EDITORIAL

Clarification of boundaries and scope of cardiac POCUS vs. Targeted Neonatal Echocardiography

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The last decade has witnessed exponential growth in the field of Neonatal Hemodynamics and Point-of-Care Ultrasound in the United States and Canada, driven in response to the need for improvement in understanding and management of the rapidly changing cardiovascular physiology in critically ill neonates. It led to the emergence of the neonatal hemodynamics consultation within neonatology, which integrates physiologic information from a targeted neonatal echocardiography (TNE) assessment within the clinical context according to the 2011 guidelines for training and clinical practice [1, 2]. Several observational studies have demonstrated evidence of benefit to patient outcomes [3–5] which, though desirable for maximizing patient care and outcomes, requires systematic training, time, and resource commitment to develop programs. In addition, most centers are not yet able to provide 24/7 coverage for hemodynamic consultation. Cardiac point-of-care ultrasound (cPOCUS) on the other hand is defined as a brief emergent cardiovascular assessment that may be clinically useful in certain scenarios. Despite a clear distinction between the two disciplines and their legitimate place in practice, there appears to be a lack of awareness regarding the appropriate usage and interface. The purpose of this commentary is to provide guidance on scope of practice of neonatal hemodynamics consultation and cPOCUS within the United States and Canada, further providing a framework that clinicians may find useful for clinical practice and program development.

SCOPE OF CARDIAC POCUS

Cardiac POCUS refers to a basic, time-sensitive, and focused ultrasound assessment of the heart to assist in urgent or emergent clinical decision-making and guide resuscitative interventions. It is aimed to answer problem-oriented clinical questions using discrete outcome measures, that complement clinical data and facilitate management of infants with "normal" cardiac anatomy. Multiple consensus statements have been published regarding the use of rapid cardiac assessment by POCUS, including the American Academy of Pediatrics (AAP), the American Society of Echocardiography (ASE), and European Society of Paediatric and Neonatal Intensive Care (ESPNIC) [6–8]. As a new field in Neonatology, data on the impact of cPOCUS on neonatal outcomes are limited.

Hence, defining a scope of practice becomes essential for developing a strong framework and safe clinical implementation. POCUS education has been incorporated in medical school curriculums in the early stages of medical training in the United States (US) and Canada [9]. Thus, medical students and trainees are arriving to pediatric and neonatal clinical environments with knowledge of ultrasound, but without a robust clinical framework and competency with which to employ their skills. Therefore, expansion of American College of Graduate Medical Education (ACGME) requirements to include cardiac and non-cardiac POCUS applications within neonatology fellowship training seems a natural destination as POCUS continues to blend in clinical practice. Cardiac POCUS curriculums have been developed locally at institutions and across the world but without previous standardization of clinical protocols. Recently, national leaders in the field of neonatal POCUS have created a "National Neonatal POCUS Collaborative" to provide structure, standardize training programs and programmatic platforms, foster interdisciplinary collaboration with pediatric cardiology and pediatric radiology to ensure safe clinical implementation, and promote innovation in the use of POCUS in the NICUs across the United States. The ultimate goal is to train more providers in basic and life-saving ultrasound applications, differing in scope of practice from advanced neonatal hemodynamic evaluations.

Cardiac POCUS in neonates can be applied for the following indications:

(1) Cardiac tamponade and pericardial effusion: Cardiac POCUS can be used to detect life-threatening events, such as large pericardial effusions that cause hemodynamic compromise [10]. When cardiac tamponade is detected, cardiac POCUS allows for direct visualization to perform and safely guide pericardiocentesis [11].
(2) Guiding evaluation of global cardiac function vs. cardiac filling status in acute cardiovascular collapse: visual inspection or qualitative assessment of global systolic function may be used to evaluate whether cardiac contractility appears significantly impaired or not (binary outcome). Recent studies reported that trained, non-cardiologist pediatric critical care and pediatric emergency medicine physicians can evaluate global left ventricular function through cardiac POCUS with reasonable accuracy [12]. However, qualitative estimation alone can have wide limits of agreement and mild to moderate systolic dysfunction may be missed. In addition, this study should not be considered a comprehensive interrogation of circulatory pathophysiology. Hence, a neonatal cardiac POCUS user should be aware of these limitations. Similarly, in emergency situations cardiac POCUS can provide global information on cardiac filling through a qualitative assessment of an underfilled heart (decreased preload) or volume overload (increased preload). While this abbreviated evaluation may be used to determine whether fluid therapy vs. an inotrope is indicated, it may have poor reliability in mild to moderate diseases.
(3) Umbilical venous catheter and central lines position: cardiac POCUS can be used to facilitate central venous line insertions by confirming catheter tip positions in great veins and ruling out intracardiac locations in real time. In

