ARTERIAL LINE BLOOD SAMPLING - NEONATAL CLINICAL GUIDELINE

1. Aim/Purpose of this Guideline

This document is aimed at Health Care Professionals working in the neonatal unit who have studied the theory of caring for a neonate with an arterial line and interpretation of neonatal blood gas analysis. Practitioners sampling arterial lines are responsible for ensuring the results are recorded, interpreted and acted upon by a competent professional in Neonatal Intensive Care. In addition, practitioners must follow RCHT standards of Infection control and consider the indications for and complications associated with the use of arterial line sampling and use of the blood gas machine.

2. The Guidance

2.1. Equipment Required

- Dressing trolley
- Sterile dressing pack
- 2ml syringe for line fluid withdrawal and 2ml syringe for saline flush
- 1ml syringe for sample (use larger syringe only if other samples required total more than 1ml)
- Sterile needle
- 2% Chlorhexidine, 70% Alcohol wipe (Sanicloth)
- Appropriate requisition forms, labels and sample tubes
- Sodium Chloride 0.9% 5mL ampoule

2.2. Procedure

This procedure must be performed using an Aseptic Non-Touch Technique (ANTT)

1. Sanitize hands with alcohol gel/wash hands

2. Clean trolley with alcohol wipe and allow to dry

3. Gather equipment and identify patient, noting oxygen saturations, FiO2 requirement and any respiratory support settings

4. Explain procedure If parent present

5. Ensure the arterial line is in an accessible position

6. Open sterile pack onto trolley. Open sterile syringes x3, needle and sanicloth wipe onto sterile field

7. Double check and open 0.9% saline ampoule and place in accessible position
8. Wash hands again followed by alcohol gel and put on gloves

9. Prime one syringe, drawing from ampoule with sterile needle

10. Observe arterial trace quality and identify arterial line

11. Clean bionector thoroughly for 30 seconds with sani-cloth wipe working away from the port and allow to dry

12. Place sterile towel beneath the 3 way tap. Using an ANTT, attach sterile syringe (2ml only) to bionector making sure connection is secure and elevated to avoid any air bubble entering line. Close stopcock to infusion line to prevent contamination of sample by infusion fluid

13. Withdraw fluid gently from line until blood is obtained and fills line and syringe with pure blood seen (usually 0.5ml) Aggressive sampling may damage the artery. Turn stopcock to 45º angle to close port and prevent blood loss from open line

14. Remove the syringe and place it on the sterile field. This fluid will be re-infused

15. Attach second sterile syringe and withdraw sample (0.1 ml adequate for blood gas unless more blood is required) Turn stopcock to 45º angle, remove syringe

16. Reattach the first syringe, primed, to re-infuse the initial sample. Hold the syringe elevated, aspirate any air from port and re-infuse fluid slowly over 10 seconds to avoid sudden change in arterial pressure. Turn 3 way tap 45º to remove syringe

17. Flush line with the 3rd syringe primed with 0.9% Saline to clear line of blood. Use the minimum amount necessary

18. Turn stopcock to close the port and check waveform has returned to normal trace on monitor

19. Ensure arterial line transducer is still positioned at the level of the baby’s heart to ensure accurate blood pressure monitoring

20. Put blood sample into gas tube/lab sample tubes for processing as soon as possible

21. Discard of waste as per RCHT waste management policy, remove personal protective equipment and wash hands with soap and water, followed by alcohol gel
22. Complete documentation in baby’s notes including date, time and for blood gases action taken as a result of the blood gas

Self-directed learning packs for the Interpretation of Neonatal Blood Gases and Care of the Infant undergoing blood gas analysis can be found in Appendices 4 and 5.
3. Monitoring compliance and effectiveness

<table>
<thead>
<tr>
<th>Element to be monitored</th>
<th>Compliance with guideline</th>
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</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Neonatal Nurse Manager</td>
</tr>
<tr>
<td>Tool</td>
<td>ANNT monitoring. Staff education and training supervision</td>
</tr>
<tr>
<td>Frequency</td>
<td>Individual staff on biannual basis</td>
</tr>
<tr>
<td>Reporting arrangements</td>
<td>Report within current matrix returns. LMS training records</td>
</tr>
<tr>
<td>Acting on recommendations and Lead(s)</td>
<td>IPAC, Neonatal Consultants, Neonatal Nurse manager</td>
</tr>
<tr>
<td>Change in practice and lessons to be shared</td>
<td>Lessons will be shared with all the relevant stakeholders</td>
</tr>
</tbody>
</table>

4. Equality and Diversity

4.1. This document complies with the Royal Cornwall Hospitals NHS Trust service Equality and Diversity statement which can be found in the 'Equality, Diversity & Human Rights Policy' or the Equality and Diversity website.

