White paper

Method for direct hematology testing of capillary blood facilitates analysis in children

For many children, the worst part of their visit to the healthcare facility is the experience of the needle procedures (1). Although vein puncture is the primary method of blood collection for diagnostic testing, the method requires trained and experienced phlebotomy expertise and is often affected by pre-analytical errors. Collection of capillary blood for analysis can therefore be an option to improve the blood sampling experience in pediatric care, and at the same time mitigate many of the risks associated with blood collection in vacuum tubes. The capillary sample procedure of Boule automated hematology analyzers is a direct method specially designed to allow hematology testing in patients from whom a venous blood sample is not available.

Boule

Key challenges in pediatric blood collection

Pediatric hematology concerns infants, children, and adolescents that are diagnosed with disorders affecting the blood cells, such as infectious diseases, anemia, platelet dysfunctions, bleeding, and other blood clotting diseases. In pediatric oncology, leukemia is the most common cancer in children (2). Diagnosis of such disorders typically includes determination of a range of hematology parameters in whole blood samples.

Children are among the most difficult patients from whom to collect blood samples. Of utmost importance is to consider the child's physical and emotional well-being; yet ensuring safety and efficacy when collecting blood. Vein puncture can be both a traumatic and painful experience. Compared with adults, pediatric patients have smaller veins and an excess of subcutaneous fat, making visualization and palpation of veins challenging in children (3).

Analysis of capillary blood instead of venous blood can therefore be especially useful in pediatrics (Fig 1). A large part of the procedures in neonatal units are performed using capillary blood samples also to avoid effects of blood volume reduction and to reduce the risk of anemia (1, 4).

Fig 1. Boule hematology analyzers equipped with the micro-pipette adapter (MPA) inlet allow for CBC testing directly from a finger-stick blood sample taken directly from the patient. No vacuum tube, predilution, or tube mixing prior to analysis is required.

Pre-analytical risk factors

The capillary blood collection method is gaining popularity, as blood sampling from a fingerstick or heel-prick many times is considered less invasive to the patient and easer to perform for the health care professional (4, 5). Capillary blood collection for direct hematology testing can also help overcome many of the pre-analytical errors associated with venous blood collection in vacuum tubes, including blood clotting or hemolysis as well as erroneous labelling or incorrect tube filling. Failure to fill the vacuum tube completely, which can be the case when sample volume is limited, will cause an improper blood-to-anticoagulant ratio, resulting in erroneous test results especially affecting the platelet count. For blood collection where the sample volume is limiting, methods involving a predilution step are available. However, dilution is associated with risk of human error and with the risk of dust particles or other impurities that can affect the cell count entering the sample, resulting in poor repeatability and precision.

A complete blood count from a finger-stick sample in a minute

Boule automated hematology systems are trusted for their high reliability and ease-of-use. The systems are designed to deliver a complete blood count (CBC), including a WBC differential count, with speed and precision.

The 3-part analyzers offer a wide choice of sampling methods: from whole blood or pre-diluted blood, from open or closed tubes, from single tubes of from tubes loaded on autosampler wheels that provides constant mixing of queued samples. Analyzers equipped with the micro-pipette adapter (MPA) inlet allow for CBC testing from a simple finger-stick blood sample taken directly from the patient (Table 1). The MPA method contributes to mitigating many pre-analytical errors associated with vein puncture blood collection, vacuum tube filling, and predilution of the blood sample.

"The small volume of capillary sample is important when handling infectious diseases. Capillary sampling is also less fearful for children, feeling more comfortable when holding them by the finger rather than grabbing their arm."

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Table 1. Capillary versus venous blood collection for analysis on Boule automated 3-part hematology systems

	Capillary blood sampling for MPA inlet	Venous blood sampling for tube inlets
Simple	Although some training is required, skin puncture is often considered less complex and can be done in absence of phlebotomy expertise (5).	Vein puncture requires experienced and trained healthcare professional, e.g., phlebotomist (5)
Fast	Sample can be analyzed directly after collection, no mixing required.	Sample should be allowed to equilibrate to the EDTA for 15 min after collection and thoroughly mixed before analysis.
Efficient	Requires: • Lancet (~ 2 mm) • Boule EDTA micropipette	Requires: • Tourniquet • EDTA tube • Sample collection set (incl. holder, luer adapter, needle)
Convenient	Less risk of injury to patient (4)	Risk of (6): • Hematoma • Nerve damage • Pain • Hemaconcentration • Extravasation • Iatrogenic anemia • Arterial puncture • Petechiae • Allergies • Fear and phobia • Infection • Syncope and fainting • Excessive bleeding • Edema and thrombus

