Assessing Phlebotomy Device Preference and Specimen Quality in an Oncology Outpatient Clinic

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Background: Oncology patients have frequent venipunctures, which causes scarring, making subsequent draws difficult and painful. Novel blood collection systems may decrease discomfort in patients experiencing repeat blood draws.

Methods: Oncology outpatients (n = 101; criteria excluded 12) were recruited to determine their preference for either of two blood collection systems, the 23-gauge standard BD Vacutainer Push Button Blood Collection Set (Standard Push Button system) or the 25-gauge BD Vacutainer UltraTouch Push Button Blood Collection Set (UltraTouch Push Button system). Subjects received two blinded, randomized blood draws, one with each device and just one device for each arm. Subjects subsequently rated their blinded preference for blood collection system. Specimen quality was assessed for each device with measurements for plasma hemoglobin (Shimadzu UV-1800 spectrophotometer, Shimadzu), lactate dehydrogenase, and potassium (Vitros 4600/5600 analyzer, Ortho Diagnostics).

Results: Preference for the 25-gauge UltraTouch Push Button system over the 23-gauge Standard Push Button system was significant (UltraTouch, n = 51; Standard n = 30; no preference, n = 8; P = 0.0196). Regarding sample quality, the 25-gauge UltraTouch Push Button system had significantly lower plasma hemoglobin (average 5.34 mg/dL) vs the 23-gauge Standard Push Button system (9.37 mg/dL; P < 0.0001); serum lactate dehydrogenase and potassium differences were not statistically significant.

Conclusion: Subjects in an oncology clinic preferred phlebotomy with the 25-gauge UltraTouch Push Button system, and samples using this device had less hemolysis as assessed by plasma hemoglobin.

IMPACT STATEMENT

Preference of a novel blood collection system improved both the patient experience and specimen quality during phlebotomy in a relevant oncology patient population. The BD Vacutainer UltraTouch Push Button technology enables the use of a 25-gauge needle without compromising specimen quality.

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INTRODUCTION

Venipuncture is one of the most routinely performed minimally invasive procedures in the healthcare setting (1). Unfortunately, the collection of blood is always associated with some level of patient discomfort (2). This is especially true for patients undergoing recurrent therapy, including oncology patients undergoing chemotherapy. Chemotherapy impacts the vasculature, causing veins to become much smaller, fragile, and difficult to anchor for venous access (3). Interestingly, 95% of patients who report difficult collections also report that at least 2 attempts were required to have their blood drawn (3). Adequate vascular access is of paramount importance in oncology patients. It is important in every phase of cancer patients’ care, from the initial phase of surgical treatment or chemotherapy and during the chronic management phase of cancer care as well as in the palliative care phase (4). Oncology patients characteristically have difficult venous access for phlebotomy due to cachexia and conditions such as advanced age, scarring from repeated intravenous (IV) access, and/or repeated administration of chemotherapeutic medications. As a result, increased pain and discomfort during phlebotomy is common in this vulnerable population.

The pain or discomfort of venipuncture is dependent upon mechanical forces or traction exerted by the needle used to penetrate the skin. Smaller gauge needles may impact hemolysis by causing fluidic shear force upon red blood cells passing through the needle, while larger gauge needles may increase the flow rate too much (5, 6). An increased flow rate can cause turbulence within both the needle and the collection tube while blood is being collected. Smaller needle diameters and lower insertion forces have been shown to reduce the frequency of painful injections (7, 8). However, a negative outcome of using a smaller gauge needle may result in decreased blood flow caused by the smaller inner diameter as well as slower tube filling time. The 25-gauge UltraTouch Push Button system has reduced cannula wall thickness and therefore a larger inner diameter, while keeping the outer diameter unchanged (5) (Table 1). This technology allows clinicians to use a smaller gauge needle intending to minimize discomfort and facilitate difficult venous access without compromising sample quality (9). Hemolyzed blood specimens can produce inaccurate laboratory test results and cause spectrophotometric interferences with laboratory methods. Lactate dehydrogenase (LDH) is present in the cells in a higher concentration than in the plasma; therefore, this analyte serves as an indirect indicator of red cell damage or hemolysis (10, 11).

