Point of care ultrasound (POCUS) in Canadian neonatal intensive care units (NICUs): where are we?

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Abstract

Objectives Despite increased evidence that point-of-care ultrasound (POCUS) has the potential to improve patient care in many clinical areas, the extent of use and training in POCUS in Canadian neonatal intensive care units (NICUs) has not been described in the literature. In this study, we aimed to explore the extent to which POCUS is being used and the need for a formal curriculum with defined POCUS competencies in the field of Neonatal-Perinatal Medicine (NPM).

Methods We sent a cross-sectional electronic survey to all NPM program directors and fellows in Canada. All 13 Canadian NPM programs were invited to participate. Data were analyzed using descriptive statistics and qualitative content analysis.

Results The response rate was 69% ($n=9$) from program directors (PDs) and 29% ($n=25$) from NPM fellows. Most respondents indicated regular use of POCUS in clinical practice and ready access to a portable ultrasound machine. The most common use for POCUS was targeted assessment of patent ductus arteriosus (PDA) and persistent pulmonary hypertension (PPHN). Only six PDs reported that POCUS skills are taught to trainees in their centers and only two PDs reported that a structured program existed. Barriers to POCUS structured training include a lack of trained personnel as well as insufficient time in the busy NPM curriculum.

Conclusion POCUS is widely used in Canadian NICUs. However, a formal curriculum and assessment of competencies in this area of neonatal clinical care are lacking.

Keywords POCUS · Curriculum · Neonatal

Introduction

Point-of-care ultrasound (POCUS) is referred to as the stethoscope of the new era [1]. It includes any ultrasound procedure done at the bedside by non-radiology or non-cardiology specialists to assist with procedures, evaluates diseases and assesses therapeutic responses, all in real-time. POCUS use

has been increasing in popularity. It is commended for being a non-invasive, radiation-free option ensuring a high degree of safety, portability, low cost and accessibility [2]. It was found to improve diagnostic accuracy [3], decrease patient anxiety and discomfort [4], and reduce procedure-related complications [4, 5].

POCUS was introduced initially in Europe and Japan in the 1980s and then gradually started appearing throughout Australia, New Zealand and the United States [6]. Recently, it has been adopted in Canada in Emergency Departments and Critical Care areas. According to a Canadian survey study published in 2016, close to 50% of Canadian medical schools had implemented bedside ultrasound education in their undergraduate curriculum during clerkship rotations in Pediatric Emergency Medicine (PEM), Internal Medicine, Anesthesiology and Acute Care [7].

Widespread use of POCUS has emerged despite some barriers for implementation reported in the literature that include but are not limited to clinical workload in high-volume departments, inadequate access to formal technical

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training, supervision and review of findings, insufficient opportunities to maintain skills and test innovation, lack of equipment and funds, liability concerns and cardiology and/or radiology resistance [2, 6, 8].

In pediatrics, the adoption of the use of POCUS has been progressively increasing in PEM training programs from 65% in 2006 to 95% in 2011. Eighty-eight percent of these had incorporated POCUS in their postgraduate fellowship curricula [8–10].

A POCUS Policy Statement and Technical Report by the American Academy of Pediatrics was recently published supporting POCUS use and quality control in pediatric emergency departments [11]. These documents emphasize the need for formal POCUS education during PEM fellowship training. This sentiment is shared by the Royal College of Physicians and Surgeons of Canada, which is expected to add POCUS to the next iteration of its PEM curriculum [8].

In Neonatology, POCUS has been found to be useful and highly recommended in many clinical situations [12]. It is used as a diagnostic tool for different pathologies such as assessment for pericardial tamponade, pleural effusion, pneumothorax and other lung parenchymal diseases [5, 13, 14]. It has been utilized as a screening tool for pulmonary hypertension and for assessing the presence of the ductus arteriosus in preterm babies [15–17]. Furthermore, it has been used to guide clinical procedures including thoracentesis [5], confirmation of adequate placement of endotracheal tubes (ETT) [18], umbilical arterial and venous lines (UAC & UVC), peripherally inserted central catheters (PICC lines) [19, 20].

