PERSPECTIVE

Point-of-Care Ultrasound in Neonatology in India: The Way Forward

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The clinician-performed point-of-care ultrasound (POCUS) is a useful tool, and its scope includes bedside assessment of pulmonary (e.g., pneumothorax, pleural effusion), cardiac (e.g., pulmonary hypertension, ductus arteriosus), gastrointestinal (e.g., necrotising enterocolitis), and intracranial (e.g., intraventricular hemorrhage, cerebral blood flow velocities) pathologies, procedural guidance and rapid assessment of etiologies of acute clinical deterioration (e.g., pneumothorax, poor cardiac contractility, intraventricular hemorrhage). Despite its potential to improve patient care, a curriculum and a structured program for POCUS training is lacking in India. Homogenous approach to training and ongoing quality assurance is essential to optimize benefits of POCUS as an effective tool in clinical practice. The training needs, the legal and infrastructural barriers to successful implementation of POCUS, and strategies to implement the program at the national level are discussed.

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Point-of-care ultrasound (POCUS) has been extensively used in adult medicine but is now gaining acceptance and recognition in neonatology. While neonatologist-performed echocardiography has been at the forefront of the POCUS in neonatology, evidence has demonstrated its utility far beyond the cardiac ultrasonography (USG). POCUS augments clinical decision making, and aids in the diagnosis by providing rapid and real time information, and also improves procedural success [1]. Critically ill premature infants often cannot be safely transported out of the neonatal intensive care unit (NICU) for external radiology studies. POCUS is performed at the infant's bedside, it is radiation free, and typically can be done faster, facilitating prompt diagnosis and intervention. Experts around the world are convinced about its bedside utility, and international evidence-based guidelines are now available for use in neonatology [2,3].

Traditionally, USG is interpreted by radiologists and cardiologists whereas POCUS is clinician-performed and interpreted, thereby playing an important role in timely management of many conditions. The aim of POCUS is not to replace cardiology/radiology services but to complement it. Low- and middle-income countries (LMICs) like India have a shortage of specialized workforce, especially in tier II and tier III cities, where a major share of sick neonates are cared for. The World Health Organization (WHO) recommends that "task shifting" may be a useful tool in this context, whereby specific tasks are moved, where appropriate, from specialized health workers to health workers with shorter training and fewer qualifications, in order to make more efficient use of the available human resources for health [4]. Task shifting might mitigate medical inequity to some extent in LMICs. It is important to note that it does not mean disconnecting from speciality services. POCUS-trained clinicians will still have the backup from these experts at any given point of time. However, to make task shifting successful, efforts should be made to increase the number of health workers trained in POCUS. While there has been a rapid pace of adoption of each of the individual components of POCUS in India through workshops and modules, held at regional and national levels, it is also important to determine the adequacy of the training imparted and skill gained, so that patient care is not adversely affected by its injudicious or inadequate application. Creating a POCUS curriculum and a training program at a national level, which assures quality, and includes a certifying process, would be the pragmatic way forward.

UTILITY OF POCUS

POCUS encompasses the widespread use of bedside ultrasound as a diagnostic, therapeutic, and procedural tool (**Table I**). Role of cardiac POCUS in diagnosis and treatment of patent ductus arteriosus and pulmonary hypertension is well known. However, diagnostic echocardio-

