

JANUARY 2022
VERSION 1.0

DEFINITION

Neonatal Hemodynamics and Targeted Neonatal Echocardiography (NHTNE) is the area of enhanced competence within medicine concerned with the application of cardiac ultrasound and hemodynamic assessment to inform clinical treatment decisions in the management of critically ill neonates.

ELIGIBILITY REQUIREMENTS TO BEGIN TRAINING

Royal College certification in Neonatal-Perinatal Medicine, or equivalent

OR

Eligibility for the Royal College examination in Neonatal-Perinatal Medicine

OR

Registration in a Royal College-accredited residency program in Neonatal-Perinatal Medicine, or equivalent

(See requirements for these qualifications.)

ELIGIBILITY REQUIREMENTS TO COMPLETE A ROYAL COLLEGE COMPETENCY PORTFOLIO

All trainees must be Royal College certified in Neonatal-Perinatal Medicine, or equivalent, in order to be eligible to complete a Royal College competency portfolio in NHTNE.

MAJOR TASKS OF NEONATAL HEMODYNAMICS AND TARGETED NEONATAL ECHOCARDIOGRAPHY (NHTNE)

The discipline of NHTNE includes responsibility for the following:

1. Performance of neonatal echocardiography
2. Formulation of treatment recommendations, integrating neonatal hemodynamic and targeted echocardiographic measurements and findings with the clinical assessment
3. Consultation to the neonatal intensive care unit (NICU)

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4. Management of the NHTNE service
5. Advancement of the discipline of NHTNE through scholarship and education

At the completion of training, the diplomate will have acquired the following competencies and will function effectively as a

Medical Expert

Definition:

As *Medical Experts*, physicians integrate all of the CanMEDS Roles, applying medical knowledge, clinical skills, and professional values in their provision of high-quality and safe patient-centred care. Medical Expert is the central physician Role in the CanMEDS Framework and defines the physician's clinical scope of practice.

Key and Enabling Competencies: NHTNE diplomates are able to...

1. Practise medicine within their defined scope of practice and expertise

- 1.1. Demonstrate a commitment to high-quality care of their patients
- 1.2. Integrate the CanMEDS Intrinsic Roles into their practice of medicine
- 1.3. Apply knowledge of the clinical and biomedical sciences relevant to their discipline

Cardiovascular anatomy and physiology

- 1.3.1. Normal and abnormal structure of the heart
 - 1.3.2. Components and determinants of cardiac output
 - 1.3.2.1. Determinants of preload, contractility, and afterload
 - 1.3.2.2. Frank-Starling, stress-velocity and force-frequency relationships
 - 1.3.2.3. Systemic vascular function curves
 - 1.3.2.4. Ventricular pressure-volume loops
 - 1.3.3. Myocardial oxygen supply and demand
 - 1.3.4. Physiology of intra- and extra-cardiac shunts
 - 1.3.5. Peripheral circulation
 - 1.3.5.1. Blood pressure and volume, including neuro-hormonal control, cardiac reflexes, and baroreceptors
 - 1.3.5.2. Mixed venous oxygen saturation and the relationship of venous oxygenation and cellular metabolism
 - 1.3.5.3. Fick principle and applications to mixed venous oxygen saturation
 - 1.3.6. Regional circulation
 - 1.3.6.1. Starling forces and fluid exchange in the microcirculation
 - 1.3.6.2. Systemic and cerebral autoregulation in preterm and term neonates
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Pulmonary physiology

- 1.3.7. Physiology of the pulmonary circulation in neonates
 - 1.3.7.1. Normal transition from fetal to postnatal life
 - 1.3.7.1.1. Physiology of the normal postnatal increase in pulmonary blood flow
 - 1.3.7.2. Pathophysiology of impairment in postnatal pulmonary blood flow and potential therapeutic targets
- 1.3.8. Influence of positive pressure ventilation on systemic and pulmonary hemodynamics