4.2. Equality Impact Assessment
The Initial Equality Impact Assessment Screening Form is at Appendix 2.
## Appendix 1. Governance Information

<table>
<thead>
<tr>
<th><strong>Document Title</strong></th>
<th>ARTERIAL LINE BLOOD SAMPLING - NEONATAL CLINICAL GUIDELINE</th>
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</thead>
<tbody>
<tr>
<td><strong>Date Issued/Approved:</strong></td>
<td>November 2014</td>
</tr>
<tr>
<td><strong>Date Valid From:</strong></td>
<td>November 2014</td>
</tr>
<tr>
<td><strong>Date Valid To:</strong></td>
<td>November 2017</td>
</tr>
<tr>
<td><strong>Directorate / Department responsible (author/owner):</strong></td>
<td>Judith Clegg, ANNP, Neonatal Unit</td>
</tr>
<tr>
<td><strong>Contact details:</strong></td>
<td>01872 252667</td>
</tr>
<tr>
<td><strong>Brief summary of contents</strong></td>
<td>Arterial line sampling for neonates. Staff responsibilities. Technique. ANTT procedure</td>
</tr>
<tr>
<td><strong>Suggested Keywords:</strong></td>
<td>Neonate. Neonatal. Arterial. Blood gas. Sampling</td>
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<td><strong>Target Audience</strong></td>
<td>RCHT ✔ PCH CFT KCCG</td>
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<td><strong>Executive Director responsible for Policy:</strong></td>
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<tr>
<td><strong>Date revised:</strong></td>
<td>5.10.14</td>
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<tr>
<td><strong>This document replaces (exact title of previous version):</strong></td>
<td>CH20-Arterial Line Sampling</td>
</tr>
<tr>
<td><strong>Approval route (names of committees)/consultation:</strong></td>
<td>Neonatal Guidelines group, Consultant led</td>
</tr>
<tr>
<td><strong>Divisional Manager confirming approval processes</strong></td>
<td>Sheena Wallace</td>
</tr>
<tr>
<td><strong>Name and Post Title of additional signatories</strong></td>
<td>None required</td>
</tr>
<tr>
<td><strong>Signature of Executive Director giving approval</strong></td>
<td>{Original Copy Signed}</td>
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<tr>
<td><strong>Publication Location (refer to Policy on Policies – Approvals and Ratification):</strong></td>
<td>Internet &amp; Intranet ✔ Intranet Only</td>
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<tr>
<td><strong>Document Library Folder/Sub Folder</strong></td>
<td>Neonatal Guideline, clinical procedure</td>
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<tr>
<td><strong>Links to key external standards</strong></td>
<td>None</td>
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<tr>
<td><strong>Related Documents:</strong></td>
<td>Davies, M Mehr, W (2000). The effect of draw-up volume on the accuracy of</td>
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</table>
electrolyte measurements from neonatal arterial lines *Journal of Paediatrics & Child Health*. Vol 36:2

| Training Need Identified? | Yes. All staff need to be signed off/observed by professional staff competent in this procedure before performing this task independently |

**Version Control Table**

<table>
<thead>
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<th>Date</th>
<th>Version No</th>
<th>Summary of Changes</th>
<th>Changes Made by (Name and Job Title)</th>
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<tr>
<td>2006</td>
<td>V1.0</td>
<td>Initial Issue</td>
<td>J.Lane Sister NNU</td>
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<tr>
<td>4/2009</td>
<td>V2.0</td>
<td>Updated procedure for document library</td>
<td>J.Clegg ANNP, Neonatal Unit</td>
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<tr>
<td>4/20012</td>
<td>V3.0</td>
<td>Review and update as CH20 Arterial Line sampling</td>
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<tr>
<td>11/2014</td>
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<td>Judith Clegg, ANNP, Neonatal Unit</td>
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**All or part of this document can be released under the Freedom of Information Act 2000**

**This document is to be retained for 10 years from the date of expiry.**

**This document is only valid on the day of printing**

**Controlled Document**

This document has been created following the Royal Cornwall Hospitals NHS Trust Policy on Document Production. It should not be altered in any way without the express permission of the author or their Line Manager.
### Appendix 2. Initial Equality Impact Assessment Form

<table>
<thead>
<tr>
<th>Name of the strategy / policy / proposal / service function to be assessed (hereafter referred to as policy) (Provide brief description): Arterial line blood sampling – neonatal clinical guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Directorate and service area:</strong> Child Health, Neonatal</td>
</tr>
<tr>
<td><strong>Name of individual completing assessment:</strong> Judith Clegg</td>
</tr>
</tbody>
</table>

#### 1. Policy Aim*
Who is the strategy / policy / proposal / service function aimed at?

To provide guidance on the sampling of neonatal arterial lines by experienced neonatal staff

#### 2. Policy Objectives*

As above

#### 3. Policy – intended Outcomes*

Evidence based and standardised practice

#### 4. *How will you measure the outcome?*

Audit

#### 5. Who is intended to benefit from the policy?

Neonatal patients
Neonatal medical and nursing staff.

#### 6a) Is consultation required with the workforce, equality groups, local interest groups etc. around this policy?

b) If yes, have these groups been consulted?

C). Please list any groups who have been consulted about this procedure.

Neonatal Guidelines group, Consultant led

#### 7. The Impact

Please complete the following table.