Table I Point-of-Care Ultrasound in Neonatology: Scope of Practice

Site/procedure	*Utility for the neonatologist*	*Benefits/advantages of ultrasound*	*Comment*
Utility as a diagnostic tool			
Cardiac ultrasound	Preload assessment, fluid responsiveness. Qualitative and semi-quantitative cardiac function assessment. Diagnosis of pericardial effusion PDA assessment and treatment monitoring Pulmonary hypertension assessment and management monitoring. Recognition of abnormal cardiac anatomy, particularly duct dependant lesions.	Rapid determination of hemodynamics with serial functional assessments. Role in PDA, acute/chronic pulmonary hypertension assessment, ventricular function.	'Difficult to acquire' POCUS skill. Supplements, cannot replace clinical assessment, hemodynamic monitoring. Need for improved standardization and quality assurance. Early referral to pediatric cardiologist for structural evaluation of cardiac anatomy is warranted.
Cranial ultrasound	Estimation of cerebral blood flow velocities GMH/IVH Cerebral midline shift Hydrocephalus	Calculation of RI and PI Diagnosis of IVH useful in a 'crashing neonate' in the NICU, and may aid in the redirection of care Multiple indices are in use to monitor the size of hydrocephalus	RI and PI are useful measurements for non-invasive monitoring of ICP and prognostication in HIE Calcifications, ischemic changes, hydrocephalus and periventricular leukomalacia may be assessed by the clinician, but requires confirmation by the radiologist
Lung ultrasound	Respiratory distress syndrome TTN Pneumonias Air leaks Pleural effusion Lung edema	Can guide decision making for administration of surfactant In a 'crashing neonate': early detection of pneumothorax/ pleural effusion Aids in thoracocentesis	Rapid learning curve Reduces the number of *X*-rays and associated ionizing radiation
Abdominal ultrasound	Bowel viability assessment Bladder assessment for anuria or urinary retention	NEC: assessment of bowel peristalsis, vascular perfusion, pneumatosis intestinalis, portal venous gas, bowel-wall thickness, free fluid. May predict surgical intervention May guide peritoneal fluid aspiration	Prominent artefact may be produced by ventilators mimicking NEC and unstable infants may not tolerate the manipulation. Advantages of US over *X*-ray in NEC include real-time assessment of the bowel, earlier diagnosis and earlier identification of ominous findings. If anuric, assessment can suggest if there is urine in the bladder, requiring a urinary catheter placement.
Utility as a tool to aid in procedures			
Central line tip placement and localization	Placement of umbilical lines, PICC catheters, including lines through internal jugular, subclavian, femoral veins	Catheter tip localization can be tracked, as catheters can migrate after placement	Decreases incidence of tip malposition Time to confirm PICC line position by US is lesser compared to radiography
ETT localization	US shown to be useful in ascertaining ETT tip position	US appears comparable to *X*-rays when determining ETT position in this population.	POCUS more easily available than *X*-rays and is without radiation. A useful tool during transport.
Lumbar puncture	Reduction in number of traumatic lumbar punctures	Good resolution of image, lack of ionizing radiation and poten-	In neonates, incompletely ossified spinous processes and minimal fat

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Table I *contd. from pre-page*

Site/procedure	*Utility for the neonatologist*	*Benefits/advantages of ultrasound*	*Comment*
		tial for real time guidance	aids in locating the space more easily, compared to older children/ adults.
Suprapubic tap	Aids bladder visualization for suprapubic urine collection for cultures	Improved acquisition of urine. Number of needle insertions decreased; increased amount of urine obtained	Suprapubic urine collection through bladder aspiration ideal
Pericardiocentesis and thoracocentesis	May be useful in delivery room for neonates with hydrops or congenital pleural effusion	Useful tool in a crashing neonate with pericardial effusion.	Improves success and decreases complications associated with the procedures.

GMH/IVH:germinal matrix hemorrhage/intra ventricular hemorrhage; ICP:intracranial pressure; TTN:transient tachypnea of newborn; US:ultrasound; NEC:necrotizing enterocolitis; PICC:peripherally inserted central catheter; ETT: endotracheal tube; RI:resistive index; PI:pulsatility index; ICP:intracranial pressure; HIE:hypoxic ischemic encephalopathy; POCUS:point of care ultrasound.

graphy must be differentiated from 'cardiac POCUS,' wherein, the former is cardiologist-performed to assess the structural anatomy of the heart. Conversely, cardiac POCUS is clinician driven, to assess the cardiac function [5]. In the Indian scenario, there is a staggering shortfall of pediatric cardiology services [6,7], potentially impacting neonatal cardiac care, particularly in tier II and III cities, and we endorse training of clinicians, not only in cardiac POCUS, but also in early recognition of structural heart disease so that appropriate referral to pediatric cardiac services can be done.

Head USG is a useful bedside tool to diagnose intraventricular bleeds in a crashing neonate, when radiology services are not immediately available. Similarly, another time constrained bedside assessment is cerebral hemodynamics in hypoxic ischemic encephalopathy. The resistive index of the middle or anterior cerebral artery may have prognostic value if conducted before therapeutic hypothermia is initiated [8]. Lung ultrasound (LUS) has been used to predict surfactant need, diagnose pneumothorax, pneumonia, transient tachypnea of the newborn and pleural effusion [1,3]. Learning bedside LUS is relatively easy and can be very rewarding in diagnosing tension pneumothorax in a crashing neonate. Gut ultrasound is primarily used to evaluate necrotizing enterocolitis and may be used to predict the need for surgical intervention before the intestine perforates [9,10]. POCUS improves success rate in procedures like central line placement, bladder tapping [11] and lumbar puncture [12,13]. POCUS is also useful in ascertaining central line [14,15] and endotracheal tube position [16] (**Table I**).

