CAPILLARY BLOOD SAMPLING IN THE INFANT / CHILD GUIDELINE	
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CONTENTS

1.0 Introduction

Capillary blood gas (CBG) sampling is used as an alternative to arterial blood gas sampling for the analysis of a patients oxygenation, adequacy of ventilation and in estimating their acid-base balance. Blood gas sampling is used in children with severe cardio-respiratory disease that requires close observation. Arterial blood gas sampling involves the insertion of a cannula into the brachial, radial or femoral artery and is one of the most frequently ordered laboratory tests in the paediatric intensive care setting. This may result in substantial blood loss causing anaemia, especially in the sick neonatal population which may result in an unwarranted and otherwise preventable blood transfusion (Merendino and Wissing 2006).

2.0 Definition

Capillary Blood Gas (CBG) sampling involves puncturing the cutaneous layer of the skin at a highly vascularised area. The area is warmed prior to puncturing the site this enables blood vessels to dilate thus accelerating blood flow and reducing the difference between the arterial and venous gas pressures (Shepherd *et al.* 2006).

3.0 Indications for Capillary Blood Gas Sampling

Capillary blood gas (CBG) sampling is indicated when:

- Arterial / venous access is not available for blood gas analysis.
- Non-invasive readings transcutaneous oxygen values(tcO2), end-tidal CO2 (etCO2), and pulse oximetry, are abnormal
- Assessment for commencing and alterations in invasive / non-invasive ventilation.
- Alterations in a child's clinical status, detected by history, observation and/or physical assessment.
- Monitoring the severity and progression of a documented disease process.
- To minimise the amount of blood sampling in preterm / neonates.
- To avoid central / arterial access and thereby reduce infection risk.

NB: Capillary pO2 is of little value in arterial oxygenation estimation (Yildizdas *et al.*2004).

4.0 Complications

- Pain / Distress
- Infection (i.e. callous osteomyelitis and cellulitis)
- Haematoma
- Nerve damage
- Scarring
- Bleeding / haematoma
- Bruising
- Puncture of posterior medial aspect of heel may result in tibial artery laceration
- Inappropriate management from reliance on capillary PO2 values.
- Trauma
- Bone calcification
- Burns
- Skin breakdown (repeated use of adhesive tape) (Merendino and Wissing 2006, WHO 2010).

5.0 Sampling Procedure

Equipment

- Mediswap (alcohol swab)
- Automatic incision devise i.e. Tenderfoot ® or
- Spring loaded lancet i.e. Accucheck as clinically indicated
- Sterile gauze swab x1
- Sharps Disposal Box
- Small clean disposable tray
- Non-sterile gloves; non-sterile apron
- Heparinised Capillary tube (i.e. Radiometer 55ul / 100ul)
- Capillary caps x 2 and flint
- Vaseline
- Magnet (i.e. white board magnet)
- Clot Catcher
- Hospital ID label
- Blood Gas Analyser

ACTION	RATIONALE EVIDENCE and REFERENCE
Pre Procedure **Contraindications** 1. Infants < 24 hours 2. Site: Infection, red, bruised, swollen or oedematous, haematoma 3. Hypotension / hypovolaemia 4. Right sided heart failure 5. Polycythemia (relative) 6. Peripheral vasoconstriction, poorly perfused tissue	These infants often have peripheral vasoconstriction which affects perfusion due to birth and therefore the potential for inaccurate measurement due to inadequate perfusion. Blood obtained can have altered valves from excess interstitial fluid (Folk 2007). This alters perfusion to the peripheries and elevates pCO2. Due to venous pooling and may result in an inaccurate measurement. Thick viscous blood results in shorter clotting times (Merendion and Wessing 2006, Long 2016).
Explain the procedure to child (if appropriate) and parents / guardians.	To optimise compliance and trust and to reduce anxiety (Trigg and Mohammed 2010).
Assemble equipment.	Ensuring efficiency and speed of procedure (Trigg and Mohammed 2010).
Administer pain relief i.e. 24% sucrose solution to infants.	To minimise pain and distress. Sucrose via the intra-oral route has been demonstrated to have evidence based analgesic actions for minor invasive