<table>
<thead>
<tr>
<th>Equality Strands:</th>
<th>Yes</th>
<th>No</th>
<th>Rationale for Assessment / Existing Evidence</th>
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<tr>
<td><strong>Age</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong> (male, female, transgender / gender reassignment)</td>
<td>x</td>
<td></td>
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</tr>
</tbody>
</table>

Arterial line blood sampling - Neonatal Clinical Guideline
| Race / Ethnic communities /groups | x |
| Disability - learning disability, physical disability, sensory impairment and mental health problems | x |
| Religion / other beliefs | x |
| Marriage and civil partnership | x |
| Pregnancy and maternity | x |
| Sexual Orientation, Bisexual, Gay, heterosexual, Lesbian | x |

You will need to continue to a full Equality Impact Assessment if the following have been highlighted:
- You have ticked “Yes” in any column above and
- No consultation or evidence of there being consultation - this excludes any policies which have been identified as not requiring consultation. or
- Major service redesign or development

8. Please indicate if a full equality analysis is recommended. | No

9. If you are not recommending a Full Impact assessment please explain why.

No area indicated

Signature of policy developer / lead manager / director

Paul Munyard 12:11:2014

Names and signatures of members carrying out the Screening Assessment

Keep one copy and send a copy to the Human Rights, Equality and Inclusion Lead, c/o Royal Cornwall Hospitals NHS Trust, Human Resources Department, Knowledge Spa, Truro, Cornwall, TR1 3HD

A summary of the results will be published on the Trust’s web site.

Signed __________Kim Smith________

Date __________12:11:2014________
Appendix 4

Interpreting Neonatal Blood Gases workbook

A Self-Teaching Package.
Blood Gases

Introduction.

Acid/base balance is important for adequate control of all body functions. The enzymes which control these functions are affected by small environmental changes. Disturbances of acid/base can therefore be more dangerous than the primary disease. An understanding of acid/base balance is therefore essential in Neonatal care.

This package is designed to help you to interpret acid/base values in blood gas results and assess appropriate treatment.

Section 1 gives you the relevant information.

Section 2 sets clinical situations to assess your knowledge and understanding of acid/base balance.

Section 3 contains the answers to the clinical questions.

If you need further help to understand any portion, or have problems with the questions in section 2 please ask for assistance. Do not be afraid to keep asking until you get an answer that you can understand.

Space has been left in each section for your own notes and comments.
**Acid/Base balance.**

**ACID-** A substance which yields hydrogen ions (H+) in solution. A strong acid, e.g. hydrochloric acid, gives up hydrogen ions very rapidly. Other acids, e.g. carbonic acid, which do not yield hydrogen ions so readily are called weak acids.

**BASE-** An alkaline substance which accepts hydrogen ions. Adding an acid to a base in solution gives a weaker acid as the base accepts hydrogen ions given up by the acid.

**pH- The** hydrogen ion concentration in a solution will determine acidity or alkalinity. This concentration is expressed as a value called pH. It is inversely proportional to the hydrogen ion concentration. This means that a pH of 2.0 indicates a solution with more hydrogen ions than one with a pH of 3.0, and therefore has a higher acidity. pH is a logarithmic scale which means that a change of 1 unit in pH represents a 10 fold change in hydrogen ion concentration. This means that a small change in pH is significant.

**BUFFER-** A substance which minimises changes in pH when acid or base is added to a solution. This means a strong acid base will become weaker. There are normally sufficient buffers in the body to maintain pH within narrow limits. There are 3 important buffers in the body:

- Bicarbonate
- Haemoglobin
- Phosphate
Physiological Maintenance of Acid/Base Balance.

Acids are produced during normal metabolism. These must be neutralised before they can be excreted from the body.

Excretion of acids occurs in 3 main ways:

- **The Lungs** - the main route of excretion for carbonic acid which is converted to carbon dioxide and water. When pH falls the respiratory centre in the medulla of the brain detects the change and triggers an increase in the respiratory rate to blow off carbon dioxide.

- **The Kidneys** - the main route of excretion of hydrogen ions. Bicarbonate can also be conserved by the kidneys.

- **Haemoglobin** - contains a protein buffer which neutralises acid, especially carbonic acid. This is converted to bicarbonate and then released to the plasma as sodium bicarbonate.
Normal Blood Gas Values In Neonates.

Five values need to be considered in evaluating blood gases:

- pH
- Partial pressure of oxygen (pO²)
- Partial pressure of carbon dioxide (pCO²)
- Standard bicarbonate (St HCO³)
- Base excess (BE)

**pH**
This is a measure of the hydrogen ion concentration in the blood and indicates acidity or alkalinity.

**Normal pH of arterial blood is 7.35 – 7.44**
Values below 7.35 indicate increasing acidity, while values above 7.44 indicate alkalinity.
A pH below 7.25 may have many harmful effects including reduced cardiac contractility, periventricular haemorrhage, leucomalacia and increased vascular resistance.
A pH below 7.0 for prolonged periods is generally incompatible with life.

**pO²**
This is a measure of the partial pressure of oxygen dissolved in the blood.
The unit of measurement is the kilopascal (kPa).

**Arterial blood has a normal pO² of 7 – 12 kPa.**

**pCO²**
This is a measure of the partial pressure of carbon dioxide dissolved in the blood.
The unit of measurement is the kilopascal (kPa).

