Guide to Capillary Heelstick Blood Sampling in Infants

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ABSTRACT

Capillary blood sampling is an essential method of blood collection performed by nurses of all skill levels to obtain samples for routine laboratory tests in neonates. Accuracy of results depends on proper heelstick and sample collection technique. Recent advances including development of devices designed specifically for heelstick capillary blood sampling and research into expanded safe heel capillary sampling sites are discussed. A step-by-step guide to capillary blood sampling is outlined along with evidence-based practice incorporating neonatal-appropriate disinfection and nonpharmacological analgesia that contribute to improved infant safety and comfort during and after the procedure.

KEY WORDS: blood sampling, capillary, heel, heelstick, infant, neonatal pain, neonate

Premature and critically ill neonates frequently require repeated analysis of blood chemistry, hematology and blood gas values in addition to mandated metabolic screening performed on most newborns in the United States. Properly performed capillary heel blood sampling provides a reliable, minimally intrusive means of obtaining samples from neonates. Appropriate devices, analgesia, and developmental measures combined with proper technique reduce potential for injury, infection, pain, and discomfort to the infant.

This article provides a step-by-step guideline for performing the heelstick procedure and specimen collection with proper technique.

BLOOD SAMPLING OBJECTIVES

Considerations when obtaining blood samples include accurate results, minimal potential for injury, infection, pain, and discomfort for the infant. Blood can be obtained from a neonate by various methods (Table 1). Each has advantages, and the reason for testing can dictate the most appropriate means of collection.

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Arterial blood can be collected from arterial access lines: umbilical arterial catheter (UAC), peripheral arterial line (PAL), or peripheral arterial puncture. For critically ill infants who require frequent testing, a UAC or PAL is indicated. These provide ready access to arterial blood for gases and other samples while sparing the infant multiple painful procedures. When attached to a transducer, the arterial line provides dynamic blood pressure readings.[1]

Venous blood can be obtained from an umbilical venous catheter (UVC), tunneled central venous catheter[2] (eg, Broviac, Hickman), peripherally inserted central catheter (PICC), or by venipuncture. Although research supports blood sampling from 3 French PICC lines in older children,[3] similar evidence is not available for the smaller (1.9-2 French) PICCs used for neonates. Because of the fragility of the lines, blood is not routinely drawn from neonatal PICCs unless line cultures are required. Although an available source for venous samples, tunneled central venous catheters require fastidious blood withdrawal procedure[2] to avoid potential infection.

Capillary blood from infants is obtained by heelstick. Capillary heel sampling is the usual source of blood for newborn metabolic screens.[4] Capillary blood is appropriate for routine laboratory tests, frequent bedside glucose monitoring[5] for infants at risk for hypoglycemia, and providing blood gas samples from infants whose status does not indicate the need for an arterial line.

WHY CAPILLARY BLOOD SAMPLING?

Of the means available for obtaining blood samples, capillary heel sampling is a minimally invasive technique that can be learned and performed by novice

TABLE 1. Sources and Means of Obtaining Blood Samples

	Arterial Puncture	Arterial Line (PAL, UAC)	Venipuncture	Central Venous Catheter (Broviac, Hickman)	Capillary Heelstick
General chemistry, hematology toxicology	Yes	Yes	Yes	Yes	Yes
Coagulation studies, panels,	Yes	Yes	Yes	Yes	No
Tests requiring samples >1 mL	Yes	Yes	Yes	Yes	No
Newborn screen	Yes	Yes	Yes	Yes	Yes recommended
Frequent glucose testing	No	Yes	No	No	Yes
Frequent blood gas monitoring	No	Yes	No	No	Yes (if PAL/UAC not available)
Blood cultures	Yes	Yes	Yes	Yes	No

PAL, peripheral arterial line; UAC, umbilical arterial catheter.

as well as experienced nurses. Effective capillary blood sampling can be achieved by using proper equipment, skin preparation, heelstick technique, blood collection, and reduction of infant discomfort by developmentally supportive positioning combined with oral analgesic measures.

Research supports venipuncture as less painful than heelstick in term newborns when performed by a skilled phlebotomist.[6] However, venipuncture has the potential to damage limited and valuable intravenous (IV) and PICC insertion sites.[7] These sites need to be conserved for premature and critically ill infants with ongoing requirements for maintenance fluids, parenteral nutrition, or IV medication administration.