Pathophysiology and disease states

- 1.3.9. Etiology and pathophysiology of the following disease states on systemic and pulmonary hemodynamics
 - 1.3.9.1. Patent ductus arteriosus (PDA) in preterm neonates
 - 1.3.9.1.1. Post-PDA closure syndrome
 - 1.3.9.2. Shock unrelated to congenital heart disease
 - 1.3.9.3. Acute pulmonary hypertension secondary to
 - 1.3.9.3.1. Parenchymal lung disease, including pulmonary hypoplasia
 - 1.3.9.3.2. Pulmonary venous hypertension
 - 1.3.9.3.2.1. Left ventricular diastolic and/or systolic dysfunction
 - 1.3.9.3.3. Lesions with increased pulmonary blood flow
 - 1.3.9.3.3.1. Cardiac and/or shunt lesions
 - 1.3.9.3.3.2. Arteriovenous malformations
 - 1.3.9.3.4. Idiopathic pulmonary arterial hypertension
 - 1.3.9.4. Chronic pulmonary hypertension, including due to left heart disease, pulmonary disease, or increased pulmonary blood flow from cardiac shunts
 - 1.3.9.5. Pericardial effusion and tamponade
 - 1.3.9.6. Perinatal and postnatal hypoxic ischemic encephalopathy
 - 1.3.9.7. Systemic hypertension and hypotension

Diagnostics and monitoring

- 1.3.10. Laboratory
 - 1.3.10.1. Biochemical measures of end-organ perfusion, including clinical use of central venous blood gases
 - 1.3.10.2. Biomarkers of cardiac volume and pressure loading
- 1.3.11. Non-sonographic non-invasive measurements of cardiac output, including bioimpedance- and bioreactance-based tools
- 1.3.12. Invasive catheter measurements, including central venous catheterization and diagnostic and therapeutic cardiac catheterizations
- 1.3.13. Near infrared spectroscopy

Principles of echocardiography in the neonate

- 1.3.14. Biological effects and safety of echocardiography
- 1.3.15. Physical principles and instrumentation of echocardiography, including M-mode, two-dimensional (2-D), and blood and tissue Doppler echocardiography
- 1.3.16. Equations, including Doppler, employed in the echocardiographic examination
- 1.3.17. Indications, strengths, limitations, and clinical utility of transthoracic echocardiography
- 1.3.18. Common ultrasound artifacts and their identifying echocardiographic features
- 1.3.19. Echocardiographic appearance and normal variants of cardiac structures, including cardiac chambers, valves, pericardium, and major blood vessels
- 1.3.20. Echocardiographic appearance of abnormal cardiac structures and cardiac function in disease states
- 1.3.21. Appearance and positioning of central arterial and venous catheters
- 1.3.22. Maturity-based normative data for echocardiographic indices of cardiac function in healthy neonates and within the spectrum of hemodynamic disturbance
- 1.3.23. Diagnostic test characteristics of echocardiographic measurements
 - 1.3.23.1. Reliability
 - 1.3.23.2. Measures of predictive accuracy

Therapeutics

- 1.3.24. Mechanism of action and indications for inotropic and vasoactive medications and prostaglandins
 - 1.3.24.1. Inotropic medications

*COMPETENCY TRAINING REQUIREMENTS IN NEONATAL HEMODYNAMICS AND TARGETED
NEONATAL ECHOCARDIOGRAPHY (2022)*

- 1.3.24.2. Vasopressor medications
 - 1.3.24.3. Cardiovascular vasodilator medications
 - 1.3.24.4. Prostaglandins
 - 1.3.24.5. Pulmonary vasodilators, including inhaled nitric oxide
 - 1.3.24.6. Volume expanders
 - 1.3.24.7. Diuretics
- 1.3.25. Management of PDA, including indications for and selection of conservative management, medications, and device or surgical closure
 - 1.3.26. Titration of mechanical ventilation and other methods of respiratory support in the neonate with hemodynamic instability