**Arterial blood has a normal pCO² of 4-6 kPa.**

**Standard Bicarbonate (St HCO³)**
This is a measure of the amount of bicarbonate (HCO³) in the blood.
The unit of measurement is millmoles/Litre (mml/L).

**Arterial blood has a normal value of 18-25 mml/L.**

**Base Excess.**
This is an indication of the amount of buffering agents available to mop up hydrogen ions.
The blood gas analyser performs a calculation and gives the base excess as a positive or negative value.

**Arterial blood has a normal base excess of +4 to -4.**
**Disturbances of Acid/Base Balance.**

Diminished or increased pH is the result of an alteration in the acid/base balance.

Acidosis results from an accumulation of hydrogen ions. Accumulation of a base or loss of hydrogen ions results in alkalosis. If the changes are in response to a ventilation disorder they are termed respiratory acidosis or alkalosis. A general metabolic disturbance will result in metabolic acidosis or alkalosis.
Metabolic Acidosis.

Causes.
These include an accumulation of acids for example in anaerobic metabolism (as in hypoxia) metabolic disorders, and an infusion of acid e.g. parental nutrition. Other causes include hypoglycaemia, cold stress, sepsis and hypovolaemia. Renal immaturity in preterm babies can lead to a mild acidosis, especially when parental nutrition is necessary.

Signs.
- Fall in pH (due to increased H+)
- Negative base excess (when buffering agents are used up)
- Normal or low pCO²
- Normal or low pO²

Treatment.
It is very important to treat the cause of acidosis. The pO² may need to be increased to prevent anaerobic metabolism. If infusions of amino acids are in progress they may need to be stopped.

As sodium bicarbonate can lead to metabolic alkalosis and intraventricular haemorrhage it should only be used with extreme caution. Treatment with sodium bicarbonate usually takes the form of half correction, and is not be regarded as a cure of acidosis.

Base required in mmol = \( \frac{\text{B.E.} \times \text{wt} \times 0.3}{2} \)

In extreme prematurity substitute 0.6 for 0.3 in the equation.
**Metabolic Alkalosis.**

**Cause**
Inappropriate treatment with sodium bicarbonate is the most common cause. Persistent vomiting or gastric suctioning with loss of gastric hydrochloric acid can also lead to metabolic alkalosis. Generation of bicarbonate by the kidney in response to low potassium levels.

**Signs**
- A rise in pH (because of increased alkalinity of the blood)
- A rise in St HCO₃⁻
- Normal pCO₂ and pO₂

**Treatment**
The underlying cause must be treated.
Respiratory Acidosis

Causes
This is due to poor gas exchange. It is frequently seen in respiratory distress syndrome. Other causes include perinatal hypoxia.

Signs
- A fall in pH
- A rise in pCO²
- pCO², B.E. and St HCO³ may be normal.

Treatment
It is usually necessary to commence mechanical ventilation or CPAP. If the baby is already on mechanical ventilation then assess the adequacy of ventilation and consider the following actions:
- the rate may need to be increased
- peak pressure may need to be increased
- the PEEP may need to be decreased
- longer expiratory time may allow CO² to be exhaled more efficiently.
Normal Blood Gas Values In Neonates.

Five values need to be considered in evaluating blood gases:

- **pH**
- Partial pressure of oxygen (pO\(^2\))
- Partial pressure of carbon dioxide (pCO\(^2\))
- Standard bicarbonate (St HCO\(^3\))
- Base excess (BE)

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The unit of measurement is the kilopascal (kPa).

**Arterial blood has a normal pO\(^2\) of 7 – 12 kPa.**

**pCO\(^2\)**
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The unit of measurement is the kilopascal (kPa).

**Arterial blood has a normal pCO\(^2\) of 4-6 kPa.**

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This is a measure of the amount of bicarbonate (HCO\(^3\)) in the blood.
The unit of measurement is millmoles/Litre (mml/L).

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Accumulation of a base or loss of hydrogen ions results in alkalosis.
If the changes are in response to a ventilation disorder they are termed respiratory acidosis or alkalosis.
A general metabolic disturbance will result in metabolic acidosis or alkalosis.
**Causes.**
These include an accumulation of acids for example in anaerobic metabolism (as in hypoxia) metabolic disorders, and an infusion of acid e.g. parental nutrition. Other causes include hypoglycaemia, cold stress, sepsis and hypovolaemia. Renal immaturity in preterm babies can lead to a mild acidosis, especially when parental nutrition is necessary.

**Signs.**
- Fall in pH (due to increased H+)
- Negative base excess (when buffering agents are used up)
- Normal or low pCO₂
- Normal or low pO₂

**Treatment.**
It is very important to treat the cause of acidosis. The pO₂ may need to be increased to prevent anaerobic metabolism. If infusions of amino acids are in progress they may need to be stopped.

As sodium bicarbonate can lead to metabolic alkalosis and intraventricular haemorrhage it should only be used with extreme caution. Treatment with sodium bicarbonate usually takes the form of half correction, and is not be regarded as a cure of acidosis.

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**Cause**
Inappropriate treatment with sodium bicarbonate is the most common cause. Persistent vomiting or gastric suctioning with loss of gastric hydrochloric acid can also lead to metabolic alkalosis. Generation of bicarbonate by the kidney in response to low potassium levels.