Capillary sample blood collection procedure

Improper preparation and blood collection procedures can cause discrepancies between capillary and venous blood values. In hematology, for example, the tendency of the platelets to clump or adhere to tissue and to the walls of the capillary sampling tube can affect the test results. Consequently, the platelet count can be 5% to 10% lower in capillary blood, and if platelet clumping occurs, the lymphocyte count can be falsely elevated. It is therefore important to follow general guidelines for capillary blood sample collection to obtain reliable results (7).

The sampling procedure should ensure a good blood flow. A deep and firm puncture allows for free-flowing drops of blood. To increase the blood flow, the site for puncture can be warmed for some few minutes before disinfection and puncture of the skin. To minimize interstitial and intracellular fluids in the sample, the first drop of blood should be wiped off with a clean tissue. The sample should be analyzed directly after collection, and for optimal results, no longer than 10 min from collection.

For analysis on Boule automated 3-part hematology systems, follow the below steps based on the procedure for optimal collection of capillary blood specimens given in the CLSI standard GP42-A6 (8).

Wash hands, put on gloves and any other safety equipment specified by established local laboratory protocol for contact with potentially biohazardous materials.

1. Choose site for skin puncture. See CLSI standard GP42-A6 for details on recommended site for finger and heel punctures (8).
2. Warm the skin site for 3–5 min before puncture to increase blood flow to the site (arterialization). This can be done using a warm, moist towel or other warming device.
3. Disinfect by cleansing the site with 70% aqueous solution of isopropanol or appropriate disinfectant. Allow the skin to dry before puncture.
4. Remove MPA adapter from the analyzer by gently pulling the handle.
5. Perform the puncture (Fig 2A) by following the lancet packaging insert for instructions on proper preparation and use:
   a. Position lancet firmly against the puncture site and puncture skin.
   b. It is important to perform a deep and firm puncture to obtain free flowing drops of blood, which decreases incorrect or non-reproducible results.
   c. Properly discard lancet per laboratory protocol.
6. Collect specimen (Fig 2B):
   a. After puncture, wipe away the first drop of blood with a clean tissue or gauze pad (first drop of blood often contains excess tissue fluid).
   b. By holding puncture site downwards and applying gentle, intermittent pressure above the site, the blood flow will be enhanced. Do not use scooping motion or strong repetitive pressure ("milking") to the site, as this can cause hemolysis or contaminate sample with excess tissue fluid.
   c. When second drop forms:
      i. Either use the micropipette holder to grasp a micropipette (holding the micropipette in one end, instead of in the middle, is best for filling and insertion). Aspirate the sample, holding the micropipette at a slightly downward angle for quickest fill, while being careful to only allow the tip of the pipette to touch the drop of blood (not the finger directly).
      ii. Or turn the patient's palm downward and position the micropipette directly under the puncture site to collect blood drops.
   d. Dispose of all materials according to laboratory protocol.

   Attention: Fill the micropipette completely with fresh whole blood and wipe off excessive blood on the outside surface (Fig 2C). Be careful not to wick blood from open ends of the micropipette.
7. Complete procedure:
   a. Transport sample to analyzer for processing by inserting the filled micropipette into the MPA devise using the micropipette holder and insert the devise into the analyzer and an analysis cycle with automatically begin (Fig 2D).
   b. Samples should be analyzed directly after collection and, for optimal results, no longer than 10 minutes from collection.

Following general recommendations, the results obtained with capillary samples using the MPA inlet are comparable with those obtained with venous blood samples using the open tube (OT) inlet (Table 2).