Despite increasing evidence of the potential for POCUS to improve patient care, their use and availability of training in NICUs in Canada has not been determined. To our knowledge, no study has described the current state of POCUS training in Canadian NPM programs or the perspectives of both program directors (PDs) and trainees regarding POCUS technology and its clinical importance.

The purpose of this study was to examine the current state of POCUS use, available resources, and training among NICU physicians and trainees in Canada. We also aimed to explore the attitudes and needs of NPM trainees for formal curriculum in this evolving area of neonatal care.

Methods

Study design and survey development

We designed a cross-sectional survey to conduct this study. We identified survey items from reviewing POCUS literature in other areas of clinical care. The survey assessed demographics, practice setting, use of POCUS, presence or lack of formal or informal curriculum, attitudes toward POCUS teaching and

learning and needs and opinions around implementing POCUS as one of the competencies required for NPM trainees.

We formulated eighteen questions in total including multiple-choice responses, statements to be rated using a 5-point Likert-type scale and one open-ended questions. There were four questions to be answered by PDs only (the number of trainees in their respective program, number of neonatologists in their NICU, number of admissions per year, type of patient population served in NICU). To improve reliability and enhance the clarity of the items, a survey design expert from the research institute reviewed the questions to ensure content validity. The survey was pilot tested by two senior NPM fellows and one neonatologist prior to its implementation. The survey was then further modified to accommodate suggestions.

Survey administration

After the Children's Hospital of Eastern Ontario (CHEO) Research Ethics Board approved the study protocol, the survey was distributed using the online survey tool, Redcap®, an electronic data capture tool with survey capability [21]. There are currently 13 neonatal-perinatal medicine training programs across Canada. We identified all PDs from the Royal College of Physicians and Surgeons of Canada (RCPSC) website which provides their names and email addresses. At the time of survey dissemination (November 2017), there were 85 NPM fellows in training; this information was collected directly by our local PD from the PDs across Canada during one of the meetings at the Royal College. Considering email confidentiality and policies in Canada, we had no direct access to trainees' emails. The email to PDs included the study information letter and a link to the survey. PDs were asked to forward the link to all trainees in their respective programs. Since we could not reach non-responders in the absence of consent, two follow-up emails containing a survey reminder letter were sent out at four-week intervals to all PDs to be forwarded to their respective trainees. Data collection continued until 6 weeks after the last reminder letter was sent.

Data analysis

All data were processed and analyzed using SPSS® (IBM SPSS Statistics for Windows, Version 21.0). Descriptive statistics and qualitative content analysis were used to present the study results.

Results

Demographics

Nine PDs (69%) and 25 NPM fellows (29%) completed the survey. Training programs had a variable number of trainees;

two programs had less than five trainers, and one program had 20 trainees. Other programs had 5–10 trainees on average. There was an average of 10–15 neonatologists in the NICUs. The response from PDs indicated that trainees are getting exposure to high-risk obstetric cases, preterm infants, surgical and postsurgical patients. Five NICU's admit cardiac/post cardiac surgical patients and one NICU provides Extracorporeal Membrane Oxygenation (ECMO) service. The average admission rate in all NICUs is between 500 and 1000 patients/year.

POCUS use in NICU

Of all respondents, seven PDs (78%) and 22 trainees (88%) indicated that POCUS is being used in clinical settings by either trainees or neonatologists. Six PDs (67%) and 15 trainees (60%) indicated that there are 1–4 neonatologists/trainees who can perform POCUs in their NICUs; one PD and 7 trainees (28%) indicated that there are 5–10 neonatologist/trainees performing POCUS in their NICUs; two PDs (22%) and 3 trainees (12%) reported that POCUS is not utilized in their NICUs.

POCUS is performed for various indications in NICUs as shown in Fig. 1. The application of POCUS in cardiac assessment is the most common area of POCUS use. It is used for targeted assessment of patent ductus arteriosus (PDA) and persistent pulmonary hypertension (PPHN), volume status assessment and monitoring of inotropes effect on cardiac function.

Access to ultrasound machines and POCUS training

Seven PDs (78%) and 20 trainees (80%) trainees indicated that they have access to a portable ultrasound machine for use in the NICU. Only five PDs (56%) and 16 trainees (64%)

had a dedicated NICU machine. Only one PD (11%) and nine trainees (36%) indicated that POCUS is available 24 h a day in their NICU, while two other PDs (22%) and two trainees (16%) reported that POCUS is only sometimes available 24 h a day in their units.