	procedures in neonates. The sweetness of sucrose appears to elevate pain thresholds via endogenous opioid pathways and result in decreased crying in the infant. Sucrose last approximately 3 – 5minutes with a peak action at 2 minutes. (Kassab *et al*. 2012, Stevens *et al*. 2013, Hockenberry *et al*. 2017).
Position infant with soother and swaddling as condition allows.	Effects of sucrose are intensified with sucking Maintaining containment during the procedure reduced stress (Folk 2007, Morrow and Hidinger 2010).
Procedure Wash hands thoroughly, put on disposable plastic apron and non-sterile gloves as per ANTT level 3 guidelines.	Prevention of cross infection (OLCHC 2005, 2007, 2011). (Universal Precautions).
Incision / Puncture Site Choose Site: • ***Child*** Fleshy pads of middle and ring finger (non-dominant hand). Perform puncture across finger print (perpendicular to ridges) and not parallel (Figure 1). (Appendix 1) NB: Avoid thumb, index and little finger.	These areas are highly vascularised and are the only acceptable sites for finger pricks. Sides and tip of the finger should be avoided as the flesh is only half as thick, there are more nerve endings and bone is closer to the surface. This technique allows the blood to form a bead as it emerges from the tissue instead of channeling away along ridges from the puncture site (Peters 2017). Thumb should not be used due to the skin often being too thick / callous; index finger may be more sensitive. Little finger should be avoided as tissue thin and not sufficiently thick to guarantee that the bone will not be penetrated (Centre for Phlebotomy Education 2009, Gob, 2009, WHO 2010).
• ***Neonate / Infant*** (not walking) Medial / lateral (inner and outer) planter aspects of a heel (Figure 2) (Appendix I). NB: Avoid posterior curvature of the heel.	Lateral and medial planter surfaces of the heel are the only acceptable sites in the neonate / infant. Calluses will have formed on the heels of babies who are walking, thus making puncture and sampling more difficult.
Optional - Earlobe	Skin may also be only 1mm thick and this increases the risk for bone damage and osteomylitis (Folk 2007, Centre for Phlebotomy Education 2009, WHO

	2010, Hazinski 2013. Peters 2017).
Maintain warmth of the chosen puncture site i.e. neonates perform the procedure through the incubator portholes or by using a radiant heater. Wrapping of the site if necessary i.e. foot for 3-5 minutes with small blanket may increase skin temperature prior to sampling. NB: Do not use heating devise.	To ensure blood vessels are dilated thus accelerating blood flow and reducing the difference between the arterial and venous gas pressures (Peters 2017). Warm skin will increase capillary blood flow by 7 times and prevent the need for massaging / milking the puncture site, thus avoiding the risk of skin contamination and haemolysis (Radiometer 2008a, 2008b, Centre for Phlebotomy Education 2009). A cool, poorly perfused puncture site will provide inaccurate results (Hazinski 2013).
 Figure 1: Hold infants' foot with non-dominant hand.	(GOSH 2014).
A small smear of Vaseline may be applied to puncture site as clinically indicated.	To encourage a large clot formation and prevent smearing or dribbling of blood.
Put on disposable gloves.	Standard precautions (OLCHC 2011).
Use disposable automated incision device or puncture capillary blood sampling devise i.e.	An incision / puncture that are too deep can cause bone damage and haemolysis. Necrotizing osteochondritis is the most serious complication from lancet penetration. Be extra vigilant with extremely small premature infants as the bone may be less than 2 mm beneath the plantar heel-skin surface (Radiometer 2008b, Hockenberry *et al.* 2017).
Tenderfoot ®. • ***Micro-premmie*** (0.65mm, blue) < 1 kg • ***Preemie*** (0.85mm, white) > 1 kg • ***Newborn*** (1.00mm, pink/ blue) > 2.5 kgs. • ***Toddler*** (2.00mm, pink) older infants and toddlers	The Tenderfoot ® devise offers a permanently retractable blade or needle feature that minimises the possibility of injury and reuse (Radiometer 2008b). Tenderfoot ® also performs a gentle incision with a controlled and standardised depth to a level above sensitive nerve fibres (Lewis and Brooks 1992). Tenderfoot is reported to be less traumatic and painful, causes less bruising, inflammation, haemolysis of specimens and improved wound healing compared to conventional manual lancing devises. Fewer repeat incisions

