

Use of the BD MiniDraw and the Babson Sample Preparation Device to produce capillary blood samples with hemolysis levels equivalent to venipuncture

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Background

There is increasing demand for capillary blood collection as an alternative to venipuncture for routine testing, with an aim to improve accessibility, convenience, patient experience, and ultimately adherence. However, it is well known that capillary blood samples are typically more prone to hemolysis than venous blood samples, which may cause falsely elevated or falsely depressed results in test systems measuring analytes such as potassium, AST, and iron via the release of intracellular contents of erythrocytes or other interference mechanisms. This sample quality concern has been a barrier to widespread adoption of capillary blood for use in routine diagnostics.

New technologies have emerged to mitigate sample quality issues with capillary blood, such as the BD MiniDraw and Babson Sample Preparation Device used in the BetterWay blood testing service. The BD MiniDraw tube is designed to reduce hemolysis in capillary blood samples. The Babson Sample Preparation Device works with the BD MiniDraw and automates sample preparation steps that are prone to human error. Together, these technologies standardize collection and preparation of capillary blood.

We conducted a clinical study comparing capillary samples using the BD MiniDraw and Babson Sample Preparation Device vs. venous samples using the BD Vacutainer and manual sample preparation. From the study data, we analyzed the hemolysis levels between the two sample types to assess the quality of the capillary specimens. We also analyzed the iron measurements between the two sample types to evaluate whether the capillary specimens perform equivalently to venous specimens when using an assay known to be sensitive to hemolysis.