We hypothesized that a majority of the subjects would report a preference for the 25-gauge BD Vacutainer UltraTouch Push Button Blood Collection Set vs the 23-gauge Standard BD Vacutainer Push Button Blood Collection Set (hereafter referred to as the 25-gauge UltraTouch and the 23-gauge Standard Push Button systems). In this study, the blood samples were drawn using the standard BD Vacutainer tubes. It is critical that any change considered in the phlebotomy process does not compromise vacutainer tube fill times or sample quality.

The primary objective of this study was to determine if the 25-gauge UltraTouch Push Button system was preferred by oncology patients, a vulnerable population that undergoes frequent phlebotomy procedures. The second objective was to assess sample quality between blood collection devices by comparative measures of a limited number of plasma and serum analytes. Specimen quality was assessed by measuring LDH, potassium, and plasma hemoglobin for samples collected with the 23-gauge Standard Push Button system compared to those collected from the 25-gauge UltraTouch Push Button system.
MATERIALS AND METHODS

Ethical Consideration

The University of Maryland School of Medicine Institutional Review Board approval was obtained prior to beginning the study (HP-00088317; approved October 3, 2019). Written informed consent signatures and Health Insurance Portability and Accountability Act authorization were obtained from each study subject prior to blood collection.

Description of Study Devices

The 25-gauge BD Vacutainer UltraTouch Push Button Blood Collection Set (REF 367341; referred to as 25-gauge UltraTouch Push Button system) features the same push button safety activation mechanism compared to the 23-gauge standard BD Vacutainer Push Button Blood Collection Set (REF 367342; both from BD). However, the UltraTouch Push Button system also employs a PentaPoint comfort 5-bevel intravenous (IV) cannula and RightGauge ultra-thin wall technology (Table 1). The thinner wall creates a larger inner diameter, while maintaining the cannula’s smaller gauge size (outer diameter), thus allowing more blood to flow through the device into the blood collection tubes (10).

| Needle type                          | Gauge | ID, a inches | OD, b inches | Length, inches | Cannula edge-type | Beveled edges |
|--------------------------------------|-------|--------------|--------------|----------------|-------------------|---------------|
| Standard Push Button, 23G            | 23    | 0.015°       | 0.025        | 0.75           | Standard          | 3             |
| UltraTouch Push Button, 25G          | 25    | 0.016°       | 0.020°       | 0.75           | PentaPoint        | 5             |
| Standard Push Button, 25G            | 25    | 0.012        | 0.020°       | 0.75           | Standard          | 3             |

a Inner diameter.
b Outer diameter.
c The cannula is the thin tube of the syringe needle that is inserted through the skin.
d The bevel describes slope or trimmed angle of the needle tip that is used to puncture the skin.
e Placed to highlight comparison.

Study Subjects

The study included the continuum of oncology patients receiving care at the Stoler Pavilion, an outpatient area of the Greenebaum Cancer Center at the University of Maryland Medical Center. A majority of subjects were either receiving treatment for an acute disease or being followed up after successful treatment for blood or bone cancer (i.e., myeloma or leukemia); however, a range of oncology patients were enrolled in the study (Table 2). The inclusion criteria stipulated that subjects must be 18 years of age or older and willing to have one phlebotomy draw in addition to that required for clinical care. The exclusion criteria indicated that subjects who were not 18 years of age or older and not willing to have one phlebotomy draw in addition to that required for clinical care and those who required three or more venipunctures due to difficult venous access during the initial phlebotomy draw were excluded. A total of 101 oncology outpatient subjects were voluntarily recruited. As indicated in Table 2, study subjects (62.3% and 37.6% males and females, respectively) were ≥18 years of age (median age, 58.9 years of age (± 14.8 years)). Twelve subjects were excluded from completing the needle preference questionnaire due to requirement of additional needle sticks attributed to challenging
venous access. These subjects were removed to reduce bias for device preference.