CONTRAINDICATIONS

Heelsticks should not be performed on infants whose feet are edematous, injured, or infected or those who have anomalies that preclude putting pressure on the

SIDEBAR. Newborn Metabolic Screen

This widely mandated test has specific collection guidelines that must be followed carefully to ensure integrity of the sample and consequently, the accuracy of results. Newborn metabolic screens are usually sent to specialized regional testing facilities. Procedures are similar, but institutions must clarify and follow the directions of their specific testing facility.

The first sample must be collected between 24 and 48 hours of age. Check facility guidelines for special circumstances when infants receive a blood transfusion.

Samples must be collected from free-flowing blood that freely drops or is touched directly to the filter paper, as directed by the testing facility. Drops must not overlap and should be the approximate size of the circles on the filter paper. Some testing facilities do not require the drops to be inside the circles, as long as the samples are appropriate size and not overlapping. Filter paper containing samples must be dry before submission.

Capillary tubes and blood gas tubes containing heparin or other anticoagulants must never be used to collect and transfer blood for newborn metabolic screens because the anticoagulants interfere with metabolite analysis and can give misleading results. Consult the institution's laboratory guidelines as well as the directions of the laboratory performing the test to ensure proper submission. An excellent resource for more information and guidance on newborn metabolic screening is Bryant et al.[4]

foot. Heelsticks should not be performed on areas that are bruised or injured by multiple previous heelsticks.[7]

Heelstick samples are not appropriate for all tests. Venous or arterial sources should be used for blood cultures, which require sterile technique; special panels such as coagulation studies; and tests in which even a minimal amount of hemolysis will compromise results. Tests requiring more than 1 mL of blood should be obtained from venous or arterial sources.[7] Blood flow tapers during capillary testing, limiting sample size, and hemolysis resulting from prolonged pressure on the leg and foot can alter lab results.

Considerations for Capillary Heelstick Blood Sampling

Heel Lancing Devices

Improper lancing of the heel can result in nerve damage, bone damage, osteomyelitis, cellulitis, infection and scarring. Bone damage results from heelsticks that are sufficiently deep to pierce the calcaneus.[8,9]

Manual lancets (steel stylets with a V-shaped blade) were commonly used heelstick devices before the development and use of automated devices. The stylets expose a limited amount of capillary bed and do not have controlled incision depth; instead, they depend on pressure exerted by the clinician. Spring-loaded needle-type stabbing devices are designed to yield single drops for capillary blood glucose testing in older children and adults, and models for infants are available. These have the advantage of controlled depth but expose minimal capillary bed, resulting in limited free-flowing blood.

Automated heel lancing incision devices were designed specifically for capillary heel sampling in infants. The devices use a surgical steel blade that slices, rather than stabs. The depth and length of incision are controlled by the device. Studies comparing manual stylets with an automated heel-lancing incision device (Tenderfoot; ITC, Edison, NJ)[10-13] and spring-loaded, needle-type puncture devices with an automated heel-lancing incision device (BD Quickheel Lancet; Becton, Dickinson and Co., Franklin Lakes, NJ)[14] recommend use of the devices using automated slicing action.

Although the automated incision devices are more costly than the manual alternative or spring-loaded, needle-type devices, researchers recommend using the automated heel-lancing incision devices based on less damage to the heel,[10] less collection time, fewer punctures required,[12-14] less hemolysis in samples,[12] less pain,[14] and better wound healing.[10] A literature search of PubMed, OVID, and CINAHL using the key words *heel, heelstick, capillary blood,* and *blood sampling* identified no studies recommending the manual lancet or the puncture devices. There were no studies comparing the aforementioned automated incision slicing devices with each other, nor were there studies using brands of automated heel-lancing incision devices that use slicing action other than those listed.

A study using Tenderfoot and properly collected samples show laboratory results that are within acceptable tolerances as compared with samples from arterial catheters.[15]

Tenderfoot and BD Quickheel are available in a range of incision depths designed for different sizes of infants (Table 2). Controlled depths avoid damage to bone.[9,16] The shallower devices can be used to obtain small samples from larger infants who require frequent point-of-care glucose testing.

Heel Warming

Recent studies indicate no advantage to heel warming related to greater yield of blood from heelsticks.[7,17,18] In one of these studies, the group without warming received additional squeezing.[18] However, the authors do not recommend use of heel warmers.