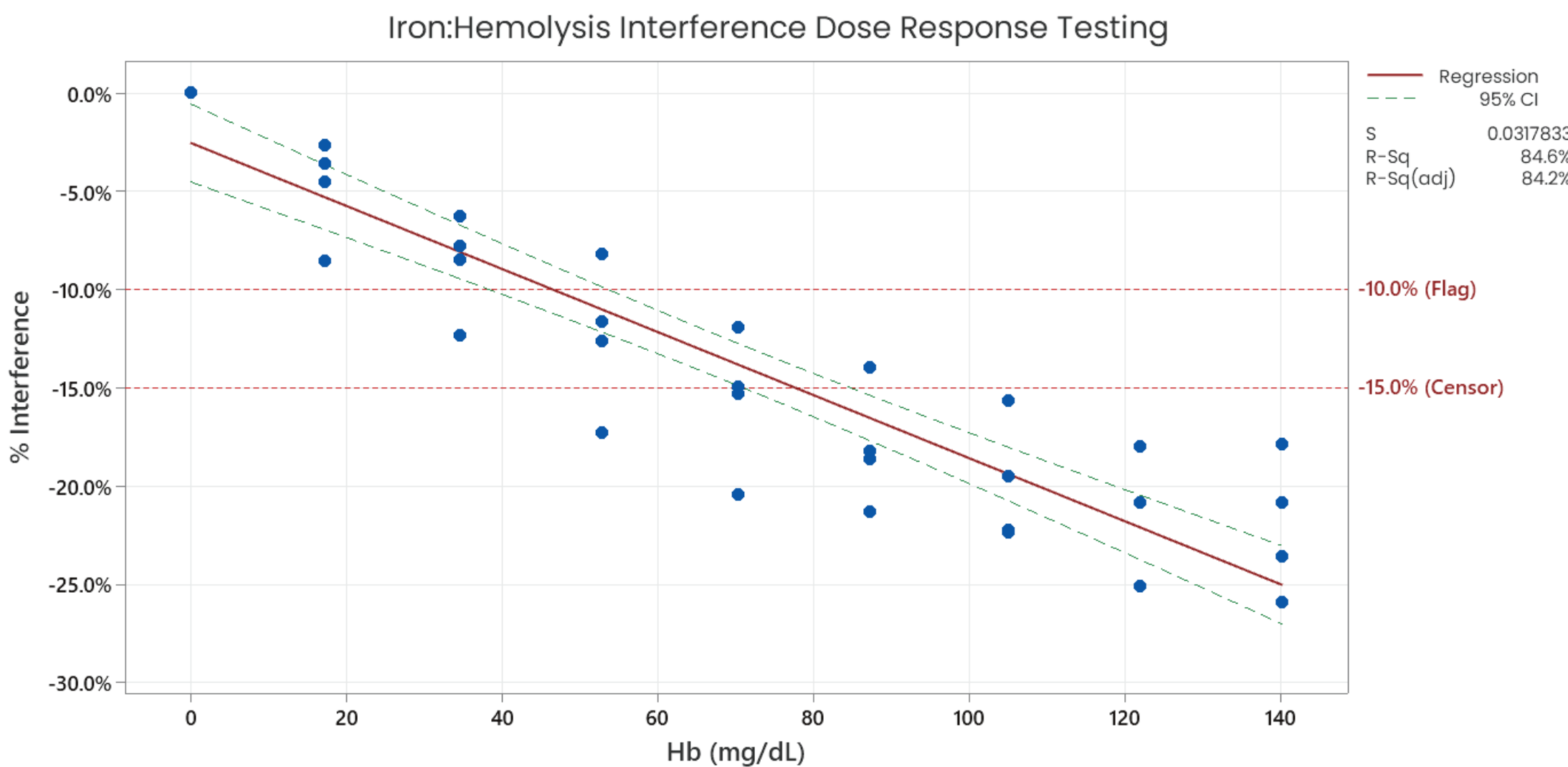
Methods

Two BD MiniDraw SST and two BD Vacutainer SST samples were collected from each of 234 ambulatory subjects. No subjects reported medications or health conditions that could contribute to in vivo hemolysis. Capillary samples were collected by trained healthcare workers (non-phlebotomists) and were mixed, centrifuged, and refrigerated by the Babson Sample Preparation Device. Venous samples were collected, mixed, centrifuged, and refrigerated by professional phlebotomists.

We evaluated hemolysis by measuring the extracellular hemoglobin concentration in each sample using the Babson Diagnostics XIHL assay. This assay is run on the Atellica CH analyzer, which performs blanked, bichromatic spectrophotometric measurements at 571 nm and 596 nm while simultaneously correcting for absorption due to lipemia. The XIHL assay has an analytical measuring range of 5.1 mg/dL to 1000.0 mg/dL (determined by the LoD using CLSI EP17 and the linear measuring interval using CLSI EP06), is standardized to the Sysmex XN-10 Hgb test (using internal standards derived from human hemolysate prepared according to CLSI EP07), and has repeatability and within-lab %CV estimates of <1.0% at ~170.0 mg/dL Hb.

For the subset of study subjects that were tested for iron (116/234), we analyzed iron measurements from paired capillary and venous samples to evaluate the impact of hemolysis on results. Capillary samples were tested using the Babson Diagnostics XIIRONm assay, and venous samples were tested using the Siemens Healthineers Atellica CH Iron_2 assay. The XIIRONm assay uses reagents and calibrators from the Iron_2 assay, but has been miniaturized to accommodate the use of small-volume capillary samples, and is validated as clinically and analytically equivalent to the Iron_2 assay. Both assays are traceable to National Institute of Standards and Technology Standard Reference Material 937. The Iron_2 assay package insert contains the following limitation: “Do not use hemolyzed samples. The use of hemolyzed samples may cause significant interference with this assay.” Through dose-response interference testing, the 10% and 15% bias limits for extracellular hemoglobin were determined to be 35 mg/dL and 55 mg/dL, respectively [Figure 1].