POCUS training

With respect to training and POCUS curriculum, 6 PDs (67%) reported that POCUS skills are taught to trainees in their centres; however, only two (22%) reported that a structured POCUS program and formal curriculum exists. Ten trainees (40%) indicated that POCUS training is available in their centres. Nevertheless, only five trainees (20%) indicated they have a formal POCUS curriculum. Six PDs (46%) and ten trainees (40%) indicated that POCUS skills are mainly taught by neonatologists. Two PDs (22%) reported that cardiologists are teaching cardiac ultrasound.

Trainees' attitude towards POCUS training and curriculum

Almost all respondent PDs and trainees agreed that POCUS would improve diagnostic accuracy (Fig. 2). Trainees agreed more than PDs to the statement "POCUS may reduce procedure-related complications" (Fig. 2). When exploring the value and importance of learning POCUS skills, all trainees and five PDs (56%) indicated it is valuable to their future career.

When asked if a competency-based POCUS curriculum relevant to neonatologists, should be part of the Royal College objectives of training in NPM, 22 trainees (88%) and 5 PDs (56%) agreed with that statement.

Fig. 1 Indications of POCUS use in NICU. *ETT* endotracheal tube, *PIV* peripheral intravenous, *Picc Line* peripherally inserted central catheter, *IVH* intraventricular hemorrhage, *PVL* periventricular leukomalacia, *PPHN* persistent pulmonary hypertension, *PDA* patent ductus arteriosus

Endotracheal Tube (ETT); Peripheral Intravenous (PIV); Peripherally Inserted Central Catheter (Picc Line); Intraventricular Hemorrhage (IVH); Periventricular Leukomalacia (PVL); Persistent Pulmonary Hypertension (PPHN); Patent Ductus Arteriosus (PDA).

Fig. 2 PDs' and trainees' attitude towards POCUS in NICU

Barriers to implementing a competency-based POCUS training in NICU

All PDs and 19 trainees (76%) reported Lack of trained personnel to be the most common barrier for implementing a competency-based POCUS training (Fig. 3). Table 1 shows additional identified potential barriers.

Discussion

POCUS has been implemented and formally taught within many Canadian training programs such as Emergency Medicine and Acute Care yet teaching POCUS skills in NICU has not been part of the training in NPM programs despite the growing body of literature that shows the merits of its use in the NICU [2, 12]. Our data showed that POCUS is being utilized for a variety of clinical diagnoses in many Canadian NICUs even though there is no standardized curriculum and certainly there is no system in place to ensure minimum competency in this emerging area of neonatal care. Our findings are similar to the results in the Nguyen et al. survey which found that in the United States, formal POCUS training was available only to 29% of NPM fellows as compared to 90% of Pediatric Critical Care Medicine (PCCM) fellows [2].

We identified several barriers to the successful implementation of a POCUS curriculum, similar to barriers identified

Fig. 3 Barriers to implementing competency-based curriculum

Table 1 Other potential barriers to POCUS training

Lack of dedicated time to get training due to other competing educational priorities
Lack of time and resources to develop POCUS curriculum
Lack of teachers who are expert in POCUS
Acquiring full spectrum of POCUS skills including cardiac ultrasound might take longer than what a 2-year fellowship program can accommodate
Resistance from radiology and cardiology

by other critical care programs prior to their successful implementation of the POCUS curriculum [12, 22]. The lack of trained personnel was one of the most important barriers which speaks to the need for organizing faculty development sessions and adequately training faculty before a POCUS program and curriculum could be implemented. The other important barrier was the cost or unavailability of ultrasound equipment. In this study, even though most programs and trainees had access to ultrasound machines, not everyone had a dedicated machine for their NICU. We can all agree that to build an effective training program, availability of bedside ultrasound equipment is vital [12, 22].

When POCUS is utilized in Canadian NICUs, it seems that it is mostly used for cardiac applications such as assessment of PDA, PPHN and volume status and there was a lower level of use for the other indications of POCUS. This was not surprising knowing that targeted neonatal echo (TnEcho) programs have become more available in many Canadian NICUs [16]. Nevertheless, a survey across Canadian NICUs by Finan et al. in 2014 showed only 34% out of 142 respondent neonatologists had access to TnEcho. This was a very low rate as compared to Australia and New Zealand where 85% of the respondents could perform cardiac sonography in their units [16, 17].