TABLE 2. Automated Heel-Lancing Incision Devices for Neonates

Infant Size (Manufacturer Description)	Incision Depth	Incision Length	Product Description	Comment
<1 kg	0.65 mm	1.4 mm	Tenderfoot Micro-preemie	
>1 kg <1.5 kg Low birth weight	0.85 mm	1.75 mm	BD Quickheel, Preemie Lancet, Tenderfoot Preemie	Smaller devices can be used.
>1.5 kg newborn (birth to 3-6 months)	1 mm	2.5 mm	BD Quickheel, Infant Lancet, Tenderfoot Newborn	Smaller devices can be used.
6 months-2 years	2 mm	3 mm	Tenderfoot Toddler	Smaller devices can be used.

Analgesia/Comforting/ Developmental Positioning

Use of Sucrose

Numerous recent studies indicate that sucrose provides analgesia and that the effect is intensified with sucking.[19-23] Studies used a range of sucrose concentrations and doses. Sucrose was administered in different methods: with oral syringe, dropper, nasogastric tube, and on dipped pacifier. Sucrose is most effective when administered orally 2 minutes before the procedure.[19] The optimal dose of sucrose has not been firmly established. Stevens et al[19] suggest a range of 0.05 mL to 0.5 mL of a 24% solution based on infant size. NeoFax recommends a maximum of 2 mL with administration on dipped pacifier; sucrose can also be drawn into a dropper.[24] A dipped pacifier carries approximately 0.1 mL.[20]

Research shows that sucrose's effect occurs as a result of the sweet taste; the sucrose must make contact with the infant's tongue and buccal mucosa.[25,26] Sucrose administration via nasogastric tube is not effective.[26] The nurse must assess the infant's ability to suck and tolerate sucrose administration by pacifier or dropper. Sucrose administration may not be appropriate for infants who are in unstable condition, those unable to suck, or those who are receiving ventilation.

Positioning and Handling

Developmentally appropriate care includes positioning, swaddling, and environmental controls that enhance infant comfort during painful procedures[21,27] (Figure 1). Research indicates that facilitated tucking (assisting infant in flexing and bringing extremities to midline), swaddling, the use of pacifiers, and combining these measures with the administration of concentrated sucrose solution and sucking results in less measurable pain and quicker resolution of infant distress after the procedure.[21,23,27] Maintaining containment during and after procedures reduces stress.[28] In addition to environmental developmental measures, including light/noise reduction, the nurse must evaluate the infant's state and cues because combining clustered care with procedures may overstimulate and stress the infant and result in sensitized behavior responses.[21,29,30]

Site Selection

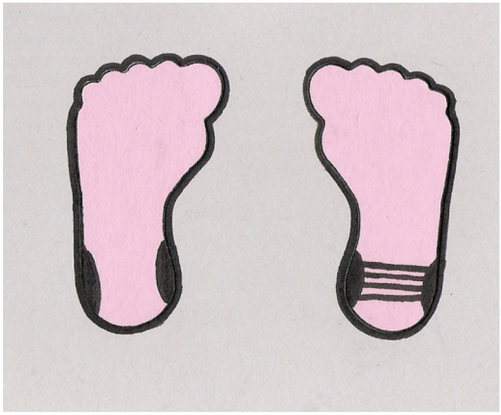
Blumenfeld et al[8] published recommendations based on postmortem studies performed on neonates in 1979 to determine optimal sites for heelsticks. The recommendations for heelstick sites included: (1) performing heel puncture on the most medial or lateral portions of the heel; (2) limiting puncture depth to 2.4 mm; (3) avoiding the posterior curvature of the heel; and (4) avoiding previous areas that may be infected. In the nearly 3 decades since this article was published, these guidelines have been the standard for capillary blood sampling from the heel. The recommendations remain safe and valid.[7] The skin to calcaneum depth is too shallow for incision at the end of the heel and places the infant at risk for bone damage and osteomyelitis.[7-9,16]

Development and implementation of controlled-depth automated heel-lancing incision devices prompted researchers to investigate expanding the recommended areas. The purpose was to determine if additional sites could avoid overuse and lessen damage to the sides of the feet for infants requiring multiple capillary blood samples. Two recent studies[9,16] used ultrasound to measure the skin-to-calcaneum distance on live neonates. The studies indicate the skin-to-calcaneum depth on the plantar surface between the historically approved sites for infants >33 weeks' gestation is 3 mm. This is sufficiently deep to render safe incision with controlled-depth automated devices having a maximum incision depth of 2.5 mm. The areas defined by Blumenfeld et al remain the standard.[7] The researchers suggest that the sampling area can be expanded safely for infants >33 weeks' gestation if repeated samplings have rendered the sides unsuitable and if controlled-depth devices are used (Figure 2).