**Signs**
- A rise in pH (because of increased alkalinity of the blood)
- A rise in St HCO$_3$
- Normal pCO$_2$ and pO$_2$

**Treatment**
The underlying cause must be treated.
Causes
This is due to poor gas exchange. It is frequently seen in respiratory distress syndrome. Other causes include perinatal hypoxia.

Signs
- A fall in pH
- A rise in pCO²
- pCO², B.E. and St HCO³ may be normal.

Treatment
It is usually necessary to commence mechanical ventilation or CPAP. If the baby is already on mechanical ventilation then assess the adequacy of ventilation and consider the following actions:
- the rate may need to be increased
- peak pressure may need to be increased
- the PEEP may need to be decreased
- longer expiratory time may allow CO² to be exhaled more efficiently.
Respiratory Alkalosis.

**Cause**
Incorrect management of mechanical ventilation is the most common cause, allowing excessive elimination of CO$_2$. A very low pCO$_2$ leads to a fall in cardiac and cerebral blood flow so this situation can be dangerous. It can, however, be used therapeutically in cerebral oedema cautiously down to a level of 4kPa.

**Signs**
- a high pH
- a low pCO$_2$

**Treatment**
The rate and or pressure must be reduced.
Mixed Acidosis

Cause
Poor gas exchange leading to anaerobic metabolism and an excess production of hydrogen is the usual cause of mixed acidosis.

Signs
- low pH because of general acidosis
- low pO² because of poor gas exchange
- high pCO² because of poor gas exchange
- low St HCO³ because bicarbonate is used to buffer carbonic acid
- low B.E. because buffers are being used up.

Treatment
The respiratory acidosis will be corrected if gas exchange is improved. This may also help correct the metabolic acidosis. Sodium bicarbonate may be required if the metabolic acidosis is severe.

Summary
This table will provide a quick reference to distinguish the different types of acidosis:

<table>
<thead>
<tr>
<th>Acidosis</th>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
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</thead>
<tbody>
<tr>
<td>Metabolic</td>
<td>Low</td>
<td>Normal or low</td>
<td>Normal or low</td>
<td>Slightly low</td>
<td>Low</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>Mixed</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
Compensation

This is a physiological response to a disturbance in acid/base balance. The primary cause of the disturbance remains despite near normal blood gas values. Normal acid/base balance can only restored by treating the underlying cause of the disturbance.

Compensated Metabolic Alkalosis
Metabolic alkalosis is caused by an accumulation of bicarbonate. The body will attempt to retain CO² to compensate. This can result in hypoventilation.

Signs
- pCO² and St HCO³ will be raised
- pH will be normal.

Compensated Metabolic Acidosis
Accumulation of hydrogen ions is the primary cause of metabolic acidosis. The body will try to lower carbonic acid levels to compensate. This will result in hyperventilation.

Signs
- pCO² and St HCO³ will be low
- pH will be near normal.

Compensated Respiratory Alkalosis
This is usually caused by hyperventilation with a resulting low pCO². Renal excretion of bicarbonate will be increased to restore the carbonic acid/bicarbonate ratio to normal.

Signs
- pCO² and St HCO³ will be low
- pH will be normal.
Compensated Respiratory Acidosis
This is often found in chronic lung disease, with a persistently raised pCO² and decreased renal excretion of bicarbonate.

Signs
- pCO² and St HCO³ will be raised
- pH will be normal.

This table is designed as a quick reference to distinguish different blood gas results. Work from the top downwards, establishing first whether there is acidosis or alkalosis, then whether it is respiratory or metabolic then moving on to determine whether it is mixed or partially compensated. Only pH, pCO² and B.E. are considered.

<table>
<thead>
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<tr>
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<td>+</td>
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<td>M</td>
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<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td>pH</td>
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<td></td>
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<td>Respiratory</td>
<td>pCO²</td>
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<td>Raised</td>
<td>N</td>
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<tr>
<td>B.E.</td>
<td>+</td>
<td>N</td>
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<td>Respiratory</td>
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<tr>
<td>Raised</td>
<td>N</td>
<td>Lowered</td>
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<tr>
<td>B.E.</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Respiratory</td>
<td>pCO²</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>PC</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>B.E.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>N</td>
<td>Raised</td>
<td>Raised</td>
</tr>
<tr>
<td>PC</td>
<td>N</td>
<td>Lowered</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>R</td>
<td>R</td>
<td>R</td>
</tr>
<tr>
<td>PC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B.E.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>+</td>
</tr>
</tbody>
</table>

Once you are confident that you understand the material in this section work through the exercises in the next section to test your knowledge and understanding of blood gases.

If you need help with any part please ask any member of staff who is already certified to take blood gases.

Arterial line blood sampling - Neonatal Clinical Guideline
Section 2

Exercise 1
Define what is meant by “acid”

Define what is meant by “base”

What does pH indicate?

What is the function of a buffer?

How does the body excrete acids?

Exercise 2
Fill in the upper and lower limits of normal arterial blood gases in neonates.