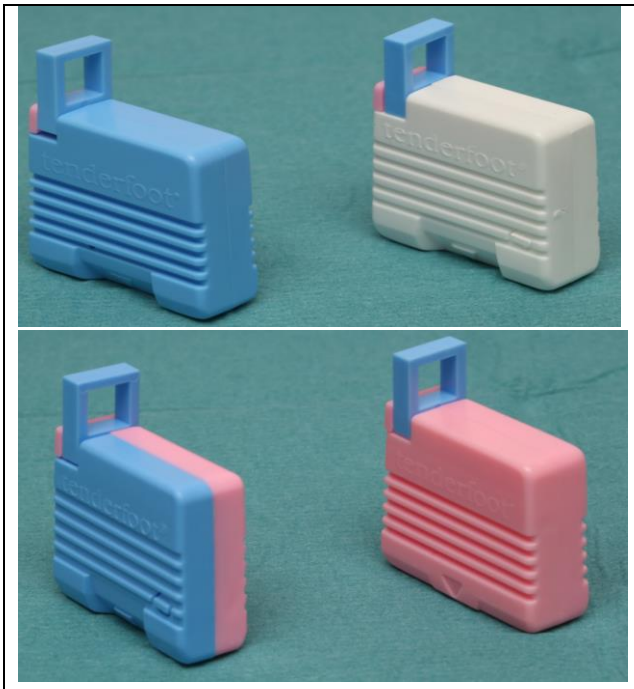

Figure 2: Tenderfoot Devices: Micropreemie (top left); Preemie (top right); Newborn (bottom left) and Toddler (bottom right) (OLCHC Medical Illustration 2016)

Accu-Chek
(Low depth setting, 1.3mm) Child
(Medium depth setting, 1.8mm) Adolescent

Place the disposable automated capillary sampling devise on the selected site and activate the trigger.
Avoid any previous puncture sites.
Remove from foot.

Wipe away the first drop of blood with a gauze swab, whilst holding the infants' heel and allowing blood drop to hang.

Select appropriate Radiometer heparinised capillary tube:
55ul tube – PH, blood gas and oxygen saturation
100ul tube – PH, blood gas, saturation, electrolytes, glucose and lactate

Filling the Capillary Tube
Elevate puncture site during procedure as clinically indicated.
Do not squeeze the finger/toe/heel/earlobe too

have been reported, to obtain sufficient blood without squeezing the heel. Also 2.6 times less punctures which resulted in shorter collection times. It is thus superior, more effective, with reduced adverse complications and is recommended by researchers (Shepherd *et al*. 2006, Sorrentino *et al*. 2017).

Lancet or puncture devices for heel blood sampling are not recommended (Folk 2007, WHO 2010).

This may lead to infection due to bacterial contamination (WHO 2010).

The first drop of blood is often contaminated with tissue fluid, containing high potassium levels which could identify inaccurate blood results. It also may cause an erroneous low pCO2. (Merindino and Wessing 2006, Radiometer 2008b).Other capillary tubes may not have sufficient heparin to prevent sample clotting (Radiometer 2008a, 2008b).

Excessive squeezing will cause haemolysis of the blood sample and can impede blood flow and lead to bruising. Friction to the sole of the infant may

