Research Article

Painless Blood Sampling Technique: A Way of Injecting

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Abstract

In and out patients of different age groups are subjected to repeated skin piercing in order to complete the diagnosis, which may cause psychological consequence due to the painful experience or because of phobia fear of needles. We attempt to review most experimental studies investigating the effectiveness of the currently used techniques in reducing the pain related to blood sampling. Venepuncture Methods have been always linked with pain. Nevertheless, it is the most common technique used worldwide. The effectiveness of this methods is mainly depends on the quality of the equipment used as well as the phlebotomist qualification. Polymer microfluidic blood sampling device is a recent innovation that aims to improve the technological ease of blood sampling and to minimize the frequency of venepuncture that the patient exposed to. However this method can only help in-patients. 3D Micro-Needle is the most recent technology that grapes the attention of health care manufacture. Despite the success of this technology in providing less painful alternative for blood sampling, the application of this technology is yet to be adopted in the current practices in hospitals. Dried Blood Spot (DBS) Method is the favourable and the common sampling tool for neonatal screening of various diseases worldwide. This method has been developed into many forms aiming to reduce the pain. Also, laser technology is a method of blood sampling that puncture the fingertip. Till now, this method is mainly used for collecting capillary blood rather than vine blood which limits its applications. In Conclusion, Nowadays and despite the evolution of technology, the need of the health care sector for integrated and effective technology that provides painless blood sampling has not been met yet.

Keywords: Blood sampling technique; Painless; Dried blood spot

Introduction

Blood examination consists of three phases pre-analytical, analytical and post analytical. Most important phase is the pre-analytical which depends on phlebotomist and equipment efficiency. Today, by automation, the analytical stage of laboratory work is created. In the post-analytical process of laboratory research failures in laboratory medicine arise more commonly. The key causes of laboratory errors are the pre-analytical process and particularly the pre-analytical phase. In all non-laboratory procedures (e.g. research ordering, preparing of patients, sampling of blood, and transportation of samples), the most complex and most prone to errors is phlebotomy. In the diagnosis, administration and treatment of patients in health care, phlebotomy is a pivotal invasive operation. Although a significant proportion (60%-80%) of medical decisions are focused on the outcomes of laboratory testing, any mistake in the phlebotomy phase could have a severe effect especially on patients, but also on medical practitioners and the general health care system [1].

In and out patients of different age groups are subjected to repeated skin piercing in order to complete the diagnosis, which may cause psychological consequences for them due to some painful experiences or because of phobia fear of needles. Especially in infants, mentally ill people, and sometimes even in adults. Piercing skin can cause discomfort, pain and even serious reactions. Blood samples phobia is an observed phenomenon that accompanies almost everybody from day one in life when identifying blood groups and many other medical applications for different reasons. According to several studies, Trypanophobia, which considered being underrated phobia, is affecting 33%-63% of children and 14%-38% of adults. Some patients who have fear from needles, postpone or escape from this procedure. In some cases, patients with chronic diseases such as diabetes and chemotherap, do not follow treatment plans due to this phobia. Fear pressure may result in fainting and nausea. Moreover, needles fear has effect on samples' quality and validity. In addition, the phlebotomist plays an important role in forming the patient experience in blood sampling. The extent to which the phlebotomist is professional may affect the whole vein puncture procedure including the pain level or post-procedural irritation [2].

This document attempts to review most recent literature on blood sampling techniques. In particular, experimental studies that aimed to design an innovative solution for painless blood sampling that insure pleasant experience for the patients without affecting sample quality and validity. We will explain some definitions that frequently mentioned in the paper. The word phlebotomy derived from ancient Greek, which simply means "lancing a vein (fléba from flés) (tomia from témno)." Sensu

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strictu implies the method of inducing, for clinical reasons, blood loss (bloodletting) (1) (source 1). The term 'veni puncture' is considerably more modern in this regard, as it applies to the process of extracting and analysing blood (by piercing the vein's wall with a needle rather than cutting it with a lancet). The terms phlebotomy, vein puncture, and blood drawing are nowadays synonymous [3].