Figure 1



Results

In the hemolysis evaluation, the capillary samples (n=391) had a mean extracellular hemoglobin concentration of 13.1 mg/dL (95% CI 12.2 - 13.9) and a range up to 54.0 mg/dL; the venous samples (n=396) had a mean of 14.0 mg/dL (95% CI 13.1 - 14.8) and a range up to 164.9 mg/dL [Figure 2]. The analysis excluded results below the LoD of 5.1 mg/dL as well as samples with insufficient quantity. Based on a one-way ANOVA performed using Minitab statistical software, where $\alpha=0.05$, the difference in mean hemolysis between sample types was not significant (p-value 0.140) [Figure 3].

In the comparison of iron measurements, 98.3% (114/116) of the paired samples were within the total allowable error of $\pm 15\%$ (derived from CLIA 2024), with individual biases ranging from -22.2% to +32.5%. Iron measurements ranged from 15.5 $\mu\text{g/dL}$ to 244.5 $\mu\text{g/dL}$ in the study population, spanning the reference interval [Figure 4], though no samples were contrived to interrogate the upper limits of the measuring interval. The mean percent difference between specimen types was estimated at -2.4%. Using Passing-Bablok regression comparing a single capillary sample replicate versus the mean of two venous sample replicates, the slope and y-intercept were within acceptance criteria for equivalence estimated at 1.00 and -3.0 $\mu\text{g/dL}$, respectively.

