INTRODUCTION

The role of echocardiography in the neonatal intensive care unit (NICU) has changed over the past few years. Previously, nearly all echocardiographic studies in the NICU were performed by pediatric cardiologists to diagnose or monitor congenital heart disease (CHD) and to screen for patent ductus arteriosus (PDA).The terms functional echocardiography and point-of-care echocardiography have been introduced to describe the use of echocardiography as an adjunct in the clinical assessment of the hemodynamic status in neonates ***(Mertens et al., 2011)***.

The increasing availability of echocardiography with miniaturization of the technology has resulted in more widespread use of echocardiography in NICUs around the world**.** Perhaps the most significant challenge for the application of so-called functional studies is that newborns in the NICU with hemodynamic instability are at a much higher risk for having underlying CHD. In addition, newborns in the NICU are unique in that they are in the process of transition from fetal to postnatal circulation ***(Evan et al., 2011)***.

Point-of-care ultrasound is increasingly used by in the intensive care setting to support clinical decisions. The technology may be applied to evaluation of the neonatal heart, brain, and abdomen/pelvis and to facilitate vascular access. The provision of real-time information on cardiovascular performance and systemic hemodynamics, non-invasive nature of the technique, rapidity of data acquisition and report generation, and ability to perform longitudinal functional assessments have all contributed to the increased use of functional echocardiography by in the neonatal intensive care unit (NICU). The lack of a reliable measure of systemic blood flow is one example of a clinical situation which has prompted to perform point-of-care echocardiography examinations ***(Osborn et al., 2004)***.

Targeted neonatal echocardiography (TNE) is proposed to "describe the bedside use of echocardiography to longitudinally assess myocardial function through evaluation of LV systolic and diastolic functions, RV function, systemic and pulmonary blood flow, intracardiac and extracardiac shunts, organ blood flow and tissue perfusion ***(Kluckow et al., 2007).***

Continuous, reliable and real-time assessment of major determinants of cardiovascular function in preterm and term neonates has long been an elusive aim in neonatal medicine. Accordingly, aside from continuous assessment of heart rate, blood pressure and arterial oxygen saturation, bedside monitoring of major determinants of cardiovascular function of significant clinical relevance such as cardiac output, systemic vascular resistance, organ blood flow distribution and tissue oxygen delivery and coupling has only recently become available. Without obtaining reliable information on the changes in and interactions among these parameters in the neonatal patient population during postnatal transition and later in the neonatal period, development of effective and less harmful treatment approaches to cardiovascular compromise is not possible ***(Soleyman et al., 2010).***

AIM OF THE WORK

To assess normal values of the parameters of TNE in healthy newborns.

POINT-OF-CARE ULTRASONOGRAPHY

During the past 50 years, diagnostic ultrasonography has replaced auscultation as the primary method of evaluating the mechanics of the heart and peering into the abdomen, vasculature and uterus without exposing patients or fetuses to ionizing radiation. In cardiovascular medicine, echocardiography is the most used and cost-effective imaging method, despite the development of many other powerful new technologies ***(Scott et al., 2014).***

Point of care ultrasonography is defined as ultrasonography brought to the patient and performed by the provider in real time. Point-of-care ultrasound images can be obtained nearly immediately, and the clinician can use real-time dynamic images (rather than images recorded by a sonographer and interpreted later) allowing findings to be directly correlated with the patient's presenting signs and symptoms ***(Gluckman et al., 1993).*** Point-of-care ultrasonog-raphy is easily repeatable if the patient's condition changes. It is used by various specialties in diverse situations (see Table 1) and may be broadly divided into procedural, diagnostic, and screening applications ***(Moore and Copel, 2011)***.

Table (1): List of the most common applications of point of care ultrasounds ***(Moore and Copel, 2011)***.

Speciality	**Ultrasound applications**
Anaesthesia	Guidance for vascular access and regional anaesthesia
Cardiac	Echocardiography, intracardiac mass
Critical care	Proceedural guidance, pulmonary assessment, focused echocardiography
Emergeny medicine	FAST, focused emergency medicine and procedure guidance
Neonatology	Cranial and pulmonary assessment
Rheumatology	Monitoring of synovitis and proceedure guidance
Gynecology	Assessment of cervix and uterus and critical guidance

The use of point-of-care ultrasonography will continue to diffuse across medical specialties and care situations. Future challenges include gaining a better understanding of when and how point-of-care ultrasonography can be used effectively, determining the training and assessment that will be required to ensure competent use of the technology, and structuring policy and reimbursement to encourage appropriate and effective use ***(Moore and Copel, 2011)***.

Experts who published the vast majority of papers on clinical use of lung ultrasound in the last 20 years elaborated these specific 73 recommendations. A number of these recommendations will potentially reshape the future practice and knowledge of this rapidly expanding field. These applications will benefit patients worldwide as rigorous assessment, classification, and publication efforts continue to make this critical information available to all clinicians. The advantages of correct use of bedside lung ultrasound in the emergency setting are striking, particularly in terms of saving from radiation exposure, delaying or even avoiding transportation to the radiology suite, and guiding life-saving therapies in extreme emergency ***(Giovanni et al., 2012).***

Now, clinicians are able to diagnose pneumonia in children and young adults using point of care ultrasono-graphy with high specificity ***(Vaishali et al., 2013)***.