**Study Methods and Design**

For our study, a total of 101 subjects were recruited and enrolled in the study by research staff members to determine their preference for either the 23-gauge Standard Push Button or the 25-gauge UltraTouch Push Button system. A total of 12 subjects were excluded following screening, enrollment, and blood draw (due to 3+ additional venipunctures). Accordingly, preferences for 89 subjects were recorded in this analysis.

This study had an all-comers design; as such, all adult patients receiving phlebotomy in the cancer center’s outpatient phlebotomy area were equally eligible to participate. Because of this design, no group or individuals were specifically recruited with regard to age, sex, race, disease diagnosis, or duration of disease.

Based on the study’s design, subjects were randomized and blinded regarding both the identity and order of blood collection devices used. Each oncology subject had two blood collections: one from each arm, one draw using each blood collection system. One collection was performed using the 23-gauge Standard Push Button system currently in use at the oncology clinic, and the other was performed using the 25-gauge UltraTouch Push Button system. The same number and volume of lithium heparin BD Vacutainer® tubes were collected with both draws. Four teaspoons of blood (20 mL) were collected during each draw.

After the phlebotomy draws, each subject was asked to complete a two-item questionnaire, independently from the study staff and phlebotomist indicating their preference of the blood collection devices used. The preference was rated as (a) “Device used for first draw preferred”; (b) “Device used for second draw preferred”; or (c) “No difference in preference.” To increase study precision, the same trained phlebotomist collected samples from each subject.

**Specimen Quality**

Specimen quality cannot be compromised with use of an alternate blood collection system as this may impact the level of care for patients.

**Table 2. Subjects’ demographics and diagnoses.**

| Subjects                          | n (%)   |
|----------------------------------|---------|
| All subjects                     | 101 (100) |
| Sex                              |         |
| Women                            | 63 (62.3) |
| Men                              | 38 (37.6) |
| Age                              |         |
| <30                              | 4 (4.0)  |
| 30–39                            | 9 (8.9)  |
| 40–49                            | 13 (12.7) |
| 50–59                            | 16 (15.8) |
| 60–69                            | 36 (35.6) |
| 70–79                            | 18 (17.8) |
| >80                              | 5 (5.0)  |
| Diagnosis by cancer type         |         |
| Myeloma                          | 24 (23.8) |
| Leukemia                         | 19 (18.8) |
| Lymphoma                         | 14 (13.9) |
| Lung                             | 8 (7.9)  |
| Prostate                         | 7 (6.9)  |
| Brain                            | 5 (5.0)  |
| Other                            | 4 (4.0)  |
| Colorectal                       | 3 (3.0)  |
| Throat                           | 3 (3.0)  |
| Head and neck                    | 3 (3.0)  |
| Renal                            | 2 (2.0)  |
| Sarcoma                          | 1 (1.0)  |
| Bone                             | 1 (1.0)  |
| Cervical                         | 1 (1.0)  |
| Liver                            | 1 (1.0)  |
| Pancreas                         | 1 (1.0)  |
| Stomach                          | 1 (1.0)  |
| Testicular                       | 1 (1.0)  |
Therefore, samples from the 23-gauge Standard Push Button system were used for clinical care measurements and data collection during the study. To address specimen quality, samples collected using the 23-gauge Standard Push Button system were compared with those from the 25-gauge UltraTouch Push Button system for level of hemolysis. For this purpose, plasma hemoglobin, LDH, and potassium were measured and compared as indicators of hemolysis during blood collection, using each system.

Specimen quality was assessed with objective quantitative analytical measurements. LDH and potassium measurements were conducted using specimen collected in lithium heparin tubes collected with each phlebotomy system on the Vitros 4600/5600 analyzer (Ortho Clinical Diagnostics, Inc.), which were in routine use in the University of Maryland Medical Center clinical core laboratory, a CLIA-licensed, College of American Pathologists (CAP) -accredited facility. Plasma hemoglobin was quantified with a Shimadzu UV-1800 spectrophotometer (Shimadzu Corporation), using absorbance measurement at 578 nm, with correction for absorbance at 562 nm and 598 nm. The procedure was performed in an alkaline pH environment maintained with Tris buffer to optimize the measurement. Paired measures for all patient samples were limited by several logistical constraints, principally related to limited availability of staff and equipment. All analyte measures were performed by trained, competent staff, who routinely operate and report values for these analytes.

