Cardiovascular Monitoring and Management of Neonatal Hypotension - NICU

Reference no.: NIC RC 06

1. Introduction

This guideline is designed for medical staff to ensure appropriate and prompt monitoring, assessment, and treatment of cardiovascular status in critically ill neonates.

2. Aim and Purpose

Low mean arterial blood pressure (MABP) and low blood flow are associated with peri/intraventricular haemorrhage, ischaemic cerebral lesions, poor long-term neuro-developmental outcome and mortality in the preterm infant.

- ✓ Blood pressure should be monitored regularly while the infant remains unwell
- ✓ The MABP (mmHg) should be managed with the aim of maintaining it at or above the infant's gestation in weeks
- ✓ The response to therapy should be clearly recorded along with remedial action taken.

3. Abbreviations Used

MABP : mean arterial blood pressure
µg/kg/min (microgram/kg/minute)

4. Main body of Guidelines

Which babies need blood pressure monitoring and how?

- All sick ventilated babies in intensive care should have **invasive continuous arterial blood pressure monitoring** via an umbilical arterial catheter (UAC) or peripheral arterial line (PAL) if possible. This is the most reliable and accurate way of recording blood pressure in sick or small neonates.
- In stable and term babies ***Intermittent non-invasive oscillometric blood pressure monitoring*** (Dinamap) is acceptable. However, it has well recognized disadvantages:
  1. less accurate in small infants especially at low blood pressures, may overestimate mean blood pressure by 5-10 mmHg
  2. Fail to identify transient hypotension or unstable blood pressure

How to assess and identify the need to support cardiovascular status in neonates?

Assessment for compromise in cardiovascular output is **not** based on MABP alone. Infants may have a MABP within the acceptable range but still have a low systemic output that requires cardiovascular support therapy.

The best way to evaluate BP during transition is to think of an **Evaluation pressure** and **Trigger pressure**. The initial evaluation pressure can be based around gestational age equivalent values on day one. The trigger pressure is the value upon which we decide to intervene, this should not be a single value alone, but based on clinical, biochemical, or other objective assessment criteria

In order to support cardiovascular status or treat hypotension promptly, accurate assessment of the following indicators of cardiovascular output is essential and should be documented.

1. **Hypotension**: There is no agreed definition of hypotension in newborn babies. Blood pressure level correlates positively with gestational and postnatal age. A commonly accepted **working definition of hypotension is that mean arterial blood pressure (MABP) in mmHg is below the value of the infant's gestational age in completed weeks**.
   Before intervening for a low blood pressure, it is paramount to reconfirm the low MABP after re-calibration by flushing, re-zero the arterial line and ensuring a contemporary good arterial waveform on the monitor, along with assessment of other objective clinical and biochemical criteria

2. **Heart rate :** Hypotension may be associated with tachycardia or bradycardia depending on the cause of hypotension. Tachycardia can affect diastolic filling and poor coronary perfusion, while bradycardia is associated with poor cardiac output.

3. **Urine output**: accurate recording of urine output in all critically ill babies will provide valuable information on the systemic output over the previous few hours and hence the need for intervention. Urine output should generally be maintained above 1ml/kg/hour and subsequent recording of urine output will clarify the effectiveness of treatment.

4. **Blood lactate concentration**: Elevated lactate levels suggested poor end organ perfusion and significant tissue hypoxia. Normal level is below 2 mmol/l. The base excess is generally unhelpful as it does not correlate with the blood lactate concentration in this situation.

5. **Peripheral perfusion**: skin perfusion may be guided clinically with capillary refill time on the centre of the chest, although this measurement may be affected by ambient temperature and subject to inter-observer variation.

6. **Echocardiogram:** Functional echo when available will aid decision making in management of Hypotension. Do not delay treatment while awaiting an echocardiogram.

What is the treatment regimen for infants with a low systemic output?

Immediate management of a low systemic output or a confirmed low MABP should be directed at identifying and treating the underlying cause before volume expansion or inotropic support.

Potential causes of shock in neonates are --Immature myocardium and vasomotor tone, PDA, Sepsis, Hypoxia, Therapeutic Hypothermia, Respiratory Conditions eg RDS, PPHN, Mechanical Ventilation/Pneumothorax, Blood loss and adrenal insufficiency.

Volume Expansion – Considered cautiously and sparingly (10ml/kg to maximal 20ml/kg). **Indications:** hypovolemic conditions eg: septic shock, haemorrhage and Necrotising Enterocolitis.

- **0.9% saline**: current evidence suggests that 0.9% saline is as effective as 4.5% Human Albumin Solution [6].

- **Blood transfusion** (See blood transfusion guideline): consider if haemoglobin is <140g/l, if associated with signs of poor tissue oxygenation.

- **Fresh Frozen Plasma/Cryoprecipitate**: in the presence of coagulopathy, then Fresh Frozen Plasma (FFP) or cryoprecipitate may be more appropriate than 0.9% saline.