Carefully performed study was done by ***Tsung et al., (2012)*** who compared between ultrasound and X-ray findings of lung consolidation. The study was conducted on patients seen in the emergency department with clinical suspicion of community acquired pneumonia requiring chest radiography for evaluation. Enrolled patients had clinical exam findings documented on a standardized form and underwent point-of-care lung ultrasound examination. Ultrasound findings of lung consolidation with sonographic air bronchograms correlated 100% with chest X-ray findings of bacterial pneumonia (reported as consolidation or infiltrate) in eight patients. All of these patients were confirmed to have pneumonia based on the clinical course at 2-week follow-up.

In newborns, lung ultrasound signs are similar to those previously described in adults, although these signs will be context specific. Lung ultrasound allows diagnosis of RDS with accuracy similar to CXR even if there is no correlation between the different radiographic stages of RDS and ultrasound findings ***(Copetti et al., 2008).***

Point of care ultrasonography is almost always performed without continuous ECG monitoring, forcing the clinician to use other methods to determine the presence of impending tamponade. Visualization of right ventricular free wall collapse during early diastole can be performed using M-mode (which is a common feature of point-of-care ultrasound systems), and clearly defines the presence of tamponade physiology. Inferior vena cava plethora can be identified using M-mode, or simply by observing the IVC during the respiratory cycle using standard B-mode (grayscale) imaging ***(Armstrong and Ryan, 2009)***.

Clinicians who detect the presence of a pericardial effusion in patients without clinical evidence of shock should proceed directly to further evaluate the movement of the right ventricular free wall and the respirophasicity of the inferior vena cava. This may allow for early diagnosis and management of cardiac tamponade before the development of hemodynamic collapse ***(Nagdev and Stone, 2011)***.

It was demonstrated that point-of-care ultrasonogra-phic diagnoses obtained in the emergency department agree with a post hoc clinical analysis of the etiology of symptomatic undifferentiated hypotension. An ultrasonogra-phic protocol that includes lung examination may simplify the diagnostic process by reducing the viable diagnoses of hypotensive states and may allow immediate diagnosis of life-threatening conditions that can be reversed by prompt therapeutic interventions. The incorporation of ultrasono-graphy into routine emergency evaluation of undifferentiated hypotension helps to guide early interventions. This approach influences the outcome of hypotensive patients and associated management costs ***(Volpicelli et al., 2013).***

In the study done by ***Peiman et al., (2014)*** Pulmonary embolism was diagnosed in 110 (30.8%) out of 357 enrolled patients. Multiorgan ultrasonography yielded a sensitivity of 90% and a specificity of 86.2%, lung ultrasonography of 60.9% and 95.9%, heart ultrasonography of 32.7% and 90.9% and vein ultrasonography of 52.7% and 97.6% respectively. Among the 132 (37%) patients with multiorgan ultrasonography negative for PE plus an alternative ultrasonographic diagnosis or plus a negative D-dimer, no patients had PE as final diagnosis. Multiorgan ultrasonography is more sensitive than single-organ ultrasonography, increases the accuracy of clinical pre-test probability estimation in patients with suspected PE and may safely reduce the MCTPA (multi detector computed tomo-graphy pulmonary angiography) burden.

Point of care ultrasounds can be used to diagnose pneumopericardium. The association of two echocardio-graphic signs can suggest a pneumopericardium: comet-tail artifacts moving within the pericardium, and the partial disappearance of the heart image at some points during the cardiac cycle ***(Xavier et al., 2012)***. This is different from pneumothorax ***(Stone et al., 2010)*** in which the heart image disappears completely during systole. The comet-tail artifacts are a common finding in pleural ultrasonography, prompting the search for their origin. They may be absent in cases of hydropneumopericardium, when air bubbles are found within effusion fluid ***(Yuce et al., 2010).***

Point-of-care echocardiography is a goal-directed bedside ultrasound that can aid clinical decision making, enhance diagnostic confidence, and facilitate judicious consultation in the hemodynamically unstable or critically ill or injured child in the emergency department. Similar to other applications of ultrasound in the emergency department, it is designed to answer a binary (yes/no) question: Is there a pericardial effusion with tamponade? Is the left ventricular function normal or depressed or hyperdynamic? Is the cardiac preload decreased or normal or increased ***(Mindy and Pershad, 2011)***.