Principles of the management of a NHTNE service

- 1.3.27. Care and maintenance of echocardiography equipment
 - 1.3.27.1. Disinfection and sterilization procedures
 - 1.3.28. Image archiving and storage systems
 - 1.3.29. Quality assurance and peer review
- 1.4. Perform appropriately timed clinical assessments with recommendations that are presented in an organized manner
 - 1.5. Carry out professional duties in the face of multiple competing demands
 - 1.6. Recognize and respond to the complexity, uncertainty, and ambiguity inherent in medical practice

2. Perform a patient-centred clinical assessment and establish a management plan

- 2.1. Prioritize issues to be addressed in a patient encounter
 - 2.1.1. Determine the question(s) to be answered by the NHTNE consultation
- 2.2. Elicit a history, perform a physical exam, select appropriate investigations, and interpret the results for the purpose of diagnosis and management, disease prevention, and health promotion
 - 2.2.1. Identify whether targeted echocardiography is indicated in the patient's assessment
 - 2.2.2. Perform transthoracic echocardiography for the evaluation of
 - 2.2.2.1. Hypotension or shock
 - 2.2.2.2. Cardiac function
 - 2.2.2.3. Hypoxia or hypoxic respiratory failure

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- 2.2.2.4. PDA
- 2.2.2.5. Position of central arterial or venous catheters

- 2.2.3. Integrate echocardiographic findings with the clinical assessment and findings of other hemodynamic studies and monitoring data
- 2.2.4. Formulate a differential and most likely diagnosis based on relevant findings

- 2.3. Integrate the patient's and family's¹ goals for care into the development of the management plan
- 2.4. Establish a patient- and family-centred management plan
 - 2.4.1. Integrate knowledge of neonatal hemodynamics, cardiovascular anatomy, and imaging to provide consultative advice for neonates with
 - 2.4.1.1. PDA (in preterm neonates)
 - 2.4.1.1.1. Post-PDA closure syndrome
 - 2.4.1.2. Shock unrelated to congenital heart disease
 - 2.4.1.3. Acute pulmonary hypertension, due to
 - 2.4.1.3.1. Parenchymal lung disease, including pulmonary hypoplasia
 - 2.4.1.3.2. Pulmonary venous hypertension
 - 2.4.1.3.3. Lesions with increased pulmonary blood flow
 - 2.4.1.3.4. Idiopathic pulmonary arterial hypertension
 - 2.4.1.4. Chronic pulmonary hypertension
 - 2.4.1.5. Pericardial effusion or tamponade
 - 2.4.1.6. Perinatal or postnatal hypoxic ischemic encephalopathy
 - 2.4.1.7. Systemic hypertension or hypotension
 - 2.4.2. Provide recommendations for patient management, which may include
 - 2.4.2.1. Continuation of current management
 - 2.4.2.2. Initiation or titration of
 - 2.4.2.2.1. Inotropic medications
 - 2.4.2.2.2. Vasopressor medications
 - 2.4.2.2.3. Cardiovascular vasodilator medications

¹ Throughout this document, references to the patient's family are intended to include all those who are personally significant to the patient and are concerned with their care, including, according to the patient's circumstances, family members, caregivers, legal guardians, and substitute decision-makers

COMPETENCY TRAINING REQUIREMENTS IN NEONATAL HEMODYNAMICS AND TARGETED NEONATAL ECHOCARDIOGRAPHY (2022)

- 2.4.2.2.4. Prostaglandins
- 2.4.2.2.5. Pulmonary vasodilators, including inhaled nitric oxide
- 2.4.2.2.6. Volume expanders
- 2.4.2.2.7. Diuretics

- 2.4.2.3. Deprescribing of medications
- 2.4.2.4. Management of PDA (in preterm neonates)
 - 2.4.2.4.1. Conservative care
 - 2.4.2.4.2. Pharmacologic
 - 2.4.2.4.3. Device closure
 - 2.4.2.4.4. Surgical closure