Data Analysis

Differences in proportion reflecting three category outcomes were documented as (a) the 25-gauge UltraTouch Push Button system was preferred; (b) the 23-gauge Standard Push Button system was preferred; or (c) one system was not preferred over the other (i.e., no preference). Proportions were compared to determine whether one system was preferred over the other. Results of the quantitative numerical measurements conducted to determine the presence and extent of hemolysis (LDH, potassium, and plasma hemoglobin) from blood collection with the two devices were collated and analyzed using the paired \( t \)-test. \( P \) value < 0.05 signified a statistical significance.

RESULTS

A clear majority of the 89 subjects (51, 57.3%) preferred the 25-gauge UltraTouch Push Button system. Eight subjects (9%) indicated no preference difference, while only 30 subjects (33.7%) indicated a preference for the 23-gauge Standard Push Button system (\( P = 0.0021 \)). Thus, these findings were statistically significant as indicated in Fig. 1.

Hemolysis

Subjects’ samples collected with the 25-gauge UltraTouch Push Button system recorded lower plasma hemoglobin, an indicator for hemolysis;
these findings suggested improved specimen quality ($P < 0.0001$, paired *t*-test). The average plasma hemoglobin (reference range: 0.5–10 mg/dL) was 5.34 mg/dL for the 25-gauge UltraTouch Push Button system vs 75% higher at 9.37 mg/dL for the 23-gauge Standard Push Button system. Plasma hemoglobin values were consistently higher across the distribution of measured values, comparing Standard Push Button vs UltraTouch Push Button systems (first quartile: 4.9 vs 3.5 mg/dL; third quartile: 10.5 vs 7.0 mg/dL). LDH measurements (reference range: 313–618 units/L) were 526.7 units/L vs 531.8 units/L ($P = 0.5037$) for the 23-gauge Standard Push Button system (first quartile: 410.5 units; third quartile: 564.5 units) and the 25-gauge UltraTouch Push Button system (first quartile: 419.5 units; third quartile: 548.5 units), respectively. Potassium measurements (reference range: 3.5–5.1 mmol/L) were 4.159 mmol/L vs 4.125 mmol/L ($P = 0.2919$) for the 23-gauge Standard Push Button system (first quartile: 3.9 mmol/L; third quartile: 4.4 mmol/L) and the 25-gauge UltraTouch Push Button system (first quartile: 3.9 mmol/L; third quartile: 4.3 mmol/L), respectively. Therefore, LDH and potassium comparison results between the phlebotomy devices were not statistically significant (Fig. 2).

**DISCUSSION**

This study assessed phlebotomy device preference and comparative specimen quality in a relevant population of oncology subjects. We have demonstrated a statistically significant preference for the novel 25-gauge UltraTouch Push Button system over the currently used 23-gauge Standard Push Button system in an oncology patient population that is among patient groups that would benefit the most from such technology. Further, we have shown that the performance of the device reduces apparent hemolysis in blood specimens, as assessed by plasma hemoglobin measurements.

It has been previously shown that the use of smaller bore needles can increase the risk of
specimen quality issues (7). Additionally, use of needles with a smaller bore, such as a typical (or standard) 25-gauge needle, has been discouraged due to risk of hemolysis, which can lead to rejected specimens (5, 7). In fact, the Clinical and Laboratory Standards Institute (CLSI) guidelines have specifically recommended that phlebotomists avoid the use of 25-gauge needles because slower blood flow increases the risk of hemolysis and specimen rejection by the laboratory (5). However, with the advances in technology, the most recent edition of the CLSI guidelines, reflects a modified view, given variations in the interior diameters of 25-gauge needles for blood collection (5). Revised CLSI guidelines state that “use of 25-gauge needles should only be avoided if frequent hemolysis is observed” (5).

