Capillary blood

Can it replace venous blood?

The “when, where, what and how” of capillary blood

Many blood analyses can be performed either with venous blood or with capillary blood. If no large amounts of blood are required and an analysis in whole blood is possible, capillary blood should always be preferred. Reasons for this are:

It is patient-centered: The majority of patients opt for capillary blood collection compared to other collection techniques. It is more comfortable and less painful.

It is easier: Capillary blood collection is simply done by a quick stab to the fingertip, which can be performed by almost anyone anywhere after minimal training. No phlebotomist or doctor is needed to receive the blood.

And sometimes it‘s even a must, as in cases where the veins of patients are inaccessible, in burn patients, in neonates, in patients with clot-forming tendencies, just to name a few.
This is possible because new technologies for blood analysis require less and less sample volume and can be performed with easy-to-use instruments. In connection with capillary blood, some facts have to be considered which are explained here in detail:

When does capillary blood make sense?

Capillary blood collection is currently performed mainly in the following cases:

- When only a small amount of blood is needed.
- If venous blood cannot be drawn because, for example, veins are not accessible, as in older patients, patients with obesity or burn victims.
- If the patients are newborns and babies, taking large amounts of blood can cause anaemia or cardiac arrest.
- If risk is to be minimized in patients with anticoagulant tendencies.[1]

In addition, there is also a significant percentage of patients (about 20%) who are afraid of needles and therefore prefer capillary extraction.[2]
Capillary blood collection has many advantages. Why is it not done more often, especially when you consider the risks associated with venipuncture? These are venous damage, damage to surrounding tissue, bleeding, venous thrombosis, infection and gangrene as well as cardiac arrest to name but a few.[1] Initially, many physicians remain with venous sampling as the laboratory system is based on the handling of standardized tubes with fairly large dimensions of 13 x 75 mm or even 16 x 100 mm.

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Therefore, a change to capillary blood collection, where only a few drops of blood are collected, must be accompanied by a change in the analytical process. Either there is a shift to near-patient testing/ point of care instruments or new concepts of capillary blood collection, stabilization and handling are needed.

Where should capillary blood be taken from?

Capillary blood is easy to collect because the sites are easily accessible: At the fingertip, earlobe, heel base or big toe. When selecting the puncture site and the type of lancet, the patient‘s age, the accessibility of the puncture site and the required blood volume should be taken into account. Choose a site that is warm, pink and free of calluses, burns, cuts, scars, bruises or rashes. It is typically performed at the fingertips of adults and at the heel of infants as the likelihood of dripping on the patient‘s clothing is lower.

What to consider: Are there differences between capillary and venous blood?

The differences between capillary and venous blood in most cases are minimal. However, there are some discrepancies in hemoglobin and hematocrit values and in platelet counts.[3] It is well known that capillary blood has higher hemoglobin and hematocrit values than venous blood. Water is leaving the capillaries during the passage through the capillary and gets absorbed afterwards in the venules again.[1] Small disparities exist in glucose, potassium, total protein and calcium and 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. Similarly, when undertaking an INR test where prothrombin (clotting) time is measured, there is increased imprecision due to pre-analytical factors such as the length of time it takes to collect the sample and initiate a test. Limitations such as these are not a factor when a laboratory tests venous samples. But also the way in which the capillary blood is taken has to be considered to avoid discrepant results.

How should capillary blood be collected correctly?

The Clinical Laboratory Standards Institute (CLSI) recommends to use a skin-puncture device which is sterile, disposable and single-use with a permanently retractable blade or needle to reduce the possibility of accidental needle stick injuries and reuse. There are two types of lancing devices that are used for collection of capillary blood: puncture devices and incision devices.
Of course, thicker lancets with greater penetration depths are more painful, but you get higher blood volumes, which in many cases is better than having to perform repeated finger-pricks.[4]

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Lancet types	Capillary blood vol. (mean)	Body part / flow / comments
30G – 28G	44.1 µl	Fingerstick / low flow (single drop) / less painful
25G – 21G	79.1 µl	Fingerstick / medium flow
18G – 0.8 mm	124.9 µl	Heelstick / high flow /newborn babies or laboratories where a larger volume of blood is required

Source: Own table according to[4]

Typically, only a limited amount of blood will easily flow from a capillary puncture, which is a challenge. There is the risk that the person collecting the capillary sample starts to milk the finger by squeezing, scooping, scraping and trying to cross out the blood of the finger. This leads to contamination of the specimen by hemolysis and/or tissue fluid.[5, 6] If this happens, the sample is diluted and incorrect values are generated.