- 2.4.2.5. Titration of respiratory and cardiovascular support

3. Plan and perform procedures for the purpose of assessment and/or management

- 3.1. Prioritize the procedure, taking into account clinical urgency and available resources
- 3.2. Perform targeted neonatal echocardiography
 - 3.2.1. Acquire echocardiographic images and measurements
 - 3.2.1.1. Apply best practice guidelines to select diagnostic mode and scanning protocol
 - 3.2.1.2. Manipulate equipment to optimize image acquisition
 - 3.2.1.3. Identify cardiac structures, including cardiac chambers, valves, pericardium, and major blood vessels
 - 3.2.2. Use computer applications and post-processing tools to optimize imaging analysis
 - 3.2.3. Perform measurements and calculations of echocardiographic indices
 - 3.2.4. Interpret the hemodynamic findings

4. Establish plans for ongoing care and, when appropriate, timely consultation

- 4.1. Implement a patient-centred care plan that supports ongoing care, follow-up on investigations, response to treatment, and further consultation
 - 4.1.1. Provide recommendations for the timing of NHTNE reassessment
 - 4.1.2. Determine the need for and the timing of consultation with the pediatric cardiology service

5. Actively contribute, as an individual and as a member of a team providing care, to the continuous improvement of health care quality and patient safety

- 5.1. Recognize and respond to harm from health care delivery, including patient safety incidents
- 5.2. Adopt strategies that promote patient safety and address human and system factors

Communicator

Definition:

As *Communicators*, physicians form relationships with patients and their families that facilitate the gathering and sharing of essential information for effective health care.

Key and Enabling Competencies: NHTNE diplomates are able to...

1. Establish professional therapeutic relationships with patients and their families

- 1.1. Communicate using a patient-centred and family-integrated approach that encourages trust and is characterized by empathy, respect, and compassion
- 1.2. Optimize the physical environment for patient comfort, dignity, privacy, engagement, and safety
 - 1.2.1. Consider patient temperature, infection prevention, stability, minimal handling, operator skill and/or experience, and limited scan time when performing targeted neonatal echocardiography
 - 1.2.2. Give appropriate attention to the neonate's comfort during the targeted echocardiographic examination
- 1.3. Recognize when the perspectives, values, or biases of families, physicians, or other health care professionals may have an impact on the quality of care, and modify the approach to the patient accordingly

2. Elicit and synthesize accurate and relevant information

- 2.1. Seek and synthesize relevant information from the patient record and complementary diagnostic investigations

3. Share health care information and plans with patients' families

- 3.1. Participate, in the role of NHTNE consultant, in the sharing of health care information and plans with families

- 4. Engage patients' families in developing plans that reflect the patient's health care needs and goals**
- 5. Document and share written and electronic information about the medical encounter to optimize clinical decision-making, patient safety, confidentiality, and privacy**
 - 5.1. Document clinical encounters in an accurate, complete, timely, and accessible manner, in compliance with regulatory and legal requirements
 - 5.1.1. Provide image capture and imaging documentation to facilitate reference to previous or subsequent imaging
 - 5.1.2. Store images that provide support for the diagnosis, treatment plan, and differential diagnosis for the presenting symptoms and findings
 - 5.1.3. Develop a written report, using appropriate terminology, summarizing all of the salient positive and negative echocardiographic findings
 - 5.1.4. Provide written clinical conclusions, integrating imaging and clinical data
 - 5.2. Communicate effectively using a written health record, electronic medical record, or other digital technology
 - 5.3. Share information with patients' families and others in a manner that enhances understanding and that respects patient privacy and confidentiality

Collaborator

Definition:

As Collaborators, physicians work effectively with other health care professionals to provide safe, high-quality, patient-centred care.

Key and Enabling Competencies: NHTNE diplomates are able to...

