 - Evaluation of systemic blood flow
 - Evaluation of pulmonary hemodynamics
 - Evaluation of response to therapy (eg, inotropes)
 - Line position
 - Sudden unexplained cardiorespiratory deterioration
8. The targeted neonatal echocardiographic report is useful for each of the following:
 - Determining whether a patent ductus arteriosus is hemodynamically significant
 - Assessment of systemic blood flow
 - Facilitating choice of inotropes or other cardiovascular intervention (eg, volume) and assessing response to intervention
 - Evaluation of pulmonary hemodynamics
 - Facilitating whether to commence inhaled nitric oxide and assessment of response to intervention

(continued)

Appendix (continued)*Use of Targeted Neonatal Echocardiography*

9. In terms of promptness and content of information provided by the neonatologist-performed targeted neonatal echocardiography service in your unit, it is best described as appropriate:
- 95%–100% of the time
 - 70%–95% of the time
 - 40%–70% of the time
 - 10%–40% of the time
 - <10% of the time
10. How long does it take to get a report on targeted neonatal echocardiography?
- <6 hours
 - 6–12 hours
 - 12–24 hours
 - 24–72 hours
 - Not applicable
11. When a medical treatment decision is initiated on the basis of the information obtained from neonatologist-performed functional echocardiographic scan, how frequently is a pediatric cardiologic scan required before treatment?
- Always
 - Most often
 - Half the time
 - Infrequently
 - Never
12. Do you personally perform targeted neonatal echocardiography?
- Yes
 - No
13. If the answer to question 12 was yes, how many targeted neonatal echocardiographic studies do you perform every month?
- <10
 - 11–20
 - >20
14. Do you use targeted neonatal echocardiography for research?
- Yes
 - No
15. If yes, what component of research is addressed? (Check all that apply.)
- Basic/translational
 - Clinical/patient-related research

Training

16. Which of the following best describes your training in targeted neonatal echocardiography? (Check all that apply.)
- Taught by a trained neonatologist
 - Self-directed learning
 - Taught by sonographers
 - Taught by pediatric cardiologists
 - Attended formal course
 - Used Web-based tools/books/educational CDs
 - Not applicable

17. Is a targeted neonatal echocardiography teaching/training program available at your institution?
- Yes
 - No
18. If yes, to whom is this training offered? (Check all that apply.)
- Institution's staff neonatologists
 - Institution's neonatal fellows
 - Institution's pediatric residents
 - Institution's general pediatricians
 - Other members from interprofessional team (nursing, respiratory therapy)
 - Trainees from outside institutions
19. Which of the following best describes how teaching is conducted? (Check all that apply.)
- Didactic component
 - Hands-on component
 - Logbooks maintained
 - Teaching aids (online teaching tools, CDs)
 - Clinical rotation in echocardiography laboratory
 - Program taught by neonatologists only
 - Joint program taught by neonatologists and cardiologists
20. How many hours of echocardiography training are provided to each student per week (including self-teaching)?
- <2 hours
 - 2–5 hours
 - >5 hours
21. What is the duration of the echocardiography training program?
- <8 weeks
 - 8–12 weeks
 - 12–16 weeks
 - >16 weeks

Evaluation

22. What is provided to the trainee at the end of the program?
- Certificate of attendance
 - Letter outlining activities
 - Certificate of successful completion of the program
23. Is there a formal assessment process at the end of training?
- Yes
 - No
24. If yes, are trainees required to be successful in this assessment to obtain certification/recognition of training?
- Yes
 - No
25. What form does this assessment take? (Check all that apply.)
- Practical assessment (trainee observation in performance of echocardiography)
 - Written examination
 - Multiple-choice questions
 - Assessment of logbook

(continued)

Appendix (continued)*Evaluation (continued)*

26. If a logbook is used in the assessment process, how many echocardiograms must be available for review?
- <25
 - 25–50
 - 51–75
 - 76–100
 - >100
27. After successful completion of training, is there a formalized process for assessment of ongoing competency?
- Yes
 - No
28. If yes, how often is this ongoing assessment completed?
- Every year
 - Every 2–3 years
 - Every 4–5 years
 - Every 6–10 years
29. What form does this assessment take? (Check all that apply.)
- Practical assessment (observation in performance of echocardiography)
 - Written examination
 - Multiple-choice questions
 - Logbook
30. If a logbook is used in the assessment of ongoing competency, how many echocardiograms must be performed per year?
- <10
 - 10–25
 - 26–50
 - >50
31. If targeted neonatal echocardiography performed by the neonatologist is not available in your unit, have you considered introducing it in your NICU?
- Yes
 - No
32. If you have decided not to introduce neonatologist-performed functional echocardiography in the NICU, what factors influenced your decision? (Check all that apply.)
- Functional echocardiography expertise not readily available
 - Not convinced this is a beneficial technology or impacts clinical outcomes
 - Colleagues not convinced this is a beneficial technology or impacts clinical outcomes
 - Readily accessible pediatric cardiology services obviate the need for functional echocardiography
 - Cost of the machine prohibitive
 - Not adopted in peer units
 - Concern about reduced revenues for cardiology department
 - Rather rely on clinical information