hard.	damage newly formed tendons (Merendino and Wissing 2006, Centre for Phlebotomy Education 2009, WHO 2010).
Attach first cap loosely at one the end of the capillary tube and insert flint wire into the tube (Appendix I) (Figures 3-5)	To adequately collect the blood sample.
Let the blood form a thick blood drop. Collect the sample by placing the capillary tube directly into the centre of a single large blood drop at the puncture site.	To ensure no air enters the capillary tube (Radiometer 2008b, Centre for Phlebotomy Education 2009).
Allow the blood to flow freely into the capillary tube by gravity and / or capillary action.	To reduce the risk of room air contamination (Radiometer, 2008a, 2008b).
During collection the capillary tube may need to be held at a downward angle which allows the capillary tube to be filled.	To ensure sufficient sample to measure.
Ensure sufficient blood flow. If blood does not flow freely from the puncture site, it may be necessary to tip the filled end downwards until a blood drop forms.	Air bubbles will be detected in the analyser and you will not get a result. Also even small bubbles may seriously affect the pO2 value and result in increased values (Radiometer 2008a, 2008b).
Blood flow may be enhanced by ensuring puncture site is held downwards. Also: • Applying gentle intermittent pressure to surrounding tissues. • Intermittent pressure proximal to finger puncture site • NB: Allow sufficient time between squeezes for blood perfusion back into the heel / finger. Fill completely avoid getting any air bubbles in the tube.	
Refrain from removing until sufficient blood is obtained. (Appendix 1: Figure 6)	To prevent contact with blood during transportation (Radiometer 2008b).
Seal the sample end of the capillary tube immediately after obtaining sample, using cap. (Appendix 1: Figure 7)	To prevent the risk of blood spillage, reduce the risk of room air contamination and diffusion of gases through the plastic (Radiometer 2008a, 2008b).

Mixing the Sample Mix sample immediately with magnet by moving along capillary tube. Repeat gently using repeated strokes of the magnet until sample inserted into blood gas analyser.	To ensure uniform mixing with heparin in the tube. Recommendation from company (Radiometer 2008b).
Alternatively hold the capillary tube between 2 fingers and invert continuously. Ensuring mixing wire moves from end to end with each inversion minimum 20 times or roll tube continuously between fingers (Appendix 1: Figure 8-10).	To prevent haemolysis. Recommended by Radiometer to ensure heparin dissolves and mixes and to prevent clot formation (Radiometer 2008a, 2008b).
Post Procedure ***2nd Nurse / Practitioner*** Apply pressure to the puncture site using gauze, until the bleeding has stopped.	To prevent infection and excessive blood loss especially in the neonatal population (Hazinski, 2013).
Avoid use of adhesive dressings.	Adhesive dressings keep the area moist and increase the risk of infection. They can also result in epidermal stripping in the neonates, upon removal (American Association of Respiratory Care 2001).
Remove gloves. Perform thorough hand hygiene. Put on fresh pair of non-sterile gloves as per ANTT level 3 guidelines (Universal Precautions).	Prevention of cross infection (OLCHC 2011, 2017).
Ensure the infant / child is left comfortable. Praise and thank the child either verbally or with simple gesture ie. handshake, pat on back, fun sticker as appropriate.	To provide reassurance, comfort and maintain a trusting relationship between the child and nurse (WHO 2010, Hockenberry *et al*. 2017).
Take the sample to the analyser to analyse immediately. Roll capillary tube between fingers as you go (Appendix 1: Figure 10).	To minimise the chance of clotting. Delay in analysing affects cGlucose, cLactate and pO2, (Radiometer 2008a).
Blood Gas Analyser Remove the cap from the opposite end of capillary tube.	
Use a clot catcher and take off second cap from the other end of the tube (Appendix 1: Figure 11)	To prevent any clots getting into the analyser and to keep the inlet clean. Use of a clot catcher is recommended (Radiometer 2008a).

NB: If Vaseline or similar has been used at the puncture site, ensure capillary tube is introduced into analyser from the opposite end with clot catcher attached (Appendix 1: Figures 11 and 12)	To prevent cross contamination and clots in the analyser (OLCHC, 2005).
Ensure **capillary** mode has been select: Then press ***START***. (Appendix 1: Figure 13)	This ensures the analyser measures the correct sample size (Radiometer 2008b).
Insert sample insert into the analyser. Push capillary tube in and hold sample for 5 seconds whilst analyser aspirates (Appendix 1: Figure 14 and 15)	
Enter or scan patient ID, central temperature and FI.02. (Appendix 1: Figures 16 and 17).	To ensure correct patient safety and accuracy of capillary blood gas.
Clean blood gas analyser screen and inlet following the procedure as clinically indicated.	Universal precautions (OLCHC 2011).
Dispose of equipment in an appropriate sharps container and clinical waste bin. Remove gloves and wash hands.	To promote safety and prevent cross contamination (Department of Health and Children 2002, OLCHC 2004, 2005).
Document procedure including date, time, site, infant/child's tolerance and any complications.	To ensure safe practice, continuity of care and maintain accountability (NMBI 2015a).
Record the blood results in the appropriate nursing record sheet and report any abnormalities to the medical team.	