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some patients rarefaction artefacts from the vessel walls may make it challenging to identify the actual catheter tip.

(4) In summary, cardiac POCUS should be performed for specific indications only in emergency and critical care scenarios and "not" to appraise and target management of specific physiologic states such as pulmonary hypertension, patent ductus arteriosus, and gradation of cardiac dysfunction. The recognition of its specific indications and limitations as well as the unquestionable limited nature of the ultrasound training is crucial to avoid potential pitfalls. Research is, however, needed to evaluate the reliability and validate the specific role of cardiac POCUS in improving neonatal outcomes.

SCOPE OF NEONATAL HEMODYNAMIC ASSESSMENT AND TNE

An increasing number of clinical and academic neonatal hemodynamics programs have been established at tertiary neonatal intensive care units over the last 15 years, especially in the US and Canada (currently 25 programs). Typically, these programs are highly organized, and led by neonatologists with extensive training in echocardiography, cardiovascular physiology and pharmacotherapeutics. They follow a consultative model of care, where the attending clinician requests a formal consultation to aid in the cardiopulmonary clinical management of the neonates under their care. Each hemodynamic consultation involves performing a comprehensive echocardiography assessment according to standardized imaging protocols, measuring physiologic hemodynamic and functional variables using widely published methods, interpretating the relevance of these data by integrating in the clinical context, and providing formal management recommendations. Several tertiary centers have reported their real-world experience of the clinical application of TNE-based hemodynamic consultations, which consistently demonstrate the acceptance and increasing utilization over time by neonatal physicians, a testament to TNE's perceived impact as an aid to clinical care. Specific indications for hemodynamic consultation include (1) assessment of patent ductus arteriosus (PDA) and its hemodynamic significance; (2) evaluation of acute and chronic pulmonary hypertension (PH); (3) delineation of the physiologic nature of systemic hypotension (SH) or shock; (4) appraisal of heart function in "at-risk" patients including hypoxic-ischemic encephalopathy, post-interventional closure of PDA. Published experience from TNE centers report that 40 to 50% of hemodynamic consultations result in a change in clinical management; in addition, specific factors associated with higher likelihood of impact included consultations requested in the first postnatal week, patients receiving mechanical ventilation or consultations done in the context of PH/SH management. In latter cases, >80% consultations resulted in modification of treatments [5, 13]. Systematic evaluation of the safety of performing comprehensive TNE as a first study in patients deemed low risk for structural heart defects has also been established; specifically, in comparison to subsequent anatomic scans performed by the pediatric cardiology service [14]. The evidence supporting TNEs impact on clinical care is steadily increasing, with investigations moving from impact on the clinical decision-making process to evaluating its impact on meaningful clinical outcomes. Matched case-control study and comparison to historical cohorts indicated the superiority of TNE-guided care for improving post-operative stability of preterm neonates undergoing PDA ligation [15] and management of those needing mechanical ventilation following preterm prolong rupture of membranes [16]. Recently, in a large pre-post study, systematic application of TNE-based hemodynamic screening evaluation followed by physiology-based management improved key outcomes for peri-viable infants with PDAs and reduced the composite outcome of severe brain injury or death among extremely low gestational age infants [3]. The likely contributors to these gains are likely related to the expert model of care, extent of training received by hemodynamics/TNE practitioners and ongoing volume of clinical experience in the index center where more than 2000 consults are performed annually.