An area of increasing utility of POCUS, impacting neonatal outcomes, is in a 'crashing' neonate. An International working group of experts in POCUS have designed a 'Crashing infant protocol' [2] incorporating lung, cardiac, cranial, abdominal, and central line POCUS to assess the underlying mechanism of deterioration (e.g., pneumothorax, pleural effusion, cardiac contractility, cardiac filling, cardiac tamponade, pulmonary hypertension, congenital heart disease, gut injury, intracranial bleed and mispositioned central lines). Similarly, it has been suggested that in the following critical situations, POCUS would play a useful and critical role: *i*) Infants unresponsive in a neonatal resuscitation protocol, *ii*) Unexplained acute respiratory failure or worsening hypoxemia unresponsive to usual respiratory support, *iii*) Unexplained acute circulatory shock or worsening hypotension, lactic acidosis, oliguria, unresponsive to volume expansion, and vasopressors, and *iv*) Unexplained drop in hemoglobin >20% in 24 hours with suspicion of acute bleeding [1].

If USG is, indeed, helpful in safely undertaking a procedure, the greater risk is likely in not learning and employing POCUS during the performance of these procedures. It is beyond the scope of this article to elaborate on the methodology and benefits of each of the POCUS components.

STATUS OF POCUS IN INDIA

A recent survey on uptake of POCUS in Indian neonatal intensive care unit reported an impressive 72% of the respondents having access to POCUS [17]. Only 26% and 40% of the units had round the clock availability of pediatric cardiology and radiology services, respectively. In this context, bedside POCUS trained clinicians might play a key role in rendering emergent imaging services. Though, a good percentage of neonatologists had access to POCUS in India, only 25% had underwent a structured training. Interestingly, about 25% of the participants had

self-learned, with the help of educational materials. The lack of adequate training might adversely affect the providers, the patients, and the institutions. A useful technology should not become hazardous because of its use or lack of use. The major reason for lack of access to POCUS has been non-availability of trained personnel, and the dogmatic application of the pre-conception and pre-natal diagnostic techniques (PC-PNDT) Act [17].

Barriers to Usage

Absence of a comprehensive training program: A POCUS clinician needs to not only performs USG in a standardized manner, but also interpret the study, integrate this information into the clinical setting, and monitor changes associated with the intervention. This level of acumen can only be achieved with a dedicated and structured training program, which is currently lacking in India. Though workshops (*http://iapneocon2023jaipur.com/themes/assets/pdf/workshop/SCAN%20Workshop.pdf*), e-learning modules (*https://www.drpradeepsuryawanshi.com/neopocus-course/*), and classroom teaching exposes clinicians to POCUS, it does not translate into expertise. In addition, the number of experts and centers that run structured POCUS programs are limited. Absence of a formal curriculum and accreditation process limits its utility. Time constraint on the part of trainees and teachers, suboptimal machine maintenance and repair, inadequate access to supervision and review of the scans, and inability to retain previously learned skills are hindrances to successful implementation of a program.

Legal considerations: Legal considerations may also impact successful implementation of POCUS. While the PC-PNDT Act plays a significant role in curbing female feticide in India, it possibly might act as a deterrent to practice POCUS, as even the smallest error in fulfilling the requirements of the Act, is viewed seriously by the authorities [18]. Though, the use of ultrasound in neonatal transport and retrieval is feasible and useful [19,20], the PC-PNDT act precludes use of portable machines. Health practitioners may perform POCUS with little or no training, and without formal accreditation, leading authorities to call for reform and regulation of its use. The study of a major legal database from a developed country suggests that POCUS use and interpretation is not a significant cause of lawsuits against neonatologists [21]. In fact, failure to perform POCUS might be a greater medicolegal issue [22]. Any clinician practicing medicine is prone to misdiagnosis and its medicolegal implications. Development of a robust clinical governance, adequate training, appropriate documentation and record keeping might mitigate such risks.

Infrastructural support: It is important to note that to run a successful POCUS program, clinicians should have access to a dedicated ultrasound machine, power backup, and data storage facility, which needs resource inputs. Many neonatal centers in India are privately owned, where 'cost effectiveness' could be a major consideration. Cost would also be a major consideration in public hospitals.