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Exercise 3
Which value in the table below is outside of the normal range?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.34</td>
<td>8.4</td>
<td>4.8</td>
<td>16</td>
<td>+3</td>
</tr>
</tbody>
</table>

Exercise 4
Which value in the table below is outside of the normal range?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.31</td>
<td>7.5</td>
<td>10</td>
<td>21</td>
<td>-2</td>
</tr>
</tbody>
</table>
**Exercise 5**
Here are 3 pH values:
1. 7.4
2. 7.5
3. 7.2

Which value is normal?

Which value indicates acidosis?

Which value indicates alkalosis?

**Exercise 6**
Here are 3 B.E. values:
1. +2
2. +10
3. -11

Which value is normal?

Which value indicates metabolic alkalosis?

Which value indicates metabolic acidosis?
Exercise 7
The following table represents a set of blood gas results from a neonate. What type of acid/base disturbance do they indicate?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.25</td>
<td>7</td>
<td>9</td>
<td>24</td>
<td>0</td>
</tr>
</tbody>
</table>

What may have caused this disturbance?

How should it be corrected?

Exercise 8
Here is another set of blood gas results. What type of disturbance is indicated?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.24</td>
<td>6</td>
<td>5</td>
<td>14</td>
<td>-8</td>
</tr>
</tbody>
</table>

Which values did you use to make your decision?

Exercise 9
This set of blood gas results indicates acidosis. What type?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.22</td>
<td>5</td>
<td>8</td>
<td>16</td>
<td>-6</td>
</tr>
</tbody>
</table>

How might it have been caused?
Exercise 10
Which values in the blood gas results below are outside of the normal range?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.22</td>
<td>5</td>
<td>6</td>
<td>12</td>
<td>-10</td>
</tr>
</tbody>
</table>

What type of acidosis is indicated?

Exercise 11
What kind of acidosis is present in the following results?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>4</td>
<td>7</td>
<td>16</td>
<td>-8</td>
</tr>
</tbody>
</table>

Exercise 12
Which values are outside normal ranges in the following results?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.24</td>
<td>8</td>
<td>9</td>
<td>21</td>
<td>-3</td>
</tr>
</tbody>
</table>

What type of acidosis is present?

Exercise 13
What kind of acidosis is present in the following blood gas results from a ventilated baby?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
<th>FiO²</th>
<th>I:E ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.25</td>
<td>8</td>
<td>10</td>
<td>20</td>
<td>-3</td>
<td>40%</td>
<td>1:1</td>
</tr>
</tbody>
</table>

What would you do to correct it?
Exercise 14
What kind of acidosis is present in the following blood gas results?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
<th>FiO²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.28</td>
<td>4</td>
<td>9</td>
<td>18</td>
<td>-4</td>
<td>70%</td>
</tr>
</tbody>
</table>

What could you do to correct it?

Exercise 15
What kind of acidosis is present in the following blood gas results?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
<th>FiO²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.21</td>
<td>5</td>
<td>9.5</td>
<td>17</td>
<td>-6</td>
<td>60%</td>
</tr>
</tbody>
</table>

Is it severe or slight?

How would you correct it?

Exercise 16
What kind of acidosis is present in the following blood gas results?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
<th>FiO²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>6</td>
<td>10</td>
<td>22</td>
<td>-2</td>
<td>35%</td>
</tr>
</tbody>
</table>

Is it severe or slight?

How would you correct it?
Exercise 17
What kind of acidosis is present in the following blood gas results of a baby receiving parental nutrition?

<table>
<thead>
<tr>
<th>pH</th>
<th>pO²</th>
<th>pCO²</th>
<th>St HCO³</th>
<th>B.E.</th>
<th>FiO²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.19</td>
<td>8</td>
<td>5</td>
<td>13</td>
<td>-11.5</td>
<td>air</td>
</tr>
</tbody>
</table>

Is it severe or slight?

What could you do to correct it?
Appendix 5

Royal Cornwall Hospitals
NHS Trust

Skills Training Packages

Care of the Neonate Undergoing Blood Gas Analysis

Developing Practice Through Education.
Contents

- Aim
- Objectives
- Definition
- Summary Sheet
- Responsibilities Of An Assessor
- Child Health Directorate Criteria
- Learning Outcomes
- Cascade of Training
- Self-Directed Learning Method
- Theory Assessment
- Practical Assessment
- Reading List
- Evaluation
- Assessment Record
- Standard
- Audit Tool

The concept of the Self Directed Learning Packages have resulted from funding from the Cornwall and South Devon Education Purchasing Consortium and the subsequent joint project work of the Consortium Project Team, consisting of a representative from Royal Cornwall Hospitals NHS Trust, Plymouth Hospital NHS Trust and South Devon Healthcare NHS Trust.

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Aim

To educate and train Health Care Professionals to sample, process and report on blood gas sampling from neonates safely and competently. The skills will be in accordance with relevant Trust procedures, with underpinning theoretical knowledge to ensure evidence based practice.

Objectives

- That all Health Care Professionals are aware of and adhere to Trust guidelines, policies, procedures and standards which relate to blood gas sampling in neonates.
- That neonates receive the best care and treatment in accordance with current understanding and research.
- That staff continue to maintain their competence through regular performance of this skill.
- For staff to seek out current literature relating to blood gas sampling in neonates and question their own practice, the practice of others and the Trust guidelines to ensure practice changes with the dynamic of new information.

