Capillary Blood Collection: Best Practices

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Skin puncture or capillary blood collection involves puncturing the dermis layer of the skin to access the capillary beds which run through the subcutaneous layer of the skin. Blood obtained via skin puncture is a mixture of undetermined proportions of blood from arterioles, venules, capillaries, plus interstitial and intracellular fluids. The proportion of arterial blood is greater than that of venous blood, due to the increased pressure in the arterioles leading into the capillaries versus the pressure in the venules exiting the capillaries. Warming of the puncture site further “arterializes” the blood and increases blood flow.

Capillary blood collection is the preferred method of blood specimen collection for newborns and infants. Clinical Laboratory Standards Institute (CLSI) recommends capillary blood collection via heelstick for infants less than one year of age.\(^1\) For children older than one year, capillary blood collection via fingerstick should be considered, where appropriate.

Capillary blood collection may also be used for adults under certain circumstances including:

- Patients with fragile, superficial or difficult to access veins
- Patients where multiple unsuccessful venipunctures have already been performed, especially if the test(s) requested requires only a small volume of blood
- Patients with burns or scarring in venous blood collection sites
- Extremely obese patients
- Patients requiring frequent blood tests
- Patients receiving IV therapy in both arms or hands
- Patients at risk for serious complications associated with venipuncture, venous thrombosis, or deep venous puncture (e.g. deep vein puncture in infants, thrombophlebitis)
- Patients requiring only one blood test for which a capillary specimen is appropriate
- Patients whose veins are “reserved” for intravenous therapy or chemotherapy
- Point-of-care testing where only a few drops of blood are needed

Capillary blood collection is inappropriate for:

- Severely dehydrated patients
- Patients with poor circulation
- Coagulation studies requiring plasma specimens
- Tests that require large volumes of blood (i.e. Erythrocyte Sedimentation Rate (ESR) and blood cultures)

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It is important to understand that there are differences between some analytes in capillary blood as compared to venous or arterial blood specimens. Glucose, potassium, total protein, and calcium have been reported to show statistically and/or clinically important differences. With the exception of glucose, the concentration of these analytes is lower in capillary blood.

The following tests are commonly performed using capillary blood:

- Point-of-Care testing (POCT, i.e. blood glucose monitoring)
- Complete Blood Count (CBC), hemoglobin & hematocrit (H&H)
- Peripheral Blood Smear (manual slide for white blood cell (WBC) differential)
- Neonatal Blood Gases
- Neonatal Bilirubin
- Neonatal Screening (filter paper or blood spot testing)
- Electrolytes

The recommended Order of Draw for capillary blood collection is different from blood specimens drawn by venipuncture. CLSI recommends the following order of draw for skin puncture:

- Blood gases
- EDTA tubes
- Other additive tubes
- Serum tubes

After warming (arterializing) the site, it is recommended to collect capillary blood gases first, as the blood becomes increasingly more “venous” if the collection is delayed. Likewise, if collection of blood for a CBC (K2EDTA tubes) is delayed, there is an increased likelihood of erroneous cell counts due to platelet clumping.

**Device Selection**

There are two types of lancing devices that are used for collection of capillary blood: puncture devices and incision devices. Puncture devices (e.g. BD Microtainer® Contact-Activated Lancets) puncture the skin by inserting either a needle or blade vertically into the tissue. Puncture devices are preferable for sites that are repeatedly punctured (e.g. blood glucose monitoring). Incision devices (e.g. BD Microtainer® Quikheel™ Lancets) slice through the capillary beds. Incision devices are less painful than puncture devices and require fewer repeat incisions and shorter collection times, and are therefore, recommended, especially for infant heelsticks. Both types of devices come in a variety of styles, sizes and depths.
<table>
<thead>
<tr>
<th>Device</th>
<th>Device Name</th>
<th>Device Type</th>
<th>Width x Depth (mm)</th>
<th>Intended Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD Microtainer® Contact-Activated Lancet (Purple)</td>
<td>Puncture (needle)</td>
<td>30 G x 1.5 mm</td>
<td>Fingerstick – Low Flow (single drop)</td>
<td>Demonstrates significantly less pain for your patients than comparable products*</td>
</tr>
<tr>
<td>BD Microtainer® Contact-Activated Lancet (Pink)</td>
<td>Puncture (needle)</td>
<td>21 G x 1.8 mm</td>
<td>Fingerstick – Medium Flow</td>
<td></td>
</tr>
<tr>
<td>BD Microtainer® Contact-Activated Lancet (Blue)</td>
<td>Puncture (blade)</td>
<td>1.5 mm x 2.0 mm</td>
<td>Fingerstick – High Flow (500 μL from single puncture)</td>
<td></td>
</tr>
<tr>
<td>BD Microtainer® Quikheel™ Lancet (Pink)</td>
<td>Incision (blade)</td>
<td>1.75 mm x 0.85 mm</td>
<td>Heelstick – Low Flow (premature infants) Low birth-weight babies or full-term infants where lower blood volume is required</td>
<td></td>
</tr>
<tr>
<td>BD Microtainer® Quikheel™ Lancet (Teal)</td>
<td>Incision (blade)</td>
<td>2.5 mm x 1.0 mm</td>
<td>Heelstick – High Flow (infants) Full-term infants where higher blood volume is required</td>
<td></td>
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</tbody>
</table>