Support of speciality services: We suggest that pediatric cardiology and radiology services should be part of the program, even if they support it remotely. Limited availability of these services, and resistance from the specialities are important barriers to the successful implementation of this program.

THE WAY FORWARD

There are only a few neonatal POCUS guidelines [2,3] and accredited training programs [23] around the world. Few other medical subspecialties have structured curriculum-based approach to POCUS training (critical care medicine, emergency medicine, obstetrics/gynecology, family practice, and anesthesia) [24-27]. The Australian Society of Ultrasound Medicine (ASUM) runs the neonatology POCUS program (heart, head, lung and abdomen), which includes an online physics course, hospital-based training, completion of basic and advanced training, and logbook requirements. A certification board reviews recommendations for certificate in clinician performed ultrasound and refers to ASUM Council for award. Re-certification occurs at five-yearly intervals [23].

Identifying a core national group comprising of expert neonatologists, radiologists and pediatric cardiologists under the umbrella of a national body (e.g., National Neonatology Forum/Indian Academy of Pediatrics) should be the first step. A proposed design of the POCUS program is depicted in **Fig.1**. A POCUS governance structure should be in place with clearly defined roles. The apex national body should take care of the training, curriculum, liaise with government authorities and do the need assessment. The national body shall define the scope of POCUS practice, its limitations, and guidelines around mandatory consultive service referrals. The regional bodies should do a mentoring role and provide guidance on rules and regulations. The institutional POCUS heads shall look after training and record keeping. Quality assurance is everyone's responsibility.

Need assessment: Newborn diseases are no different in India compared to the rest of the world. However, the prevalence of a higher incidence of pathologies like Gram negative septicemia and intrauterine growth retardation must be factored in while assessing the need for a curriculum. POCUS programs should be aimed at the front level providers in neonatology (practicing neonatologists, neonatal trainees and pediatricians looking after sick neo-

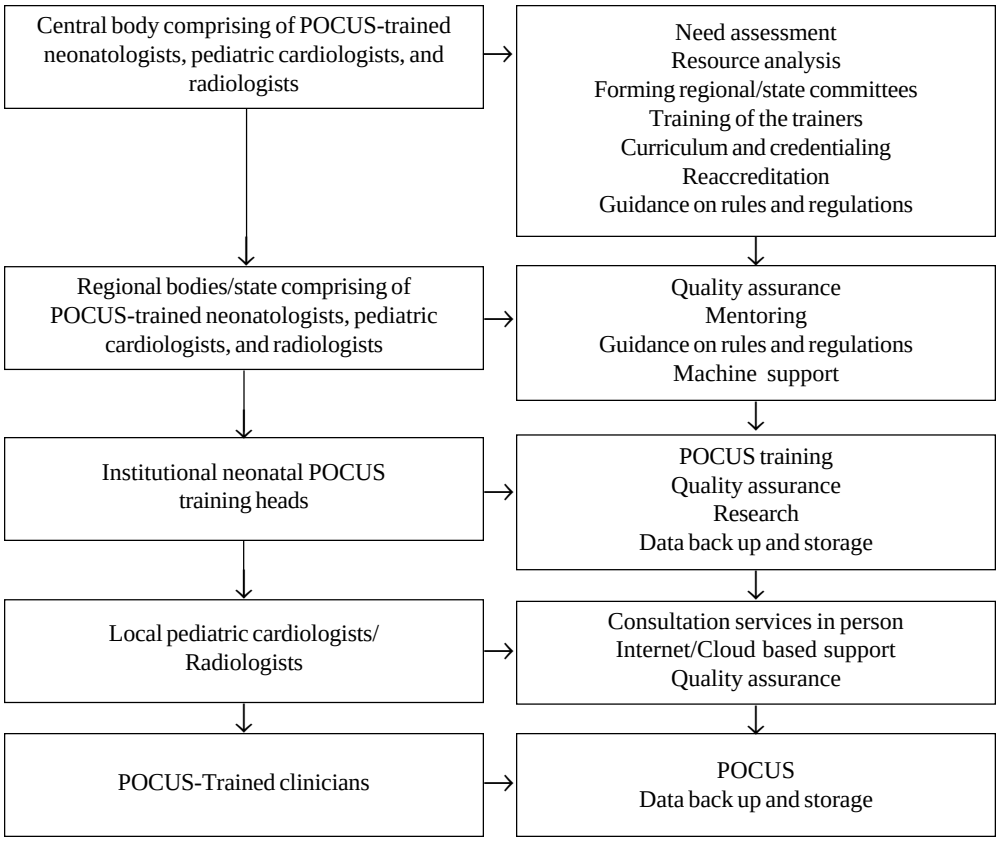

Fig. 1 Proposed design of a point-of-care ultrasound (POCUS) program.