- **Reassess cardiovascular status** following volume expansion, if still suboptimal commence on inotropic support. In addition, **correct any electrolyte imbalance** if present (hypocalcaemia, hypomagnesaemia hypophosphataemia, hypernatraemia, hyperkalaemia, hypoglycaemia)

Inotropic support: Indications: infants who remain hypotensive after cautious volume expansion and/or in the absence of specific hypovolaemic conditions as stated above, will need inotropes. Depending on the cause of hypotension the choice and combination of inotropes may vary. Choice of Inotropes should be discussed with the consultant on call.

The most recent Cochrane review of dopamine vs. dobutamine would suggest using dopamine as first line therapy based on the fact that it is more likely to result in an increase in blood pressure and if this fails the addition of dobutamine may be considered. The evidence that dopamine is more effective only extends as far as the short-term effect on blood pressure and there is an argument that dobutamine may be more likely to increase systemic blood flow. Dopamine is associated with increased pulmonary pressure and can cause right to right to left flow across PDA leading to tissue hypoxia, hence in recent years adrenaline is preferred to dopamine . Dopamine and Adrenaline are vasopressors and the combination should be used cautiously. If there is a significant PDA present or if there is echo evidence of cardiac dysfunction the use of dobutamine before dopamine may be more logical.

Inotropes frequently used in neonatal practice.

Dopamine

- Indication: Dopamine is more effective than dobutamine in the short-term treatment of systemic hypotension in preterm infants.
- Route: preferably via a central line (UVC/long line as it may cause significant local vasoconstriction).
- Dosage regimen: start at 5microgram/kg/minute, gradually increasing to maximum of 20 microgram/kg/minute.

Dobutamine

- Indications: if no central line access to deliver high doses of dopamine or failure to response to a good dose of Dopamine infusion. Dobutamine is preferred to dopamine in preterm infants with significant PDA and in infants with cardiac dysfunction.
- Route: as it has no vasoconstrictive action, it can be infused via peripheral venous cannula., if central access is no
- t available.
- Dosage regimen: start at 5microgram/kg/minute, gradually increasing to a maximum of 20 microgram/kg/minute.

Adrenaline:

- Indication: Adrenaline is a vasopressor and an inotrope and hence is recently preferred over high dose Dopamine. It can be used in combination with Dobutamine. Although high dose adrenaline with dopamine should be used cautiously. Adrenaline can cause hyperglycemia and hyperlactatemia in high doses.
- Route: preferably via a central line UVC/long line, as it may cause significant local vasoconstriction
- Dosage regimen: Infusion at a dose of 0.02–0.3 microgram/kg/minute. Doses above 0.5microgram/kg/minute should be used with caution, it may cause renal vaso-constriction.

Hydrocortisone

- Indications: if both vasopressors or inotropes fail to improve the MABP or systemic output.
- Pretreatment: Check a cortisol level before starting hydrocortisone but note wide normal reference range.

- Dosage regimen: Start at 2.5mg/kg 4-6 hourly, IV. After 48 hours: wean if cardiovascular status stable.

N.B. Document response of treatment and reassessment of cardiovascular status following intervention.

Commonly used inotropes and vasopressor drugs in neonatal shock.

Name of drug	Dose	Site of action	Hemodynamic effects
Dopamine	1–4 µg/kg/min	Dopaminergic receptors (1 and 2)	Renal and mesenteric dilatation
	4–10 µg/kg/min	α receptors	Inotropic effects
	11–20 µg/kg/min	β receptors	Vasopressor, increase SVR and increase PVR
Dobutamine	5–20 µg/kg/min	β1 and β2 receptors, some effect on α receptors	Inotropic effects; decrease SVR; increase cardiac output
Adrenaline	0.02–0.3 µg/kg/min	α1 receptors	Inotropic effects; decrease SVR
	0.3–1 µg/kg/min	β1 and β2 receptors	Vasopressor effects; increase SVR
Noradrenaline	0.1–1 µg/kg/min	α1 and α2 receptors	Vasopressor effects; increase SVR

Name of drug	Dose	Site of action	Hemodynamic effects
Hydrocortisone	2.5 mg/kg; 4–6 hourly	Enhance sensitivity to catecholamines	Uncertain—enhance sensitivity to catecholamines
Vasopressin	0.018–0.12 U/kg/h	Vasopressin 1 receptors	Increase SVR; no inotropic effect
Milrinone	50–75 µg/kg/min bolus followed by 0.25–0.75 µg/kg/min	Phosphodiesterase III inhibitor and produces effects at β1 and β2 receptors	Inodilator effects; lusitropic effects; increase contractility; and decrease SVR

Monitoring and Support of Cardiovascular Status in Neonates

Patient group: all ventilated babies under intensive care

Type of BP monitoring and recording: Intravascular continuous monitoring via UAC or peripheral arterial cannula as first choice.