(A) (B) (C) (D) (E)

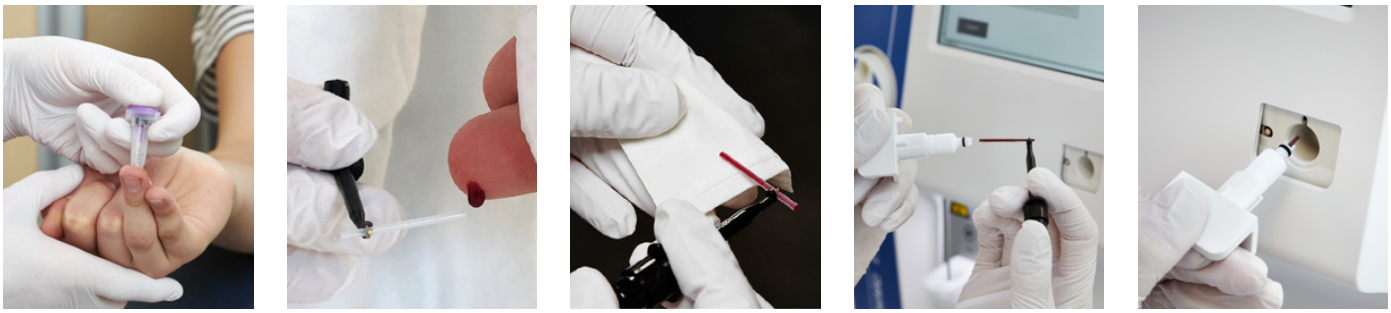

Fig 2. (A) Puncture with lancet. (B) Collect specimen. (C) Prepare micropipette. (D) Slide the tube into the adapter and (E) insert the adapter into the analyzer. CBC results are viewable on the display in about one minute.

Table 2. Comparison of capillary blood collected in micro-pipettes and analyzed in MPA mode versus venous blood collected in bullet tube and analyzed in open-tube mode

Parameter	Unit	N	Range (venous)		Mean venous	Mean capillary	Bias	Bias%	Specification limit		Result
			Low	High					Bias	Bias%	
WBC	10^9/L	52	3.5	11.3	7.0	6.8	-0.14	-2.0%	NA	± 7%	Pass
LYM%	%	52	15.3	48.3	34.6	36.8	2.13	6.1%	± 5	NA	Pass
MID%	%	52	2.3	6.6	4.3	4.4	0.08	1.8%	± 5	NA	Pass
GRAN%	%	52	45.5	81.8	61.1	58.9	-2.21	-3.6%	± 5	NA	Pass
RBC	10^{12}/L	52	3.57	5.58	4.81	4.88	0.07	1.5%	NA	± 4%	Pass
HGB	g/dL	52	11.8	16.6	14.5	14.6	0.13	0.9%	NA	± 4%	Pass
MCV	fL	52	78.0	102.0	89.3	87.6	-1.65	-1.8%	NA	± 2.5%	Pass
HCT	%	52	35.4	50.4	42.8	42.6	-0.18	-0.4%	± 2	NA	Pass
RDW%	%	52	11.8	14.0	12.6	12.8	0.17	1.4%	± 2	NA	Pass
PLT	10^9/L	52	134	352	219	204	-15.31	-7.0%	NA	± 10%	Pass
MPV	fL	52	7.6	11.3	9.1	8.5	-0.64	-7.0%	NA	± 10%	Pass

NA = not applicable

Conclusion

Drawing blood on a young child can be difficult for the child itself, its parents, as well as for the laboratory technician or nurse performing the intervention. Capillary blood collection can help improve the sampling experience for all involved. Performed in a proper manner, capillary sampling can minimize risk for pre-analytical errors, while being both more convenient for the patient and easier to perform for the healthcare professional.

Boule automated hematology analyzers equipped with the MPA capillary sample inlet are designed to facilitate hematology testing in children and other patients that are hard to puncture. The method allows CBC testing directly from a fingerstick blood sample, mitigating many of the risks associated with vein puncture blood sampling.

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Disclaimer

The results and conclusions presented in here are valid for this work only. Other conditions and assumptions could have significant impact on the outcome.

Boule automated hematology systems are for *in vitro* diagnostic use under laboratory conditions. Boule products do not make diagnoses on patients. Boule intends its diagnostic products (systems, software, and hardware) to be used to collect data reflecting the patient's hematological status. This data, in conjunction with other diagnostic information and the evaluation of the patient's condition, can be used by a trained clinician to establish a patient's diagnosis and to define clinical treatment.

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