Nurses should only perform capillary blood gas sampling having received the necessary theoretical and practical instruction to practice competently, within their scope of practice (Long 2015, NMBI 2015b). All nursing care is given with regard to guidance for good practice (OLCHC, 2008).

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Appendices

Appendix 1 – Sampling Technique

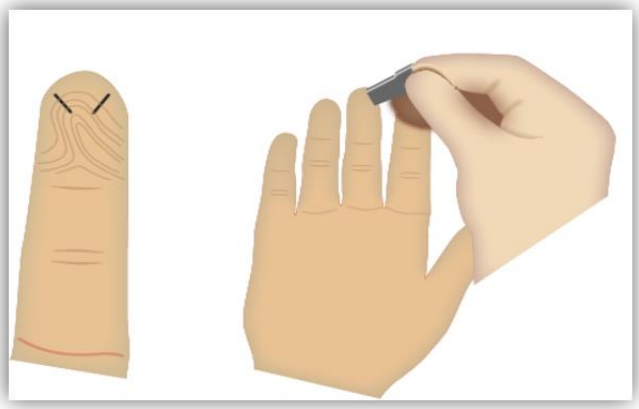


Figure 1: Site for Capillary Blood Sampling in the Child

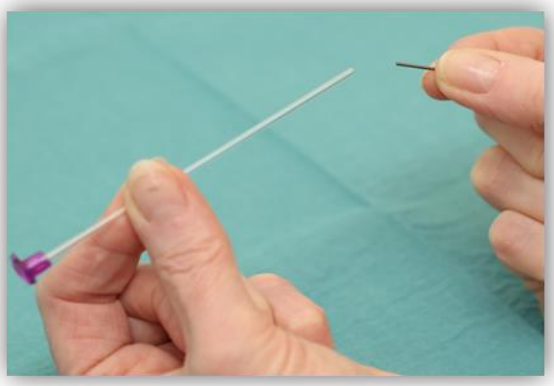
Perform puncture on lines as shown above

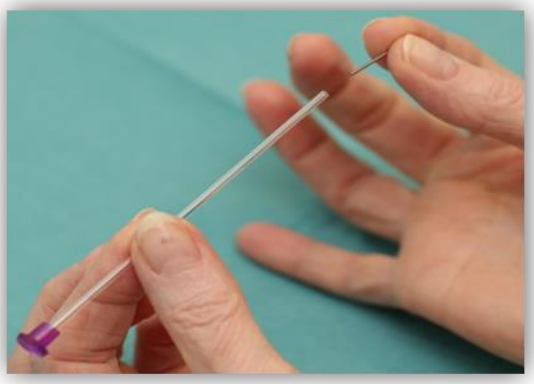
(Used with permission, Radiometer 2008b)

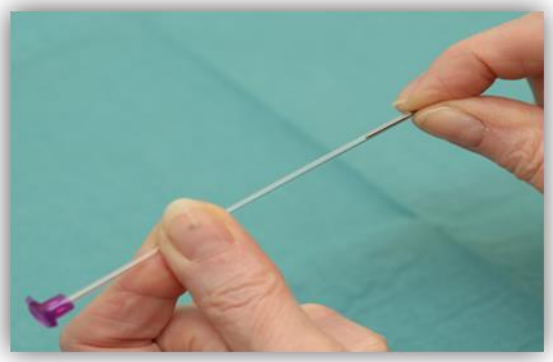
Figure 2: Site for Capillary Blood Sampling in the Neonate

Take sample from shaded area

(Medical Illustration, OLCHC, 2009)