Based on the reengineering of the 25-gauge needle, this study sought to determine venipuncture device preferences among oncology subjects for either the UltraTouch Push Button system, with a 25-gauge, 5-bevel needle or the currently used Standard Push Button system, with a 23-gauge, 3-bevel needle. In conjunction with preference, specimen quality was assessed by measuring plasma hemoglobin, LDH, and potassium for plasma samples collected with each device. Most subjects reported a preference for the 25-gauge UltraTouch Push Button system, and samples collected with this system exhibited lower hemolysis and no significant difference in measured potassium and LDH.

Similar studies have scored subjects’ preference for the 25-gauge UltraTouch Push Button system based on a 10-point anxiety scale, in which head-to-head comparison showed lower anxiety scores with the 25-gauge UltraTouch Push Button system (2). In a 2017 study, the investigators concluded that the 25-gauge UltraTouch Push Button system provided less overall pain and discomfort as compared with the 23-gauge Standard Push Button system (2). The study documented that the 25-gauge UltraTouch Push Button system increased neither hemolysis nor tube-filling times, in comparison to a 23-gauge Standard Push Button system (10). These investigators found that there were no increases observed in hemolysis index, potassium, or LDH, and tube-filling times were comparable for both devices (10). Counter to our study findings, this earlier study showed no difference in hemoglobin/hemolysis, which may be attributed to variability between phlebotomist experience or patient population.

Oncology patients are not the only population in which venous access is difficult to achieve. Pediatric samples were also shown to have similar quality attributes as compared to a comparable blood collection system (7, 12). A recent study involving the use of the 25-gauge UltraTouch Push Button system in a pediatric patient population similarly scored perceived pain as well as ease of use for phlebotomists (13).

Hemolysis is conventionally defined as membrane disruption of red blood cells that is accompanied by subsequent release of intracellular components into the serum or plasma. It accounts for over 60% of blood sample rejections in the laboratory and is the most common preanalytical error in laboratory medicine (7). To address specimen quality, samples collected using the 23-gauge Standard Push Button system were compared with the 25-gauge UltraTouch Push Button system for level of hemolysis. A previous study noted that specimen quality was maintained with the 25-gauge UltraTouch Push Button system, and comparable blood flow was shown when compared with the existing 23-gauge Standard Push Button devices (2).

The subjects in this study represented a variety of cancer diagnoses as listed in Table 2. This study was an all-comers design and therefore included subjects currently being treated for active disease as well as subjects returning for follow-up months after successful treatment. The all-comers design is not powered for a comparison of differences in hemolysis rates of subjects with specific types or
stages of cancer when using the 25-gauge UltraTouch Push Button system. However, we feel that a future study should be conducted to explicitly examine this question.

Our study had some limitations. First, a large number of males (63% or 62.3%) vs female subjects (38% or 37.6%) volunteered for our study, which may have produced gender-specific biases. We suggest that further research be conducted that is designed to specifically measure male/female perceptions of pain and discomfort during blood collection. Second, although the subjects age ranged from <30 to >80 years old, a large percentage of the subjects were in the 50 to 59, 60 to 69, and 70 to 79 age groups. Pain perception may differ by age. Third, no information was provided on the subjects’ length of time in cancer treatment, which may have influenced their sensitivity or acceptance of needle comfort/discomfort. Finally, although we tested hemolysis biomarkers, other aspects of specimen quality such as stability of key analytes, tissue fluid contamination, etc. were not assessed and were beyond the scope of this study.

In summary, our study showed that the UltraTouch Push Button system with PentaPoint comfort 5-bevel, 25-gauge needle was oncology subjects’ preferred blood collection system when compared with the 23-gauge Standard Push Button blood collection system. Specimen quality showed improvement when using the 25-gauge UltraTouch Push Button system. Based on preference and sample quality reported in our study, the findings provide the foundation and possibility to improve both the patient experience and specimen quality.

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