According to CLSI, a skin puncture device should be a sterile, disposable, single-use device with a permanently retractable blade or needle to reduce the possibility of accidental needlestick injuries and reuse. The use of manual lancets or blades without a retractable feature is a violation of OSHA regulations.

**General Site Selection**

The patient’s age, accessibility of the puncture site, and the blood volume required should all be taken into consideration when selecting the skin puncture device type and puncture site. Select a site that is warm, pink and free of any calluses, burns, cuts, scars, bruises, or rashes. The site should not be cyanotic (bluish from lack of oxygen), edematous (swollen), or infected. Avoid skin areas that have evidence of previous punctures or are otherwise compromised.

**Fingerstick Site Selection**

The recommended site for capillary collection on adults and children over one year of age is the palmar surface of the distal (end) segment of the third (middle) or fourth (ring) finger, ideally of the non-dominant hand. Fingers on the non-dominant hand are generally less calloused. The puncture should be made slightly off center from the central, fleshy portion of the fingertip and if using a blade-type puncture device, perpendicular to the fingerprint whorls. Puncturing along or parallel to the whorls may cause the blood to follow the pattern of the fingerprint, redirecting the flow and making it more difficult to collect. The index finger is often calloused and potentially more sensitive to pain due to additional nerve endings. The thumb also may be calloused and has a pulse, indicating arterial presence, and, therefore, should be avoided. The distance between the skin surface and the bone in the fifth finger also makes it unsuitable for puncture. The side and tip of the finger should be avoided, as the tissue is about half as thick as the central portion of the fingertip.

**Heelstick Site Selection**

The recommended site for heel punctures is the lateral (outside) or medial (inside) plantar surface of the heel. In small or premature infants, the heel bone (calcaneus) may be no more than 2.0 mm beneath the skin surface and no more than half this distance at the posterior curvature of the heel. Puncturing deeper than 2.0 mm on the plantar surface of the heel of small infants may, therefore, risk bone damage. When using incision devices, puncturing the heel at a 90° angle to the length of the foot is recommended. Such incisions create a “gap” puncture (one which opens when pressure is applied) and further enhance blood flow.

For infants, punctures must not be performed on:

- The posterior curvature of the heel.
- The central area of an infant’s foot (area of the arch). Punctures to this area may result in injury to nerves, tendons, and cartilage.
- The fingers of a newborn or infant less than one year old.
- Earlobes.
Best Practice for Capillary Blood Collection

The following steps should be performed in accordance with the facilities’ recommended procedures.

1. Review the test requisition(s).
2. Gather the appropriate supplies (lancing device, gloves, gauze, alcohol, bandages, etc.).
3. Positively identify the patient.
4. Verify diet restrictions (fasting required, etc.) and any latex sensitivity (if products containing latex are being used).
5. Wash hands and put on gloves.
   NOTE: All patient and laboratory specimens are treated as potentially infectious and handled according to “standard precautions.” Standard precaution guidelines are available from the U.S. Centers for Disease Control and Prevention (www.cdc.gov).
6. The patient should be sitting or lying down.
7. Select appropriate puncture site.
8. Warm the puncture site.
9. Clean the puncture site with 70% isopropyl alcohol and allow to air dry. The site must be allowed to air dry in order to provide effective disinfection.
10. Notify older children and adults of the imminent puncture.
11. Puncture the skin with the disposable lancing/incision device.
12. Wipe away the first drop of blood with a dry gauze pad (refer to each point-of-care device manufacturer’s instructions).
13. Collect the specimen in the appropriate container, and mix according to the manufacturer’s instructions.
14. Seal the specimen container.
15. Apply direct pressure to the wound site with a clean gauze pad and slightly elevate the extremity.
16. Label the specimen container in direct view of the patient or guardian to verify identification, and record time of collection. Label each container individually.
17. Properly dispose of the lancet/incision device in a puncture-resistant disposal container.
18. Properly dispose of any other contaminated materials (gloves, gauze, etc.) in a container approved for their disposal.
19. After removing gloves, wash hands before proceeding to the next patient.