- 1. Work effectively with physicians and other colleagues in the health care professions**
 - 1.1. Establish and maintain positive relationships with physicians and other colleagues in the health care professions to support relationship-centred collaborative care
 - 1.1.1. Work with the staff in the NICU to assist in the preparation and performance of targeted echocardiography studies
 - 1.2. Negotiate overlapping and shared responsibilities with physicians and other colleagues in the health care professions in episodic and ongoing care
 - 1.3. Engage in respectful shared decision-making with physicians and other colleagues in the health care professions
 - 1.3.1. Provide advice to clinical colleagues regarding the indications for and clinical utility of targeted echocardiography

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- 1.3.2. Convey information from the NHTNE assessment to the referring physician in a manner that enhances patient management
- 1.3.3. Support clinical colleagues in the development and implementation of a management plan
- 1.3.4. Work within the boundaries of the consultant role

2. Work with physicians and other colleagues in the health care professions to promote understanding, manage differences, and resolve conflicts

- 2.1. Show respect toward collaborators
- 2.2. Implement strategies to promote understanding, manage differences, and resolve conflicts in a manner that supports a collaborative culture

3. Hand over the care of a patient to another health care professional to facilitate continuity of safe patient care

- 3.1. Determine when care should be transferred to another physician or health care professional
- 3.2. Demonstrate safe handover of care, using both oral and written communication, during a patient transition to a different health care professional, setting, or stage of care

Leader

Definition:

As *Leaders*, physicians engage with others to contribute to a vision of a high-quality health care system and take responsibility for the delivery of excellent patient care through their activities as clinicians, administrators, scholars, or teachers.

Key and Enabling Competencies: NHTNE diplomates are able to...

1. Contribute to the improvement of health care delivery in teams, organizations, and systems

- 1.1. Apply the science of quality improvement to contribute to improving systems of patient care
 - 1.1.1. Participate in systemic quality process evaluation and improvement
- 1.2. Contribute to a culture that promotes patient safety
- 1.3. Analyze patient safety incidents to enhance systems of care
- 1.4. Use health informatics to improve the quality of patient care and optimize patient safety

2. Engage in the stewardship of health care resources

- 2.1. Allocate health care resources for optimal patient care
 - 2.1.1. Utilize echocardiography equipment, facilities, personnel, and time in an efficient manner
- 2.2. Apply evidence and management processes to achieve cost-appropriate care

3. Demonstrate leadership in health care systems

- 3.1. Demonstrate leadership skills to enhance health care
 - 3.1.1. Establish an effective collaborative model of care with the pediatric echocardiography laboratory and/or medical imaging department, including mechanisms for ongoing dialogue, shared imaging protocols, and clinical care strategies
 - 3.1.2. Develop institutional policies and/or guidelines regarding the hemodynamic evaluation and management of neonates and use of targeted echocardiography
 - 3.1.3. Apply knowledge of health care financing, including physician remuneration, budgeting, and organizational funding
 - 3.1.4. Develop and rationalize NICU policy and infrastructure to support the process of referrals for NHTNE consultation
 - 3.1.4.1. Identify indications for NHTNE consultation and guidelines regarding the timeliness of consultation
 - 3.1.4.2. Demonstrate an understanding of the clinical and administrative infrastructure for requesting NHTNE consultation and accessing NHTNE consultation reports and recommendations
 - 3.1.5. Manage and maintain targeted echocardiography equipment
 - 3.1.5.1. Demonstrate an understanding of the factors affecting the lifetime of equipment and recognize the need for replacement or additional equipment
 - 3.1.5.2. Demonstrate an understanding of the selection of equipment and process of equipment acquisition
 - 3.1.6. Review and create and/or optimize scanning protocols
 - 3.1.7. Develop, implement, and maintain a quality assurance program for NHTNE

4. Manage career planning, finances, and health human resources in personal practice(s)

Health Advocate

Definition:

As *Health Advocates*, physicians contribute their expertise and influence as they work with communities or patient populations to improve health. They work with those they serve to determine and understand needs, speak on behalf of others when required, and support the mobilization of resources to effect change.