Comprehensive assessment and documentation for the need to support cardiovascular status:

1. **Low MABP**: working definition of hypotension is that MABP in mmHg is below the value of the infant's gestational age in completed weeks. Reconfirm low MABP reading after re-zero the arterial line before intervening.
2. **Urine output**: indicate reduced systemic output if < 1ml/kg/hour over previous few hours.
3. **Blood lactate concentration** > 2mmol/l if significant tissue hypoxia present for a few hours.
4. **Skin perfusion** compromised if capillary refill time > 2 seconds on the center of chest.
5. **Echocardiography** – Functional Echo to aid treatment

Intervention to support cardiovascular status:

1. Identify and treat underlying cause(s) e.g. ductal shunt, pneumothorax, hypovolaemia. Correct any electrolyte imbalance if present.

2. **Volume expansion:**
   Indication: hypovolaemia secondary to septic shock, haemorrhage or NEC
   Volume: 10ml/kg to maximum 20ml/kg
   Fluid types: 0.9% saline, Blood transfusion if haemoglobin < 140g/l,
   FFP or cryoprecipitate in the presence of coagulopathy

3. **Inotropic support** -- Choice of inotropes depends on the pathology
   Dopamine: Preferably via UVC or long line
   Start at 5µg/kg/min, gradually increasing to maximum 20µg/kg/min
   Dobutamine: can be given peripherally if central line access is unavailable.
   Start at 5µg/kg/min, gradually increasing to maximum 20µg/kg/min
   Adrenaline start at 0.02-0.3 µg/kg/min, via central line or UVC

4. Reassess and document response of cardiovascular status after each intervention.

5. **Hydrocortisone :** Indicated: poor response to inotropes
   Check a cortisol level before starting Hydrocortisone.
   Start at 2.5mg/kg 4-6 hourly for 48 hours, consider weaning once stable.

.

5. References (including any links to NICE Guidance etc.)

- CESDI (1999) Confidential Enquiry into Stillbirths and Deaths in Infancy: 6th Annual Report, 1 January-31 December 1997, London: Maternal and Child Health Reseach Consortium.
- Subhedar NV, Shaw NJ, Cochrane, 21st July 2003: Dopamine verses Dobutamine for hypotensive preterm infants,
- Advances in Diagnosis and Management of Hemodynamic Instability in Neonatal Shock, Yogen Singh,1,2,* Anup C. Katheria,3,4 and Farha Vora, https://doi.org/10.3389%2Ffped.2018.00002
- Systematic Review and Meta-Analysis of Cardiovascular Medications in Neonatal Hypotension Kosmas Sarafidis, a ,* Eleni Verykouki, b Stefanos Nikopoulos, a Fani ApostolidouKiouti, Biomed Hub (2022) 7 (2): 70–79.https://doi.org/10.1159/000525133
- Clinical Guideline on Monitoring and Management of Cardiovascular Support in Neonates June 2015, Nottingham Neonatal Service by Stephen Wardle.
- Osborn DA, Evans N (2001) Early volume expansion for prevention of morbidity and mortality in very preterm infants (Cochrane Review). Cochrane Library, Issue 2, Oxford: Update Software.
- BAPM (1999) Guidelines for the Management of Respiratory Distress Syndrome, London: British Association of Perinatal Medicine
- Report of a joint working group of the British Association of Perinatal Medicine and the Research Unit of the Royal College of Physicians. Development of audit measures and guidelines for good practice in the management of neonatal respiratory distress syndrome. Arch Dis Child 1992;67:1221-7.
- So KW, Fok TF, Ng PC, Wong WW, Cheung KL. Randomised controlled trial of colloid or crystalloid in hypotensive preterm infants. Arch Dis Child Fetal Neonat Ed 1997;76:F43

6. Documentation Controls

Reference Number NIC RC 06	**Version: 3**		**Status** Final	
Version / Amendment History	Version	Date	Author	Reason
	3	Feb 2023	Dr G Joshi	Review and update
Intended Recipients: Paediatric Consultants & Nursing staff at Derby Hospital				
Training and Dissemination: Cascade the information via BU newsletter and address training				
Development of Guideline: Dr G Joshi Consultant Paediatrician and Neonatologist with Interest in Paediatric Cardiology				
In Consultation with: UHDB Neonatologists, Paediatricians & Pharmacists				
Linked Documents: (Nice guidance/Current national guidelines)				
Keywords: **Cardiovascular, neonatal hypotension**				
Business Unit Sign Off			**Group:** Paediatric Guidelines Group **Date:** 13/12/2023	
Divisional Sign Off			**Group:** Women's and Children's Clinical Governance Group **Date: 21st December 2023**	
Date of Upload			22/12/2023	
Review Date			Dec 2026	
Contact for Review			Dr G Joshi	