Blood Sampling Methods

Venipuncture methods

We will start our review from most common technique used worldwide, which is venipuncture. This technique requires experience of phlebotomist, quality of equipment and ability to conduct and select the right sight. There are many types of phlebotomy methods that recognized by their manufacturer and, in conjunction, by the mode of operation by which they are implanted.

Needle and syringe system: A metal hollow shaft with a small body by which it is attached to blood collection system that depicts Normal or "straight" needle. Thus the injection depends on the indirect mode of operation and how the operator aims the needle [3]. A hollow shaft needle is used to draw blood from venipuncture. Since the tip of the needle has a sharp beveled end with a concentric opening, it pierces the skin and cuts the vein wall, so that it is sometimes known as "epicranial" (meaning "on the edge of the head" with respect to the hole position) or "hypodermal" (meaning "under the skin" with respect to the penetration depth). Epicranial needles are made of stainless steel and vary in length and gauge of the shaft, with smaller values suggesting greater diameters. Typically, in adult populations with normal veins, a 21 g needle, equivalent to an outer diameter of 0.82 mm and an inner diameter of 0.51 mm on average, is used for venipuncture. The 23 g needle, which correlates to an average outer diameter of 0.64 mm and an inner diameter of 0.34 mm, is a safer alternative for pediatric venipuncture or for delicate and weak veins. Epicranial needles can range in length from 1.9 cm to 5.1 cm on average, but 4 cm long needles are typically used for regular venipuncture with a shaft inserted into the tissues for around 2 cm [2].

Winged butterfly system (syringe/vacuum extraction): "Butterfly" Needle System, which has its own body, provided with a pair of wing-like flexible tabs and PVC tubes that are attached to the collection unit. The wings can be bent upward and can then be positioned on the skin of the patient to support the shaft as soon as it is situated within the brain. The injection then relies on a direct mode of operation, since the needle is independent of the collection device is handled. It should be remembered that wings provide a way of binding the body of the needle to the patient's skin with strips of adhesive tape or translucent membrane dressings. This makes it easier to use the winged needle to infuse treatments as well but due to the rigid metallic shaft that can damage the vein with its sharp end for short periods [2].

Evacuated-tube system: The evacuated-tube method is a more modern device that has been adopted by Beckton and Dickinson under the trade name of Vacutainer TM (formerly Evacutainer) in 1949. The plunger is absent in such a device, and the barrel is replaced with a plastic or glass tube sealed with a preformed vacuum rubber stop. Blood can be obtained directly *via* an adaptor in a tube in which the appropriate additive is already included. A needle that is in the holder of the tube that pierces the evacuated tube's rubber stops does this process. The pierce in the rubber stop is resealed after drawing blood as the tube is separated from the holder, thereby stopping the sample from escaping out. When various additives are needed for blood testing, this method allows flipping between several tubes without interrupting the withdrawal of blood. The color-code used to direct phlebotomist to select suitable additive. The system of evacuated tubing allows the phlebotomist and his environment better protection since the blood sample is still flowing in a closed system. It even guarantees quality of many laboratory tests to prevent the mechanical stress of the blood components created by the dispensing process and to ensure that the tube is filled with the sufficient volume of blood for the additive needed [2]. The implementation of medical devices implementing safety-engineered defense systems is of course mandated by the Directive of the European Council on the prevention of acute injury (Directive 2010/32/EU) on the health care industry. The piston syringe and the evacuated-tube system are the major collection instruments. A piston syringe has been in use since the second half of the 19th century as a basic method. It is built with a plunger that pulls the blood into the barrel to which the needle can be locked directly [3].