Key and Enabling Competencies: NHTNE diplomates are able to...

- 1. Respond to an individual patient's health needs by advocating with the patient's family within and beyond the clinical environment**
- 2. Respond to the needs of the communities or populations they serve by advocating with them for system-level change in a socially accountable manner**
 - 2.1. Contribute to a process to improve health in the community or population
 - 2.1.1. Evaluate the potential utility of new and evolving echocardiography technologies and their incremental value for improving neonatal care

Scholar

Definition:

As *Scholars*, physicians demonstrate a lifelong commitment to excellence in practice through continuous learning and by teaching others, evaluating evidence, and contributing to scholarship.

Key and Enabling Competencies: NHTNE diplomates are able to...

- 1. Engage in the continuous enhancement of their professional activities through ongoing learning**
- 2. Teach students, residents, the public, and other health care professionals**
- 3. Integrate best available evidence into practice**
- 4. Contribute to the creation and dissemination of knowledge and practices applicable to health**

Professional

Definition:

As *Professionals*, physicians are committed to the health and well-being of individual patients and society through ethical practice, high personal standards of behaviour, accountability to the profession and society, physician-led regulation, and maintenance of personal health.

Key and Enabling Competencies: NHTNE diplomates are able to...

- 1. Demonstrate a commitment to patients by applying best practices and adhering to high ethical standards**
- 2. Demonstrate a commitment to society by recognizing and responding to societal expectations in health care**
 - 2.1. Demonstrate a commitment to patient safety and quality improvement
- 3. Demonstrate a commitment to the profession by adhering to standards and participating in physician-led regulation**
 - 3.1. Fulfil and adhere to professional and ethical codes, standards of practice, and laws governing practice
 - 3.1.1. Adhere to regulations regarding storage, retention, and disposal of images
 - 3.1.2. Adhere to professional requirements for confidentiality and privacy of patient data as applied to the reporting and dissemination of images, reports, and clinical documentation
 - 3.2. Participate in peer assessment and standard setting
 - 3.2.1. Promote quality assurance by discussing targeted echocardiography studies and reports with other physicians, pediatric cardiologists, and sonographers
- 4. Demonstrate a commitment to physician health and well-being to foster optimal patient care**

REQUIRED TRAINING EXPERIENCES

1. Performance of comprehensive transthoracic echocardiography in the pediatric echocardiography suite, including M-mode, 2-D, and Doppler echocardiography
2. Performance and interpretation of targeted echocardiography in a level III NICU
3. Acting in the role of NHTNE consultant in the management of critically ill neonates
4. Participation in the quality assurance activities of the NHTNE program
5. Attendance and participation in local NHTNE rounds or conferences
6. Participation in teaching and assessment of other trainees, sonographers, and physicians
7. Scholarly activity related to NHTNE, which may include a research, education, or quality improvement project

RECOMMENDED TRAINING EXPERIENCES

1. Performance and interpretation of tissue Doppler, 2-D strain echocardiography, and speckle tracking
2. Review of an image library of pediatric echocardiography and targeted neonatal echocardiography cases, including those with critical congenital heart disease
3. Participation in educational activities by attendance at regional, national, or international conferences with significant NHTNE components
4. Participation in the management and administration of the NHTNE service
5. Participation in the review and/or revision of scanning protocols
6. Creation of a proposal and business plan for development of a new NHTNE service
7. Completion of a physics of ultrasonography course, or equivalent

NOTES:

The recommended minimum duration of training to achieve expertise in NHTNE is 3-4 months in the pediatric echocardiography laboratory and 8-9 months in NICU or longitudinal equivalent.

This document is to be reviewed by the AFC Subcommittee in NHTNE by December 31, 2023.

Drafted – AFC in NHTNE Working Group - August 2021

Approved – Specialty Standards Review Committee – November 2021

Finalized – AFC in NHTNE Working Group & Office of Specialty Education – December 2021