Access to Services

33. How would you describe access to pediatric cardiology services at your institution?
- On-site
 - Off-site but accessible
 - Not accessible, necessitating patient referral
34. What pediatric cardiology services are provided at your institution? (Check all that apply.)
- Daytime weekday services
 - Evening weekday services
 - Weekend services
 - Service is off-site
35. Once a request has been made for an urgent echocardiogram from pediatric cardiology services, what is the average time until the echocardiography report is available?
- <6 hours
 - 6–12 hours
 - 12–24 hours
 - 24–72 hours
 - Not applicable
36. Once a request has been made for a nonurgent echocardiogram from pediatric cardiology services, what is the average time until the echocardiography report is available?
- <24 hours
 - 24–72 hours
 - 72 hours–7 days
 - >7 days
 - Not applicable
37. What is the average time taken for completion of a routine echocardiogram?
- <30 minutes
 - 30 minutes–1 hour
 - 1–3 hours
 - >3 hours
38. Who would most often perform these echocardiographic studies?
- Sonographers
 - Cardiology fellows/registrar
 - Cardiologists
39. In terms of promptness and content of information provided by pediatric cardiology services in your unit, it is best described as appropriate:
- 95%–100% of the time
 - 70%–95% of the time
 - 40%–70% of the time
 - 10%–40% of the time
 - <10% of the time

(continued)

Appendix (continued)*Access to Services (continued)*

40. The routine echocardiography report is useful for each of the following:
- Determining whether a patient's ductus arteriosus is hemodynamically significant
 - Assessment of systemic blood flow
 - Facilitating choice of cardiotropes or other cardiovascular interventions (eg, volume) and assessing response to intervention
 - Evaluation of pulmonary haemodynamics
 - Facilitating whether to commence inhaled nitric oxide and assessment of response to intervention
41. How do you describe your experience as a neonatologist?
- <10 years
 - 10–20 years
 - >20 years
42. Which of the following best describes your institution?
- Inborn only
 - Inborn and outborn
 - Outborn only
43. How many deliveries occur per year at your institution?
- <2000
 - 2000–4000
 - 4000–6000
 - >6000

References

1. Shah DM, Kluckow M. Early functional echocardiogram and inhaled nitric oxide: usefulness in managing neonates born following extreme premature rupture of membranes (PPROM). *J Paediatr Child Health* 2011; 47:340–345.
2. Sanders SP, Colan SD, Cordes TM et al; American Society of Echocardiography; Society of Pediatric Echocardiography; American College of Cardiology Foundation; American Heart Association; American College of Physicians Task Force on Clinical Competence (ACC/AHA/AAP Writing Committee to Develop Training Recommendations for Pediatric Cardiology). ACCF/AHA/AAP recommendations for training in pediatric cardiology. Task force 2: pediatric training guidelines for non-invasive cardiac imaging endorsed by the American Society of Echocardiography and the Society of Pediatric Echocardiography. *J Am Coll Cardiol* 2005; 46:1384–1388.
3. Kluckow M, Seri I, Evans N. Functional echocardiography: an emerging clinical tool for the neonatologist. *J Pediatr* 2007; 150:125–130.
4. Jain A, McNamara PJ, Ng E, El-Khuffash A. The use of neonatal echocardiography to confirm placement of peripherally inserted central catheters in neonates. *Am J Perinatol* 2012; 29:101–106.
5. Jain A, Sahni M, El-Khuffash A, Khadawardi E, Sehgal A, McNamara PJ. Use of targeted neonatal echocardiography to prevent cardiorespiratory instability after patent ductus arteriosus ligation. *J Pediatr* 2012; 160:584–589.e1.
6. Mertens L, Helbing W, Sieverding L, Daniels O; Working Group on Cardiac Imaging of the Association for European Paediatric Cardiology. Guidelines from the Association for European Paediatric Cardiology: standards for training in paediatric echocardiography. *Cardiol Young* 2005; 15:441–442.
7. Mertens L, Seri I, Marek J, et al; Writing Group of the American Society of Echocardiography (ASE); European Association of Echocardiography (EAE); Association for European Pediatric Cardiologists (AEPC). Targeted neonatal echocardiography in the neonatal intensive care unit: practice guidelines and recommendations for training. *Eur J Echocardiogr* 2011; 12:715–736.
8. Carmo KB, Evans N, Paradisi M. Duration of indomethacin treatment of the preterm patent ductus arteriosus as directed by echocardiography. *J Pediatr* 2009; 155:819–822.e1.
9. Sehgal A, McNamara PJ. Does point-of-care functional echocardiography enhance cardiovascular care in the NICU? *J Perinatol* 2008; 28:729–735.
10. Evans N, Gournay V, Cabanas F, et al. Point-of-care ultrasound in the neonatal intensive care unit: international perspectives. *Semin Fetal Neonatal Med* 2011; 16:61–68.
11. El-Khuffash AF, McNamara PJ. Neonatologist-performed functional echocardiography in the neonatal intensive care unit. *Semin Fetal Neonatal Med* 2011; 16:50–60.