Definition

Sample, process and report on arterial or capillary blood gases from neonates.

Summary Sheet

Training Entry Criteria
- Health Care Professionals with line managers'/senior doctors’ approval.
- Health Care Professionals who show a clear understanding of their Governing Body’s directives regarding the procedure.

Criteria for Supervisors and Assessors
• Neonatal Practice Educator.
• Competent Health Care Professional who has been assessed as reaching the trust's standard for sampling, processing and reporting on arterial blood gas sampling in neonates.
• A competent Health Care Professional who samples neonatal blood gases on a regular basis.
• The supervisor will supervise practice on a one-to-one basis.
• A supervisor is not necessarily required to be an assessor.

Policies and Procedures Associated with Neonate Blood Gas Sampling
• Trust procedure for Neonatal Arterial Line Blood Sampling.
• Trust guidelines for Health Care Professionals sampling neonatal gases.
• Trust Health and Safety Policy.
• Infection Control Policy.
• Trust Standard for Sampling Neonatal Blood Gases.
• Trust Standard for Documentation.
• Health Care Professional's Governing Body's directives on best practice.

Teaching Resources
• Equipment required for neonatal blood gas sampling.
• Blood gas machine.

Training Content/Presentation/Timetable
• Theoretical knowledge of Neonatal Blood Gas Sampling will be obtained and demonstrated using a self directed study method.
• Practical training will take place in the clinical areas.
• Training sessions should be completed in one hour.
Assessments
- It is advised that training should be completed within a period of one month.
- Each Health Care Professional will take responsibility for their own level of competence and exercise their professional clinical judgement before putting themselves forward for assessment.
- Each Health Care Professional will be responsible for maintaining their knowledge base on neonatal blood gases by reviewing the latest research and change in practice.
- Self directed theoretical study.
- Supervised progressing to assessed practice.
- Self assessment must be continuous once the individual has been assessed as competent.

Responsibilities of an Assessor.
- Always act in such a manner as to promote the safeguard the interests and well-being of patients and clients.
- Assist professional colleagues in the context of your own knowledge, expertise and sphere of responsibility, to develop their professional competence.
- Must honestly acknowledge any limit of personal knowledge and skill and take steps to remedy any relevant deficits.
- Recognise and honour the personal accountability borne for all aspects of professional practice.
- Enhance trust and confidence within a Health Care Team and promote collaborative work between other health care professionals.
- To assist Health Care Professionals in their role as clinical assessors it is expected that all experienced clinically competent Health Care Professionals complete the theoretical self directed learning section of the skills training packages.
- By completing the theoretical training the clinically competent Health Care Professional will maintain their knowledge base and ensure that they are equipped to assess other Health Care workers.
- The Practice Educators will evaluate the assessors completed theoretical section. By monitoring the assessor in this fashion the Practice Educators will be able to promote a high standard of subsequent assessments.
- Health Care Professionals who decline to complete the theoretical section of the training package may not have sufficient expertise or knowledge required to complete the theoretical section and thus would not make suitable assessors.
- Health Care Professionals who do not follow this process may compromise trainees.
Child Health Directorate Criteria.

To comply with the recommendations in the “Clothier Report”, the following advice should be adhered to when caring for children under the age of sixteen.

Children are cared for in areas other than the Child Health Directorate. When this occurs the skills contained in these packages should only be performed by Registered Sick Children nurses, experienced doctors or experienced paediatric therapists.

Personnel wishing to train in these skills who are Registered Sick Children nurse trained, experienced doctors or experienced paediatric therapists, must seek the approval of the Senior Nurse for the Child Health Directorate, Consultant Paediatrician or Therapies Manager.

For personnel working in the Neonatal Unit, approval must be sought from the appropriate Neonatal Line Manager or Consultant Paediatrician.

Learning Outcomes

At the conclusion of both the theory and the practical assessments for sampling, processing and reporting on neonatal blood gas samples you will be able to:

- Demonstrate knowledge of national, local and professional policies, procedures and standards in relation to sampling, processing and reporting on neonatal blood gas samples.
- Demonstrate knowledge of your Governing Body’s directives pertaining to responsibilities and accountability when applied to clinical skills.
- State the correct procedure for patient identification.
- Prepare and use the equipment required.
- Demonstrate the principles of the correct neonatal blood gas sampling technique following the Trust’s procedure standard.
- Demonstrate the ability to assess and identify practical problems associated with neonatal blood gas sampling and state how to deal with these.
- Demonstrate knowledge of how to identify the resources available for up to date information and practical advice.
- Demonstrate knowledge of the rationale behind self assessment and a clear understanding for how to use the Trust’s tool.
Cascade of Training

Doctors with special responsibilities for the Neonatal Unit
Continual Self Assessment
Peer Assessment

Health Care Professional
Continual Self Assessment
Peer Assessment

Medical Staff
Continual Education / Training / Assessment
Evaluation
Feedback through Education

Registered Neonatal Nurse

Registered Neonatal Nurse

Medical Staff

Medical Staff

Medical Staff

Registered Neonatal Nurse

Registered Neonatal Nurse
Self Directed Learning Method

This training package is for use by Health Care Professionals for initial training, continual updating and self assessment.