nates). Addition of an ongoing POCUS training, to the neonatal training curriculum might be useful but may overburden the already stretched curriculum. However, it should be noted here that successful implementation has been noted in training programs of other specialities [28,29]. In view of the limited availability of trained faculties and resources, it would be beneficial to start with a targeted core group of potential learners. Potential training centers and infrastructure could be identified by geographical distribution, and financial resources should be considered to run such programs. Incentives to both the trainees and trainers could also be factored in during the planning phase. Post training practice space and resources, mentoring and regulatory requirements need careful deliberation.

Training and curriculum: It must be a longitudinal institute-based training. If trainees are in practice, it is important to secure dedicated time when they will be free from clinical responsibilities and able to concentrate on USG training. Little is known about how much training or hands-on experience is needed to become proficient with POCUS. However, it is important that minimum qualifications appropriate to the performance of each type of examination are prescribed and regulated. A pool of experienced trainers is usually necessary to help with initial training efforts. Though it is ideal to have onsite full-time clinicians as trainers, it may not be feasible all the time and may warrant visiting faculties to run the course. Essential components of the standardized curriculum and credentialing should include ultrasound physics and technical aspects, supervised hands-on/simulation training and completion of a logbook comprising of a certain number of scans. Trainees should have access to videos, images, books, and online materials, as these may otherwise be limited. Stress should be on analyzing and integrating information gained from POCUS with clinical decision making. It will be critically important to depict the scope of practice, and when consultive referral should be man-datory. All the training centers should work in tandem with speciality services like pediatric cardiology and radiology. An exit examination comprising of theory and practical evaluation should be in place to assess competency and safety. Completion of the course should lead to a certification. It is possible that some clinicians may not practice POCUS after certification, and therefore,

limited period certification and re-accreditation at specified intervals could be considered. Program leadership should aim for long term sustainability and attempt to identify potential trainees who would use POCUS regularly and ultimately provide training to their colleagues. POCUS-trained clinicians should maintain a record of their scans for medico-legal reasons. Collaboration with pediatric cardiology/radiology is ideal for periodic review of the studies and interdisciplinary educational activities. Every institution running POCUS program must have radiology/cardiology referral services. If a clinician faces a POCUS-related dilemma, he/she should consult the speciality services either in person or through telemedicine. Telemedicine and cloud-based facilities could be used to facilitate review, if inhouse subspeciality services are not available [30,31]. It should be noted here that telemedicine facilities have been used in India to run retinopathy of prematurity program successfully [32], and could potentially be used successfully here as well.

Machine management: A dedicated USG machine is pivotal, and the most expensive part of the POCUS program. Public sector hospitals should be encouraged to put forward business cases to the authorities or arrange industry sponsors and advise for this could be provided by the coordinating national body. Further, advise on procurement of machines, transducer selection, data storage (internal and external), post sales service, and PC-PNDT recognition could also be provided by the national body.

Quality assurance: Quality assurance is necessary to ascertain operator competence and to ensure patient safety. Quality assurance should be done either by the local/regional experts or by external experts. In the current era, images can be reviewed remotely, and feedback can be given for ongoing safety and quality. The central body can play a constructive role to have quality assurance monitoring system in place.

Misdiagnosis and medicolegal aspects: The risk of misdiagnosis is a real concern, and some of this can be resolved by practicing within the limits of the training, and formulating guidelines about when consultative referral should be mandatory. We believe a structured training and regular accreditation process will also be useful in this context. It is a good practice to disclose the limitations of POCUS to the patients and explain the fact that it is not a replacement for cardiology/radiology services. Integration of policies with the PC-PNDT Act could further help in overcoming medico-legal barriers.

CONCLUSION

POCUS is a useful adjunct to clinical examination and has multiple applications. It is for the policy makers to consider a formal incorporation into neonatology. This would enhance competency of the frontline neonatal physicians, and ensure quality, while undertaking care of the sickest and smallest neonates. This could, eventually, translate into improved outcomes at a national level.

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