The use of point of care echocardiography by non-cardiologist in acute care settings such as the emergency department (ED) or the intensive care unit (ICU) is very common. Unlike diagnostic echocardiography, the scope of such point of care exams is often restricted to address the clinical questions raised by the patient’s differential diagnosis or chief complaint in order to inform immediate management decisions. The most common applications of the focused point of care echocardiography in the ED and ICU include but is not limited to the evaluation of patients experiencing hypotension, cardiac arrest, cardiac trauma, chest pain and patients after cardiac surgery ***(Arntfield and Millington, 2012).***

Point-of-care ultrasound examinations are used to answer specific, typically binomial, clinical questions: Does the patient with trauma have intra-abdominal bleeding? Does the patient with a swollen leg have a DVT? Is the dyspnea due to heart or lung disease? Ultrasound can also be used to visually guide procedures in real time, such as central line placement, injections, and thoracentesis. The proved efficacy and the favorable benefit/risk ratio and benefit/cost ratio qualify this technology for widespread use throughout health care ***(Hoppmann et al., 2012).***

Point of care ultrasound in pediatrics

Although point-of-care ultrasound is relatively new to pediatrics, it is growing rapidly in subspecialty fields such as pediatric emergency medicine, critical care, and neonatology. The use of point-of-care ultrasound to guide invasive procedures, quickly focus the evaluation of critically ill patients, and reduce exposure to ionizing radiation are some of the factors driving the adoption of bedside ultrasound by pediatric physicians caring for the sickest and most complex pediatric patients ***(Rebecca et al., 2015).***

A growing number of applications are especially relevant to general pediatricians. Consider how a quick scan of an erythematous, indurated, tender buttock that shows cellulitis without an abscess could prevent an unnecessary attempt at an incision and drainage. Imagine using bedside ultrasound to diagnose pneumonia in a screaming 1-year-old or to rule out an elbow fracture in a kindergartener who fell off the monkey bars, potentially sparing these children a radiograph and sparing their parents the cost and time it would take to get one ***(Rebecca et al., 2015).***

Envision identifying with ultrasound the classic donut appearance of intussusception on a crying toddler with a difficult examination and arranging transfer to an appropriate facility for reduction. These represent a small sample of the numerous opportunities to improve pediatric care with point-of care ultrasound that already have evidence to support them ***(Rebecca et al., 2015)*****.**

Point of care u/s in neonates:

Opened anterior fontanelle has been used as an acoustic window for brain assessment of preterm and very sick newborn At the beginning of 1980. Introduction of Doppler ultrasound was a new advancement in the assessment of neonatal circulation in the late 1980. This technique was used for assessment of the brain, the liver, the heart, the kidney and other organs. In the 1990s, new technique was introduced 3D, 4D ultrasounds. Neonatal cranial ultrasounds the most commonly used technique among point of care ultrasounds technique. It has been used for many countries for several years ***(Stanjovic, 2013)***. Cranial ultrasounds the most commonly used technique not only for assessment of brain morphology but also intracranial lesions; it is used also to identify the type and extent of the lesion ***(Volpe, 2008)***. The use of point of care abdominal u/s is effective in the diagnose of renal abnormalities and other congenital anomalies and to diagnose infections such as nectrotizing enterocolitis ***(Stanjovic, 2013)***.

Lung ultrasound demonstrates very unique findings in the diagnosis of TTN, whereas CXR is nonspecific ***(Copetti et al., 2007)***. Many studies showed that the ultrasound signs of lung and pleural diseases described in adults are also found in pediatric patients ***(Riccabona, 2008).*** In suspected pneumonia, lung ultrasound has demonstrated to be no less accurate than CXR. These data suggest that, when there is clinical suspicion of pneumonia, a positive lung ultrasound excludes the need to perform CXR.

The use of cardiac ultrasound has made advance in diagnosis of CHD and follow up hemodynamically unstable newborn. The role of echocardiography as been changed over the past few years previously, all echocardiograhic studies were performed by pediatric cardiologist to diagnose and monitor CHD and to screen for PDA. The initial echocardiographic study should be performed by the cardiologist within a reasonable time to exclule CHD. Once CHD has been ruled out, more focused studies should be performed by a trained echocardiographer for specific indications (will be dicussed later in this review). The neonatologists have been interested in the use of echocardiographic assessment of hemodynamic instability in neonates. The tem point of care echocardiography or targeted neonatal echocardiography (TNE) has been used to describe the use of echocardiography as an adjunct of hemodynamic assessment in newborn ***(Stanjovic, 2013)***.

Clinical Assessment of Hemodynamic State in Neonates

1. Blood pressure:

Measurement of blood pressure is the most frequently used method for assessment of the hemodynamic status in a neonatal intensive care unit ***(de Boode, 2010)***.

Three different definitions of neonatal hypotension are in widespread use. The first definition is a blood pressure below the tenth (or fifth) percentile of normative blood pressure values derived from a reference population with regard to gestational age, birth weight and postnatal age ***(Evans, 2009)*****.**

The second and probably most used definition of neonatal hypotension is that the lower border of normal mean arterial blood pressure (MABP) equals the numeric value of gestational age (GA) in whole weeks, provided no additional signs exist of hypoperfusion of endorgans, like a high serum lactate concentration or oliguria. This definition is only valid during the first 3 to 5 days of life, since MABP increases during the first three days of life with a magnitude of 2 to 10 mm Hg ***(Evans, 2009).***

The third definition of neonatal hypotension, i.e. MABP <30 mm Hg, is based on the assumption that cerebral blood flow becomes pressure dependent at a MABP around 30 mm Hg ***(de Boode, 2010)***.