FIGURE 1.

Infant is swaddled with hands to midline and pacifier in place. Low lighting and noise reduction assist in calming the infant.

FIGURE 2.



Safe incision areas are the sides of the heels on the plantar aspect of the foot. Research indicates that the plantar surface between those areas can be incised safely using a controlled-depth device if frequent sampling from the sides has rendered them unusable. Never incise the end of the heel.

PREPARATION

Ensure all equipment is available at the bedside before starting the procedure (Table 3). Depending on the institution's procedures, this may include laboratory labels for the samples. Verify orders for tests to be performed.

Proper patient identification and verification of patient blood samples at submission remain a vital priority. Follow your institution's policy guidelines to ensure the right test for the right patient.

TABLE 3. Equipment for Performing Capillary Heelstick Sampling

Equipment for Performing Capillary Heelstick Sampling
Gloves
Sucrose, pacifier, blanket for swaddling
Antiseptic in accordance with institution's policy
Pad or other means of protecting linens
Heel lancing device
Specimen collectors as appropriate:
Capillary blood gas tubes
Hematology tubes
Serum separator tubes
Newborn metabolic screen filter paper
Gauze wrap or cotton ball

PROCEDURE

Site Preparation

Proper site disinfection is essential to preventing infection (Table 4). Facilities should establish skin care and disinfection protocols in conjunction with AWHONN/NANN Evidence-Based Clinical Practice Guidelines for Neonatal Skin Care,[31] which recommends povidone iodine and chlorhexidine gluconate (Figure 3). Both products must be completely removed with sterile water or sterile saline to prevent tissue damage and contamination of sample. Allow the heel to dry before incising. Isopropyl alcohol is not recommended for premature infants.[31]

FOOT POSITION

The infant's position when obtaining a capillary blood sample must provide the sampler access to the puncture site and allow the sampler to apply pressure to

TABLE 4. Procedure for Performing Capillary Heelstick Blood Sampling

Gather equipment, including lab labels
Verify orders and identification of infant
Identify site is free of previous incisions
Administer sucrose to infant
Position infant with appropriate swaddling and pacifier
Prepare automated device
Don gloves
Cleanse site and dry
Position heel
Place automated device on site and activate
Apply pressure to leg and allow blood drop to form
Wipe away first drop
Using capillary action, fill blood gas tube first if being collected
Release pressure, allowing capillaries to refill
Guide blood drops to freely fall into tube with scoop collector
Flick hematology tube to activate anticoagulant
Place caps on tubes
Invert the tubes
Apply pressure to heel to stop bleeding
Label as directed by institution
Continue comfort measures

FIGURE 3.

Properly disinfect the site to reduce the potential for infection. Remove povidone iodine or chlorhexidine completely with sterile saline or sterile water and allow to dry. Alcohol should not be used for disinfection on premature infants.

the calf and the bottom of the foot. One method of obtaining blood without squeezing the heel is to place the fingers along the calf with thumb on the ball of the foot to provide counter-pressure (Figure 4). The fingers then apply pressure to the calf to "milk" blood toward the heel. Some practitioners prefer to place the thumb at the ankle with the forefinger along the arch of the foot. Both positions allow gentle pressure to facilitate blood flow. Regardless of the manner in which the foot is held, it is essential to avoid excessive heel squeezing to prevent sample compromise and avoid unnecessary pain to the infant. Sample compromise can occur from interstitial fluid leakage, hemolysis, and bruising.[7]

FIGURE 4.

Position the infant's foot so that pressure can be exerted on the calf. Counter-pressure can be exerted against the ball or arch of the foot. Do not squeeze the heel.