Special Specimen Collection Requirements

1. Bilirubin samples must be protected from light, both during and after collection, as light breaks down bilirubin. If collecting a capillary specimen from an infant in an incubator, turn off the ultraviolet (UV) light source above the infant during specimen collection. Collect capillary blood specimen quickly to minimize exposure of the blood specimen to light. Use amber collection containers or foil to protect specimens from light. Ensure that the UV light is turned back on before leaving the nursery.

2. For newborn screening (filter paper collection), gently touch the filter paper against the blood drop in a single step to allow a sufficient quantity of blood to soak completely through the paper and fill the preprinted circle. The paper must not be pressed against the puncture site on the heel. If the circle does not fill entirely, wipe the heel and touch a different circle to the blood drop until the circle is completely filled. Blood must soak through the paper within the circle to the other side, and must be applied to one side of the paper only.
Top 10 Keys to Obtaining a High Quality Capillary Blood Specimen

1. **Positively Identify the Patient** – Positive identification of the patient is the most important step in specimen collection. Patient misidentification can lead to incorrect diagnosis, therapy and treatment. The consequences can be serious, even fatal to the patient.

2. **Puncture Site and Lancing/Incision Device Selection** – Determine the appropriate puncture site and lancing/incision device for the patient and the tests requested. Using the wrong size lancet/incision device may result in excessive squeezing, prolonged or incomplete collection, poor specimen quality (hemolysis, clotting) and possible redraws, as well as injury to the patient (mainly children).

3. **Warming the Puncture Site** – Only a limited amount of blood will easily flow from a capillary puncture. Warming the puncture site will increase blood flow up to seven times and is critical for the collection of blood gases and pH specimens. CLSI guidelines recommend warming the skin puncture site for three - five minutes with a moist towel or commercially available warming device at a temperature no greater than 42°C.

4. **Cleaning the Puncture Site** – Allow the alcohol to air dry. Performing skin puncture through residual alcohol may cause hemolysis and can adversely affect test results. It also may cause additional discomfort for the patient. Do not use povidone-iodine to cleanse the puncture site. Povidone-iodine interferes with bilirubin, uric acid, phosphorus and potassium.

5. **Wipe Away the First Drop of Blood** – Immediately following skin puncture, platelets aggregate at the puncture site to form a platelet plug, initiating the clotting process. Without wiping away the platelet plug, bleeding may stop prior to completion of the blood collection, resulting in insufficient blood volume and redraws. In addition, the first drop of blood contains tissue fluid, which can cause specimen dilution, hemolysis and clotting.

6. **Avoid Milking, Scooping or Scraping of the Puncture Site** – It is recommended to touch the collector end of the container to the drop of blood. After collecting 2 or 3 drops, the blood will freely flow down the container wall to the bottom of the tube. Excessive squeezing (milking), scooping and scraping may cause hemolysis and/or tissue fluid contamination of the specimen. Using a “scooping” or scraping motion along the surface of the skin can also result in platelet activation, promoting platelet clumping and clotting.

7. **Collect Specimen Quickly** – Puncturing the skin releases thromboplastin, which activates the coagulation process. Specimens must be collected quickly to avoid exposure to atmospheric air and light (blood gases and bilirubin testing).

8. **Fill to the Correct Fill Volume** – Fill containers to the recommended fill volume (if indicated). Underfilled containers will have higher concentrations of additives. For K2EDTA, higher concentrations may cause erroneous results for MCV and red cell indices and cause RBC and WBC morphological artifacts. Consequently, overfilled containers will have lower concentrations of EDTA and may result in clotting.

9. **Mix Specimen** – Microcollection tubes must be inverted the appropriate number of times to ensure that the blood and anticoagulant are sufficiently mixed. Mixing is essential to prevent the formation of microclots and platelet clumps, which can cause inaccurate or erroneous test results. Small clots can also occlude sample aspiration probes or tubing in laboratory instruments, resulting in instrument downtime and/or additional unscheduled maintenance. While modern analyzers have sophisticated detection systems to recognize platelet clumps, it is still possible for platelet clumps to cause erroneous test results (e.g. platelet count, platelet volume, red cell volume, white cell count). Adequate mixing, both during and after the completion of capillary blood collection, will help minimize these occurrences.

10. **Properly Label Specimen** – Each tube should be individually labeled at the bedside prior to leaving the area. Mislabeling of the specimen can lead to incorrect diagnosis, therapy and treatment. The consequences can be serious, even fatal, for the patient.

In summary, there truly is an “art” to capillary blood collection. These 10 steps provide guidelines to assist your facility in selecting the appropriate lancing/incision device and puncture site for a successful capillary blood collection—the first time. A high-quality specimen minimizes errors and possible re-draws, while enhancing customer satisfaction and patient care.