While training is provided in many institutions, the process is not well established, and formal evaluation is rarely performed [16]. Although we asked whether either formal or informal training is available to NPM fellows, the details of formal training were not explored. What we gathered from our responses was that in most programs, neonatologists are teaching POCUS related skills. Only two PDs responded that cardiologists are doing the training; those are the programs that incorporated TnEcho in their training and not necessarily the full spectrum of POCUS skills.

It was interesting in this study to see that most PDs and trainees agreed that incorporating POCUS into neonatal care offers great benefits to this patient population. However, the lack of trained faculty to teach the skills was identified as a major barrier to implementation of a successful curriculum. Only five PDs (56%) compared to 22 trainees (88%) agreed that POCUS should be part of the Royal College objectives of the NPM subspecialty. Some of the reasons four

PDs disagreed include the challenges in finding an appropriate time for ` longitudinal POCUS training in the busy NPM curriculum as well as the time and resources needed to develop a new curriculum. In Canada, there are many clinical programs in which POCUS training was successfully built into the residency curriculum (e.g., Emergency Medicine) while other programs created an extra POCUS fellowship to complement their speciality and subspecialty training (e.g., Anesthesiology). Whether the NPM programs choose to incorporate a longitudinal curriculum in the busy NPM training program or create an extra year of neonatal POCUS fellowship, a structured curriculum with clear objectives is very important for standardization of training, competency-based assessment and quality control to assure practice quality and safety.

Over the last few years, there have been a few international consensus statements that have had a significant impact on the successful wide implementation of TnEcho training programs. We are in urgent need of an expert consensus statement that emphasizes the development of a structured training POCUS program designed specifically for neonatologists. Identifying relevant POCUS competencies, designing educational interventions and appropriate tools for assessment is paramount for a successful implementation. Since most programs report that the availability of trained faculty remains a major limitation to POCUS implementation, training faculty should be a priority.

Limitations

One of the study major limitations was the response rate from PDs and trainees; there are only thirteen NPM training programs in Canada, and four of the PDs did not respond to our survey. Also, since we asked the PDs to forward the survey to their respective fellows, it is possible that the NPM fellows from the non-respondent programs have not responded either. We believe that our data could have been more robust, and an accurate reflection of current practice had the response rate been higher.

Furthermore, our survey tools were locally developed rather than using a previously validated survey. However, a review of the literature of POCUS needs assessments informed the survey design and the survey design expert from the research institute reviewed the questions to ensure content validity.

Conclusion

POCUS skills are being used by non-radiologist physicians in different clinical settings, and it has become a very important tool used in many Canadian NICUs. However, formal

training and a structured curriculum is lacking and urgently needed.

Curriculum design should be based on clinical and educational needs. Acquiring the full spectrum of POCUS skills including TnEcho might not be feasible within the 2-year NPM fellowship program. As reported by Raimondi et al. having prior experience with POCUS will definitely strengthen the ability to learn TnEcho skills and apply them to comprehensively assess the sick infants in the NICUs [23]. Achieving full POCUS expertise takes time and dedication. Training programs may consider creating a separate POCUS fellowship to complement their speciality/subspecialty training to avoid crowding the already busy curriculum.

NPM training programs in Canada need to establish consensus to teach skills that are educationally feasible especially with the limitation in equipment availability, time restraint and lack of expert trainers. A national neonatal POCUS curriculum should be designed with clear goals, well-defined learning outcomes, effective teaching methods and appropriate assessment tools. Furthermore, to establish solid POCUS training programs, it is necessary to establish a quality assurance system that can ensure patient safety in NICUs [24].

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Compliance with ethical standards

Conflict of interest All the authors named in the submission of this article declare that they have no conflict of interest.

Ethical standards The Children's Hospital of Eastern Ontario (CHEO) Research Ethics Board approved the study protocol. Participation in this study was voluntary and responding to the survey was considered implied consent.

Informed consent Informed consent was obtained from all individual participants included in the study.

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