Incision

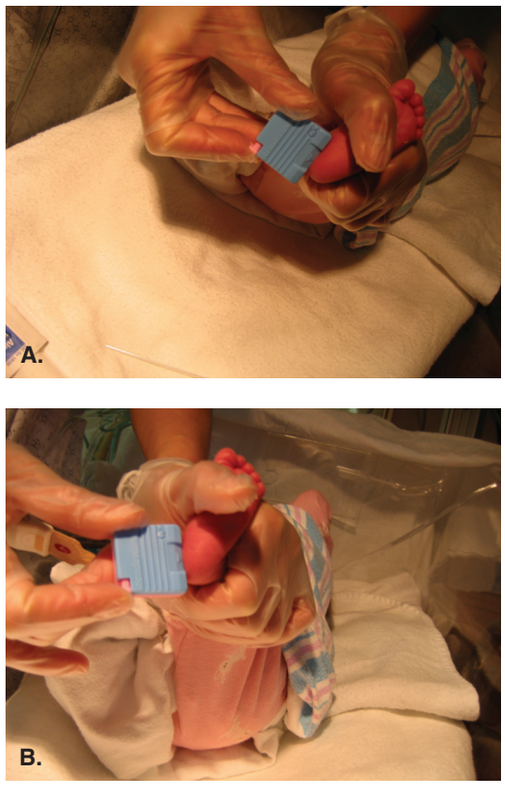
Place the automated incision device with the flat blade opening surface flush on the incision area without exerting pressure (Figure 5A-B). Depress the trigger and remove the device from the foot. Although the blades are completely retracted, the device should be disposed of in a sharps container.

After incising the heel, wipe away the first drop of blood to discard cellular debris that can contaminate the sample.[32] Apply gentle pressure to the leg, allowing large drops to form, and collect available drops. Release pressure to allow the capillaries to refill, and repeat.

Sample Collection

Blood is collected directly in a blood gas tube. When collecting a capillary blood gas sample, place the

FIGURE 5.



(A.) Place the incising device flush against the heel-stick area without exerting pressure. (B.) Depress the trigger and remove device from the area to begin collecting sample.

tube horizontally so that the blood is drawn by capillary action and does not collect air bubbles that can alter results (Figure 6).

Hematology tubes contain powdered anticoagulants. To activate the substance and minimize potential for clotting the sample, flick the side of the tube several times after the first couple of drops are in the tube. To prevent clotting, cap and invert the tube as directed by the institution's laboratory guidelines.

When using the scoop-shaped collectors provided with mini-lab tubes, use the devices to guide free-flowing blood drops to the specimen tube (Figure 7). Avoid repeated "scooping" of blood on the surface of the foot. Small clots can form in blood on the skin that can stimulate platelet aggregation and alter lab results.

If blood stops flowing, wipe the site to remove the clot, ensure time for capillary refill, and then reposition your hand and reapply pressure. If blood does not flow, choose another site and repeat procedure.

Newborn metabolic screen tests have strict collection guidelines. Samples are collected directly on to filter paper and should be free-flowing blood dropped onto or touched to the paper, depending on the guidelines of the laboratory performing the test. It is important to understand the laboratory's collection guidelines and follow them exactly to ensure accurate results.[1]

After completing blood sampling, apply pressure to the incision site with a cotton ball or gauze wrap. Avoid using adhesive bandages.[31] Continue comfort measures.

Order of Sample Collection

Collect samples in the order and manner directed by the institution's laboratory guidelines. One manufacturer of laboratory equipment recommends collecting EDTA (ethylenediaminetetraacetic acid, an anticoagulant) blood gas tubes first, then other additive tubes, including heparin or EDTA in hematology tubes, and finally serum samples (chemistry/toxicology).[32]

FIGURE 6.

Capillary blood gas samples are collected directly in the testing tube. Keep the tube horizontal to avoid air bubbles that can alter results.

FIGURE 7.

The "scoopers" included with mini-lab tubes can be used to guide drops into the tube. Avoid collecting blood that has spread onto the skin because microclots facilitate platelet aggregation and can interfere with results.

Conclusion

Advances in equipment designed specifically for capillary heelstick blood sampling as well as identification of appropriate pain-reduction measures have improved the heelstick process. Novice as well as experienced nurses are able to obtain more accurate samples than in the past, while minimizing discomfort and potential damage to the neonate.

The importance of providing accurate blood sampling and implications for further improvement in collecting blood for critical diagnostic tests in a compassionate manner provide numerous opportunities for further exploration in the field of capillary blood sampling. These include but are not limited to: further investigation into the use of Kangaroo Care and breastfeeding during procedures and the feasibility of incorporating these in the general NICU population during heelstick procedures; studies comparing similar products; qualitative validation studies of blood yield and laboratory values comparing products; qualitative validation studies of laboratory values using automated devices with and without heel warming; and longitudinal studies of NICU graduates to assess the long-term effect of multiple heelsticks on skin, heels, and walking.

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