In addition to the improvements in clinical care and research developments, seven high-quality subspecialty neonatal hemodynamic fellowship programs have been developed in the US and Canada based on the 2011 TNE guidelines. Graduates of these programs have gone on to establish and lead their own hemodynamics programs at tertiary centers across the globe, develop hemodynamic research programs which have led to exponential growth in TNE-driven hemodynamics research and secure federal grant funding. As a first of its kind, the Royal College of Physicians in Canada has now accredited TNE-based hemodynamics fellowships as a diploma by granting it the status of an Area of Focused Competency. Recently, international thought leaders in the field of neonatal hemodynamics have established an academic consortium (https://neonatalhemodynamics.com) whose vision is to advance the field through joint educational, quality improvement and research endeavors [17], and have established a presence within the American Society of Echocardiography through the creation of a Special Interest Group (https://www.asecho.org/sigs/nhts/).

TRAINING STANDARDS AND PROGRAM ESTABLISHMENT

While training standards have been proposed for both fields, there continues to be gaps and inconsistencies in program implementation. The recently published ASE guidelines for cPOCUS in pediatrics intentionally excluded patients in the NICU due to their unique physiology, particularly in the transitional period [6]. In this section we will review the current proposed training standards and potential boundaries with program implementation.

Cardiac POCUS

POCUS is a recognized discipline that is taught with increasing frequency in medical schools, pediatric residency programs, and neonatal-perinatal fellowship programs. Despite multiple consensus statements from governing bodies regarding the importance of POCUS, there remains no accepted standard for curriculum and training in the NICU setting. Cardiac POCUS training includes formal didactic sessions, simulation training, hands-on experience, and quality assurance. The American Society of Anesthesiologists, Society of Point-of-Care Ultrasound, and the American College of Emergency Physicians (ACEP) recommend a minimum of 25-50 scans, which has been used to establish a framework for practice by some institutions.

Neonatal hemodynamics

The typical route for neonatal hemodynamics/TNE training is through a highly competitive formal 1-year fellowship after completion of accredited neonatal-perinatal medicine training. Standardized curriculums include formal didactic sessions, simulation training, hands-on training which includes time in a pediatric echocardiography laboratory, and comprehensive training in advanced cardiopulmonary physiology. The 2011 ASE guidelines for TNE, stated that a minimum of 300 studies performed and 300 studies reviewed are required, although these numbers are based on expert opinion [1]. Several publications, while supporting the expert model of hemodynamic care, have advocated the need for revision of the guidelines to better reflect the indications and specific competencies required by neonatology trainees.

Implementation of an institutional program

Institutions should evaluate the need for cPOCUS and advanced Neonatal Hemodynamic assessments, ability to train learners, and processes for quality assurance prior to program development.