- It is designed for you to direct your own learning in order to achieve the competence level and trust standard required for this skill.

- The flexibility of self directed learning will allow you to utilise your time for study to obtain both theoretical knowledge and practical skills.

- You **must** successfully complete the theory preparations and assessments before your practical assessment.

- You **must** successfully complete both the theory and practical assessments before undertaking this skill unsupervised.

It is expected that you direct yourself to gain competence in the theoretical assessment using your Trust’s resources. These may include:

- Learning and Development
- Health Libraries
- Pharmacy
- Post Graduate Centre
- Practice Educators
- Senior Neonatal Nurses/Doctors with special responsibilities for the Neonatal Unit
- Neonatal Library.

It is essential that you make full use of your supervisor/assessor to help with both the learning and assessment stages of this skill.

Competency Pack

Self Directed Learning Package.
This section may be photocopied for your use and additional sheets added as necessary.
You must successfully complete these theory assessments **before** beginning any practical learning or assessment of this skill.

Name:........................................................................................................

Designation:................................................................................................

Area Of Work:.............................................................................................

Commenced date of skills training:.........................................................
Competency 1

1. How does the “Control of Substances Hazardous to Health” legislation impact upon neonatal blood gas sampling?

2. Why is it important to maintain asepsis during the neonatal blood gas sampling procedure?

3. Interpretation of neonatal blood gases- completed the separate self directed learning package.

4. What are the physiological indications for performing the procedure?

5. List the correct equipment needed to perform the procedure.
6. How will you maintain the safety of an arterial line?

7. What is the arterial line in place to facilitate?

8. What is the appropriate use of a capillary blood gas sample?

Completed Satisfactorily: Yes No

Signed (assessor):........................................................................................................

Date:.................................................................................................................................

Comments:
Competency 2

The Risks

1. How would you detect and or prevent the following potential hazards:

   a) Air Embolism:

   b) Infection:

   c) Haematoma:

   d) Haemorrhage:

   e) Discolouration of the Limbs:

   f) Faulty Equipment:
g) Incorrect Cannula Fixation:

h) Accidental Disconnection of Equipment:

**Completed Satisfactorily:**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

**Signed (assessor):**

**Date:**

**Comments:**

**Practical Assessments**

**Self Directed Learning Pack**
You must successfully complete the theory assessments **before** attempting any practical learning or assessment of this skill.

You must successfully complete **both** the theory and practical assessments **before** undertaking this skill unsupervised.

The answer booklet is available as a separate document. Contact Training or a Senior Nurse to check your answers.

---

**Practical Assessment 1**

**Demonstrate competence in identifying the baby.**
1) By correctly following the Trust’s guidelines, the baby is correctly identified.

2) Where possible, informed consent is obtained from parents.

3) The neonatal blood gas sampling is performed correctly adhering to Trust procedure.

Signed (assessor): ............................................. Yes.............No..........
Comments:

Practical Assessment 2

Disposal of Equipment.
1) Sharps were disposed of in accordance with the Trust Sharps Policy.

2) The remaining waste was disposed of in accordance with Trust Disposal of Waste Policy.

Signed (assessor): ............................................. Yes.............No..........
Comments:

Practical Assessment 3

Documentation.
1) Correct documentation of sample, route and result.

2) Operator must sign the documentation.

3) Appropriate response to the results of the blood gas sample analysis.

Signed (assessor): ............................................. Yes.............No..........
Comments:
Portfolio Evidence.

Course/Skills Acquisition
(for inclusion in relevant section of your Personal Portfolio)

Training/Courses Completed and Assessed.

<table>
<thead>
<tr>
<th>SKILL/COURSE TITLE</th>
<th>DATE</th>
<th>ASSESSOR</th>
<th>REVIEW DATES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Reflective Statements/Account on Skill Acquisition/Course.

- What have you learnt?
- Outcome
- Action

**Key elements for reflection.**

- Benefit for the patient
- Benefit for the team
- Benefit for you as a professional
- Difficulties encountered
- Difficulties envisioned
- Where do your responsibilities lie?
References and Further Reading

   Mhairi G. MacDonald, Jayashree Ramasethu, Khodayar Rais-Bahrami (Eds)

   Hall Michael, Alan Noble, Smith Susan

   Janet M. Rennie
   Churchill Livingstone ISBN: 9780702034794

4. **Comprehensive Perinatal & Pediatric Respiratory Care** (2001)
   Kent B. Whitaker 3rd edition
   Chapter 9 ISBN 13: 9780766813731
   ISBN 10: 0766813738

   2nd edition
Evaluation of the Training Package.

Title of the training package:.................................................................

Duration of training:..............................................................................

Final assessment date:............................................................................

Successful assessment:...........Yes.................................No.................

Please complete the following evaluations:

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERY USER FRIENDLY</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INFORMATION WAS CLEARLY REQUESTED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INSTRUCTIONS WERE CLEAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAVING COMPLETED TRAINING KNOWLEDGE BASE HAS INCREASED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABLE TO REFLECT ON YOUR TRAINING AND ITS BENEFITS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please return to: Learning and Development Department