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Polymer microfluidic blood sampling device

Browne and Ahn designed a 3-layer rigid polymer microfluidic blood-sampling device with integrated polymer pinch valves, which then has been developed, manufactured and demonstrated for in-line positioning between a patient and a saline infusion system [4]. The blood sampler they developed aims to minimize cross-contamination of the sample, reduce the risk of intrusive blood sampling along with microbial contamination and improve the technological ease of blood sampling. This design minimizes the frequency of venipuncture that the patient exposed to, but it will only help the patients who admitted to hospital [4]. Therefore, we are looking for better experience that includes out-patient and home care patients.

Metallic 3D micro-needle

Lee et al., have examined the characteristics of the formed metallic 3D micro needle which is used to develop blood sampling experiments. This needle designed to extract blood with specific material and dimensions that gently pierce skin tissue to make blood extraction more comfortable [5].

Dried Blood Spot (DBS) method

The Dried Blood Spot (DBS) was first used in 1913 by Ivar Christian Bang to assess blood sugar levels in rabbits. Subsequently, many scientists used this method of sample collection, but it became common only in 1963. Robert

Guthrie was the first who used it in the neonatal screening of phenylketonuria for sample collection. The capillary blood from the heel of a newborn is usually saturated. For this reason DBS is the favorable and the common sampling tool for neonatal screening of various diseases worldwide. Actually, this tool helps not only to analyze biochemical markers, but also nucleic acids as well. The entire blood collection procedure, sample handling and transport conditions are published in a standard manual in order to ensure optimum quality [6].

Microneedle: Xue et al., suggested a blood sampling system that combined micro needle and jig to avoid both needle buckling and skin deformation, which was inspired by the work of the mosquito labium. Inside a guiding jig slit, a micro needle with a thin plate-like holder is placed. With this slit, until it gets into contact with the skin, it is possible to press down the holder part, which pierces the skin to the bottom of the needle. The constricted part of the slit stops the needle from going out of the jig's central opening, preventing buckling from happening. It is effective not only to add tension to the skin but also to avoid concaved surface deformation for quick puncture without triggering sensory nerves of pain. An adhesive agent (organic adhesive film, e.g., mucin, double-sided adhesive tape, etc.) is proposed to stabilize the jig such that it does not shift in the vertical direction and to attach the bottom of the jig to the skin surface. A 3D laser lithography system was used to produce the integrated unit. A skirt-like base is provided to extend the adhesive area [7].

More recently, Nishino et al., tried to build a micro needle that mimics mosquito puncturing mechanisms by puncturing an artificial skin made from Poly Dimethyl Siloxane (PDMS), a kind of silicon rubber, and quantitatively evaluated the puncturing efficiency of the formed micro needle. However, unlike the mono layered PDMS, animal skin, including human skin, is structured over porous subcutaneous tissue to provide a stiff stratum corneum, epidermis and dermis. In this article, we suggest an artificial skin with a hard/soft two-layer composition, built from PDMS with a keratin film extracted from human hair adhered to the top surface. We tested the toughness of the keratin film (Young's module) and noticed that the rough layers of the skin, like the stratum corneum, could be qualitatively simulated. The following phenomena were replicated by the artificial skin developed: the decrease in the resistance force of animal skin at the point where the needle penetrates the surface followed by variance in resistance due to the stick-slip phenomenon as the needle penetrates deeper [8].

Laser: For capillary blood tests, Valentine V uses a laser to puncture the fingertip. It can also be used for cholesterol, haematocrit, and other measures on patients aged 5 and up, and is most widely used for blood glucose control. Although the treatment is not painless, patients who use the laser system for self-monitoring experience faster healing at their hands and less pain [9].

Conclusion

So far, there is a considerable effort that has been made to develop a technique that minimizes the unpleasant experience of blood withdrawal. However, Nowadays, despite the evolution of technology, the need of the health care sector for integrated and effective technology that provides painless blood sampling have not been met yet. Therefore, there is an urgent need for innovative solution to reduce human withdrawal errors and to insure the quality of the sample.

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