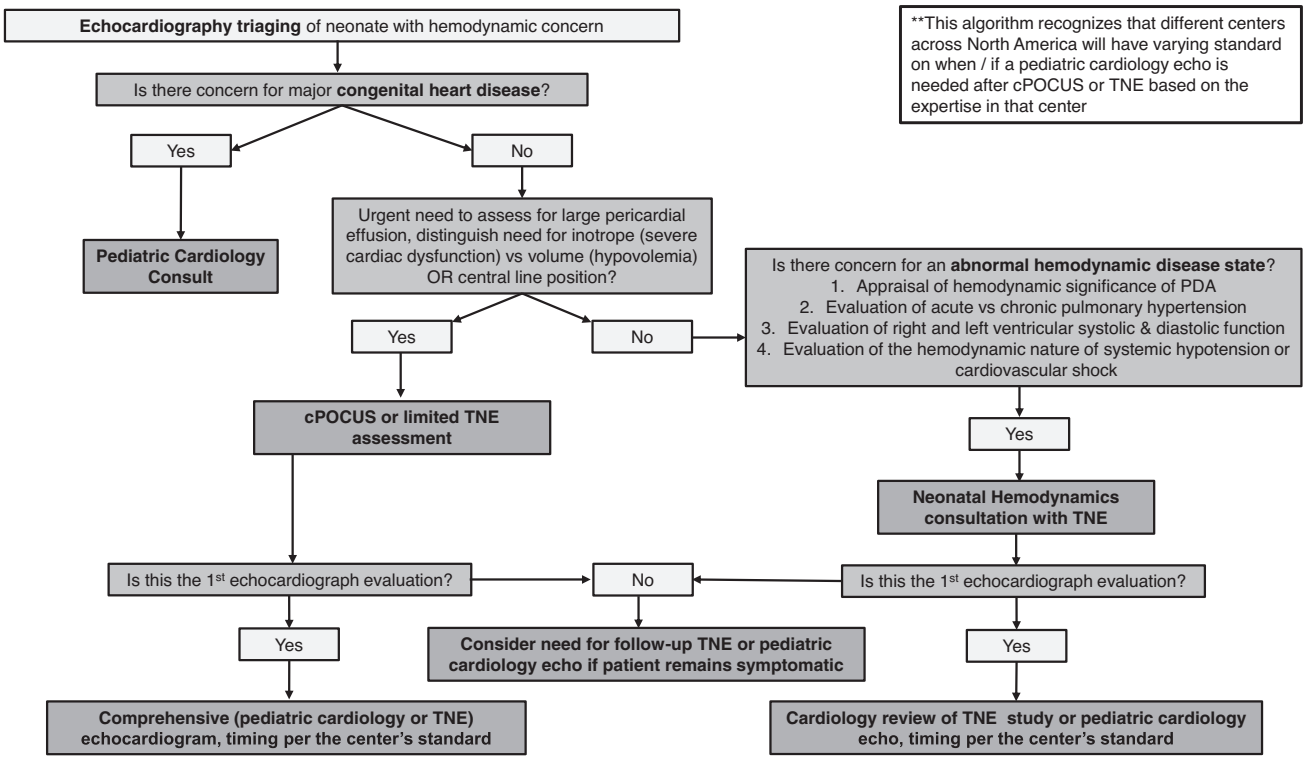

Fig. 1 Expert opinion-based framework for use of cardiac POCUS, hemodynamics consultation with TNE and pediatric cardiology consultation based on clinical indications.

Common to both cPOCUS and Neonatal Hemodynamics programs is the need for dedicated ultrasound equipment with the appropriate size and frequency range of the probes, dedicated system for image storage, standardized reporting mechanism, and experienced program director. In addition, programs should develop clinical practice guidelines that clearly delineate the indications and scope of practice. Figure 1 provides an indication-based framework demonstrating the scope and interaction of cPOCUS, TNE, and pediatric echocardiography. It is important to highlight that this algorithm is based on expert opinion and centers may wish to adapt aspects of it based on institutional standards. As cPOCUS is only used to guide decisions in a critical situation, these evaluations should be followed by a comprehensive echocardiography evaluation (TNE or pediatric echocardiogram) within an agreed timeframe specific to the institution. Without governance, programs may develop in which universal access is prioritized over ensuring that practitioners have the necessary knowledge, expertise, and critical volume of procedural exposure to optimize patient care. This may contribute to diagnostic or therapeutic inaccuracy.

In summary, the boundary between the unique fields of neonatal hemodynamics (physiology-based echocardiography) and pediatric cardiology (structural/functional echocardiography) has been clarified through published guidelines and supported through peer review. Clinicians and programs interested in building an imaging-based program to enhance cardiovascular decision-making should consider the indications and training requirements for each field and its applicability to their setting. Although the evolution of neonatologist led hemodynamic programs has led to major advancements in knowledge, clinical practice, and patient outcomes; it is important that these publications are not legitimized as endorsement of cPOCUS use beyond the indications listed in this commentary. The purpose of this commentary is not to dissuade clinicians away from performing cPOCUS evaluations, but to provide clarity regarding scope of practice. Such clarity will facilitate the expansion of both fields and enhance their synergism, while ensuring safe and comprehensive care of patients.

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AUTHOR CONTRIBUTIONS

PJM was responsible for developing the concept and framework, contributed to the writing of the first draft and approved the final version. AJ, MVF, and JLR were responsible for writing sections of the first draft and approved the final version

COMPETING INTERESTS

All of the authors have contributed to the conceptualization of this manuscript and have approved the final version. None of authors have any conflicts of interest they need to report.

ADDITIONAL INFORMATION

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