**References**

5. Product literature. BD QuikHeel™ Safety Lancet.
The need for improved workflow remains at the forefront of efficient laboratory management. This has placed additional emphasis on laboratory resources, both in the private and hospital sectors, to deliver quality services and enhance productivity. In addition, the demands for improved throughput have reiterated the focus on more rapid receipt of test results as well as reduction in preanalytical errors (e.g. hemolysis—a major reason for specimen rejection), which require sample re-draws and re-work, contributing to delays in report time. As such, more and more laboratories are including turnaround time as a key performance indicator of their services. However, many have difficulty in meeting these goals.

To address the needs for improved workflow efficiency and turnaround time, BD Diagnostics – Preanalytical Systems has introduced a new fast-clotting serum blood collection tube in the US—the BD Vacutainer® Rapid Serum Tube (BD RST). The BD RST is a 4mL-draw, 13x100mm plastic sterile blood collection tube with a gel separator and a thrombin additive. The thrombin additive promotes rapid clotting of the blood, allowing the BD RST to be centrifuged five minutes after collection to provide a quality serum specimen that can be sampled directly from the primary tube.

The five-minute clotting time of the BD RST represents a significant reduction in clotting time as compared with traditional serum gel tubes, which typically require a minimum clotting time of 30 minutes. This may result in a time savings of up to 25 minutes, improving laboratory workflow. In addition, in a recent study conducted by BD in the Czech Republic, the combination of the BD RST using a 3-minute centrifuge time on the StatSpin® Express 3 centrifuge led to significantly faster preanalytical turnaround time by an average of 38.5 minutes. The increased test result turnaround time may potentially lead to more rapid diagnosis and treatment planning, which are vital for patients in many hospital units (e.g. emergency, cardiac, intensive care). Faster patient diagnosis and treatment in the Emergency Department (ED) accelerate discharge or admission, which decrease the overall length of stay in the ED. As a result, the ED can increase patient throughput and reduce patient diversions, all key services for hospitals today.

**Clinically Proven Performance**

In order to demonstrate the clinical performance of the BD RST, seven clinical studies were conducted to evaluate the BD RST for a wide range of clinical chemistry assays—routine and special chemistry analytes (e.g. cardiac markers, female hormones, thyroid hormones). In addition, selected analytes in immunology were also evaluated (e.g. C3, C4, IgG, IgM). Following blood collection by routine venipuncture, the studies were performed to assess the tube’s efficacy and spanned a wide range of patient populations (apparently healthy adult subjects, cardiac patients, pregnant subjects, patients with a range of clinical diagnoses and conditions).
Clinical performance was evaluated on a range of instrument platforms* including:

- Abbott AxSYM®
- Bayer ADVIA® Centaur
- Beckman Coulter Access® 2
- DPC Immulite®1000
- Olympus AU5200™/AU5400™
- Ortho Clinical Diagnostics VITROS® ECi
- Ortho Clinical Diagnostics VITROS® 5,1 FS
- Roche COBAS Integra® 800
- Roche Modular

The performance of the BD RST was evaluated in comparison to a control serum gel tube at initial time. In addition, 24-hour stability was assessed for all analytes.

**Improving a Source of Specimen Rejection**

Hemolysis results from the degradation or lysis of red cells in blood samples and continues to be a frequent occurrence in clinical laboratories; prevalence may be as high as 3.3% of routine specimens, accounting for up to 40%-70% of unsuitable specimens. This is more than five times higher than other causes for specimen rejection.3 In addition, the presence of hemolysis may alter laboratory-generated analytical results, possibly causing certain analytes to be increased due to leakage of red cell constituents or interference with the test method.4 These issues contribute to increased time to test results and necessitate repeat collection by phlebotomy.

All tubes in the studies were evaluated for hemolysis (trace level or higher). The results demonstrated a significant reduction in hemolysis in the BD RST as compared to a control serum gel tube when specimens were collected via routine venipuncture. The hemolysis rate in the BD RST was 28/1034 samples (2.71%), while the serum gel tube exhibited a rate of 32/579 samples (5.53%). This reduction in hemolysis may improve specimen quality and preclude the need for repeat draws.

Today’s demands for improvements in laboratory workflow and turnaround time remain a challenge for healthcare professionals. The reduced clot time of the BD RST can aid in decreasing sample processing time, which may significantly enhance patient throughput. This is particularly vital for units of the hospital in which test results drive important medical decisions on patient treatment. ■

For inquiries on the BD RST, please contact BD Technical Services at 1-800-631-0174 or contact your local BD Sales Consultant.

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**REFERENCES**

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◆ Quality Serum Specimens with the Speed of Plasma—Introducing the BD Vacutainer® Rapid Serum Tube