Warming the puncture site will increase blood flow up to seven times. Therefore, CLSI guidelines recommend warming the skin puncture site for three to five minutes with a moist towel or a commercially available warming device at a temperature maximum of 42°C.
For most tests, you should also wipe away the first drop of blood with a dry gauze pad because it is rich in interstitial fluid, platelets and thromboplastins that cause accelerated clotting.[5]

Typically the blood can be collected by any kind of capillary tube or blood transfer device.
The capillary tube, transfers the blood directly into any kind of measurement system, like POC devices. Alternatively it stores the blood until it is analyzed or transports the blood into a micro tube for the collection of higher volumes.

Use of capillary blood for a full blood count (FBC)

For a FBC count, usually a venous sample is preferred because there are two challenges. First, most analyzers need at least 100 µl blood, although the claimed sample volume is only 20 µl. The reason is the dead volume needed to aspirate the claimed sample volume. Collecting more than 20 µl capillary blood increases the risk of milking the finger/heel which may add tissue fluid into the sample. Or more painful lancets must be used to gain higher blood volumes.[4]
The second challenge is the limited precision of capillary samples applied to a conventional hematology analyzer. If less than 20 µl of blood is available, the analysis is done in a pre-dilution mode where the blood is diluted with 480 µl diluent.

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From the diluted sample, the hematology analyzer needle takes the needed 20 µl standard sample volume. In this pre-diluted sample, only 1 of 25 cells collected gets investigated by the analyzer, the others remain in the pre-diluted solution. Therefore, the precision and accuracy of analyzers are much lower in pre-diluted mode in comparisons to whole blood mode.

With the capillary blood mode of the 5-part diff analyzer HumaCount 5D, the two challenges are solved: The needed capillary blood volume is 20 µl and almost all cells of this capillary blood volume are measured inside the analyzer. In this way, the accuracy and precision of HumaCount 5D is comparable to the specifications achieved on venous samples.

Summary

In general, capillary blood collection is much preferred by both patients and lab technicians. The method is simpler, less painful and rarely requires a „second prick." Majority of results are comparable between capillary blood and venous samples, except for a few analytes if the collection of capillary blood is done correctly.

In hematology, HUMAN offers a full 5-part diff blood count using only one drop of blood from a capillary sample, providing results with the same quality as on venous samples.

The debate in general is still ongoing on whether in all circumstances a correlation exists between venous and capillary blood results. Though there is not a definitive conclusion to this debate, there is much research to show that capillary blood can provide quality results, which may correlate to or even match traditional venipuncture reference values. Check out these 2 articles to learn more.

Osteresch B., Cramer B., Humpf H.U. (2016) Analysis of Ochratoxin A in Dried Blood Spots - Correlation between Venous and Finger-Prick Blood; the Influence of Hematocrit and Spotted Volume. Journal of chromatography.

Keevil B.G., Fildes J., Baynes A., Yonan N. (2009) Liquid chromatography-mass spectrometry measurement of tacrolimus in finger-prick samples compared with venous whole blood samples. Annals of Clinical Biochemistry. 46 (Pt 2): 144-5

Literature:

(1) R.E. McCall, C.M. Tankersley, Phlebotomy Essentials. Lippincott Williams & Willkins, 2008.
(2) Jerry Emanuelson, http://www.needlephobia.com, 1997-2016.
(3) S.M. Kayiran, N. Özbek, M. Turan, B. Gürakan; Significant differences between capillary and venous complete blood counts in the neonatal period. International Journal of Laboratory Hematology, Volume 25, Issue 1, Feb 2003.
(4) K. Jarus-Dziedzic, G. Zurawska, K. Banys, J, Morozowska; The impact of needle diameter and penetration depth of safety lancets on blood volume and pain perception in 300 volunteers: A randomized controlled trial. Journal of Medical Laboratory and Diagnosis, Vol. 10(1), pp. 1-12, January 2019.
(5) http://www.euro.who.int/__data/assets/pdf_file/0005/268790/WHO-guidelines-on-drawing-blood-best-practices-in-phlebotomy-Eng.pdf?ua-1 (2010), 10 December 2019
(6) Meites S.; Skin-puncture and blood-collecting techniques for infants: updates and problems. Clinical Chemistry, 1998, 34(9):1890–1894.

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