Figures 3-5: Inserting Flint into Capillary Tube with cap at one end
(Medical Illustration, OLCHC, 2016)

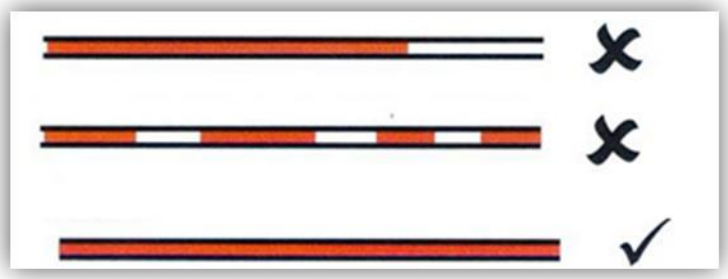


Figure 6: Correct Filling of the Capillary Tube
(Used with permission, Radiometer 2008b)

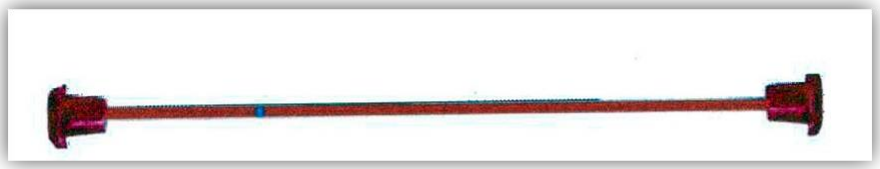


Figure 7: Attach Caps to both ends of the Capillary Tube
(Used with permission, Radiometer 2008b)

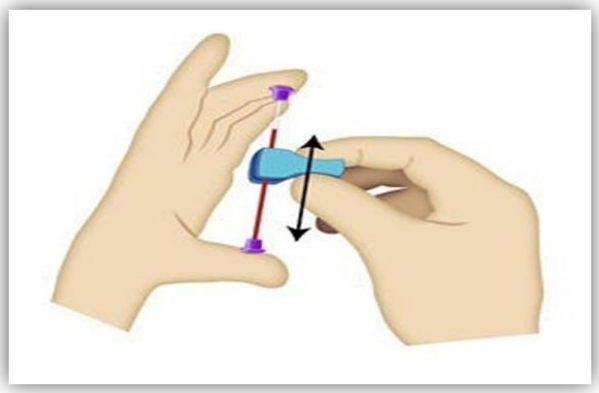


Figure 8: Mixing of Sample in Adolescents
(*Used with permission, Radiometer 2008b)*

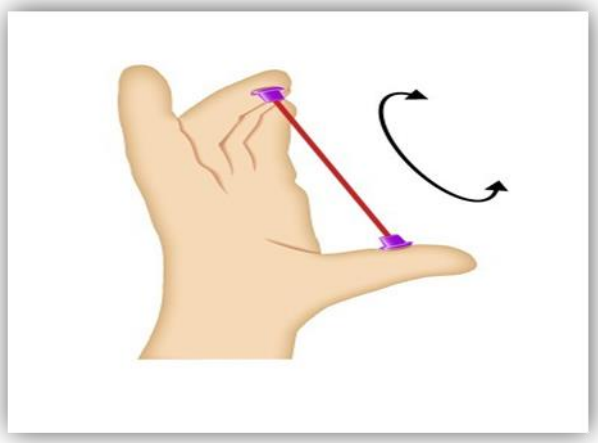


Figure 9: Mixing of Sample in Neonate or Samples Prone to Haemolysis
(Used with permission, Radiometer 2008b)

Figure 10: Rolling capillary tube between fingers
(Medical Illustration, OLCHC 2017)

Figure 11: Sample Ready for Analysing
(Used with permission, Radiometer 2008b)

Figure 12: Sample ready for analysing

Figure 13: Select type of Sample

Figure 14: Inserting sample into the analyser seconds

Figure 15: Push in and hold sample for 5 whilst analyser aspirates

Figure 16 and 17: Entering patient details: medical record number; type of sample; patient's temperature and percentage of oxygen receiving

(Figures 12 – 17. Medical Illustration, OLCHC 2017)