Figure 2

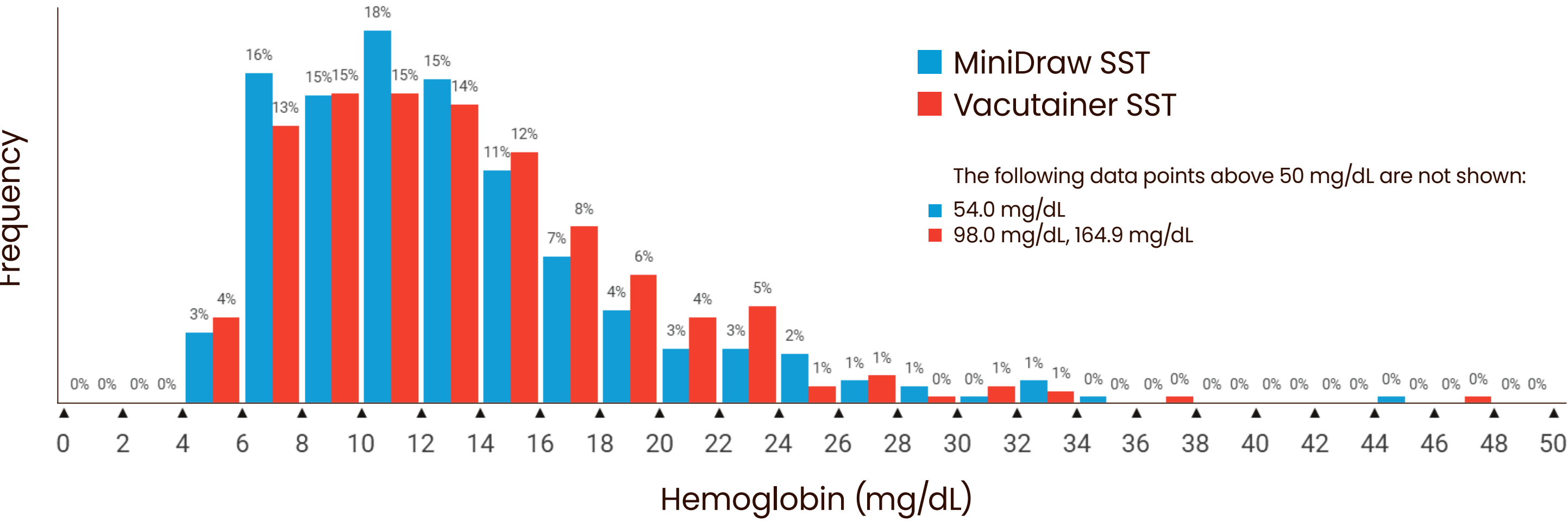


Figure 3

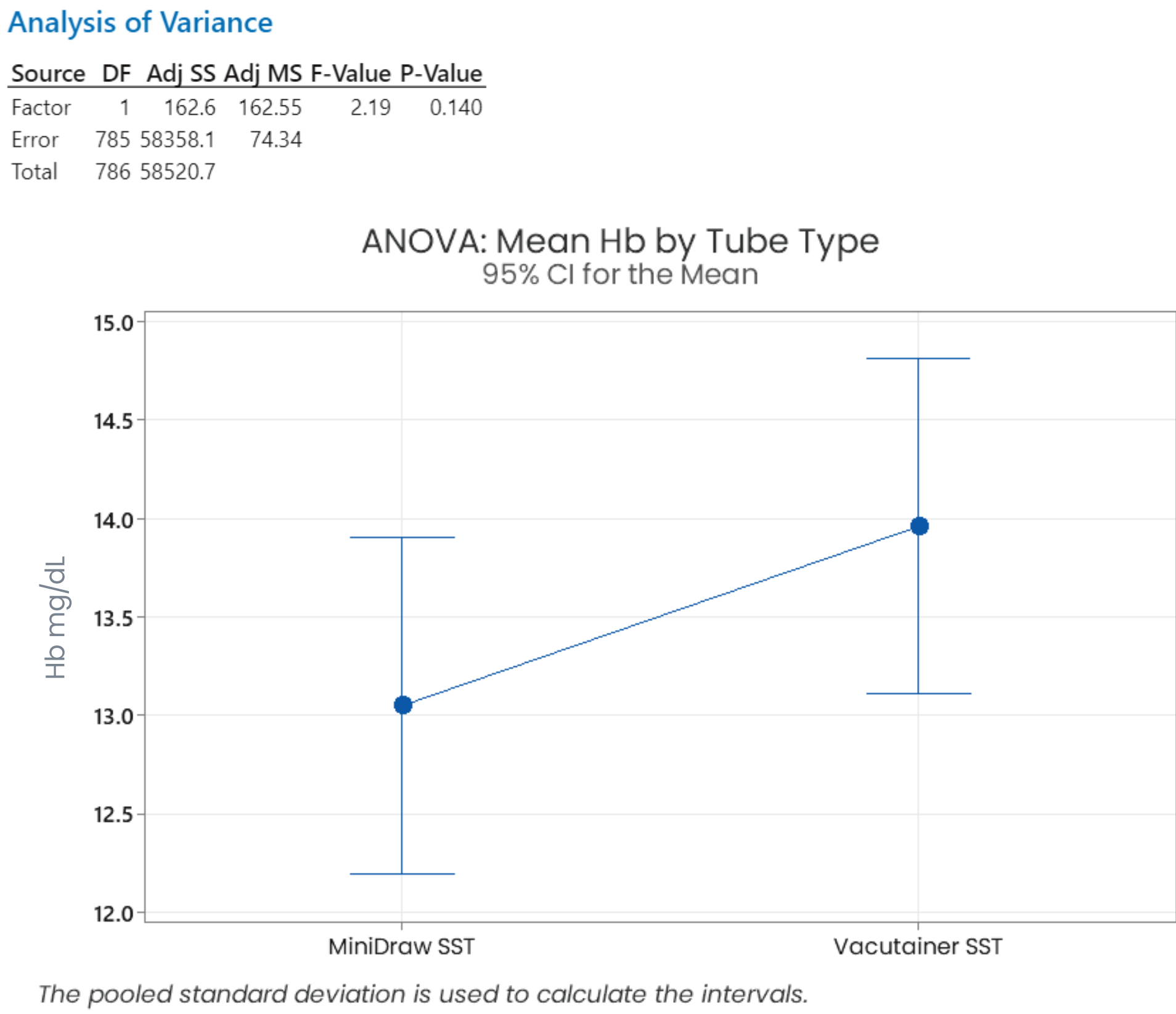
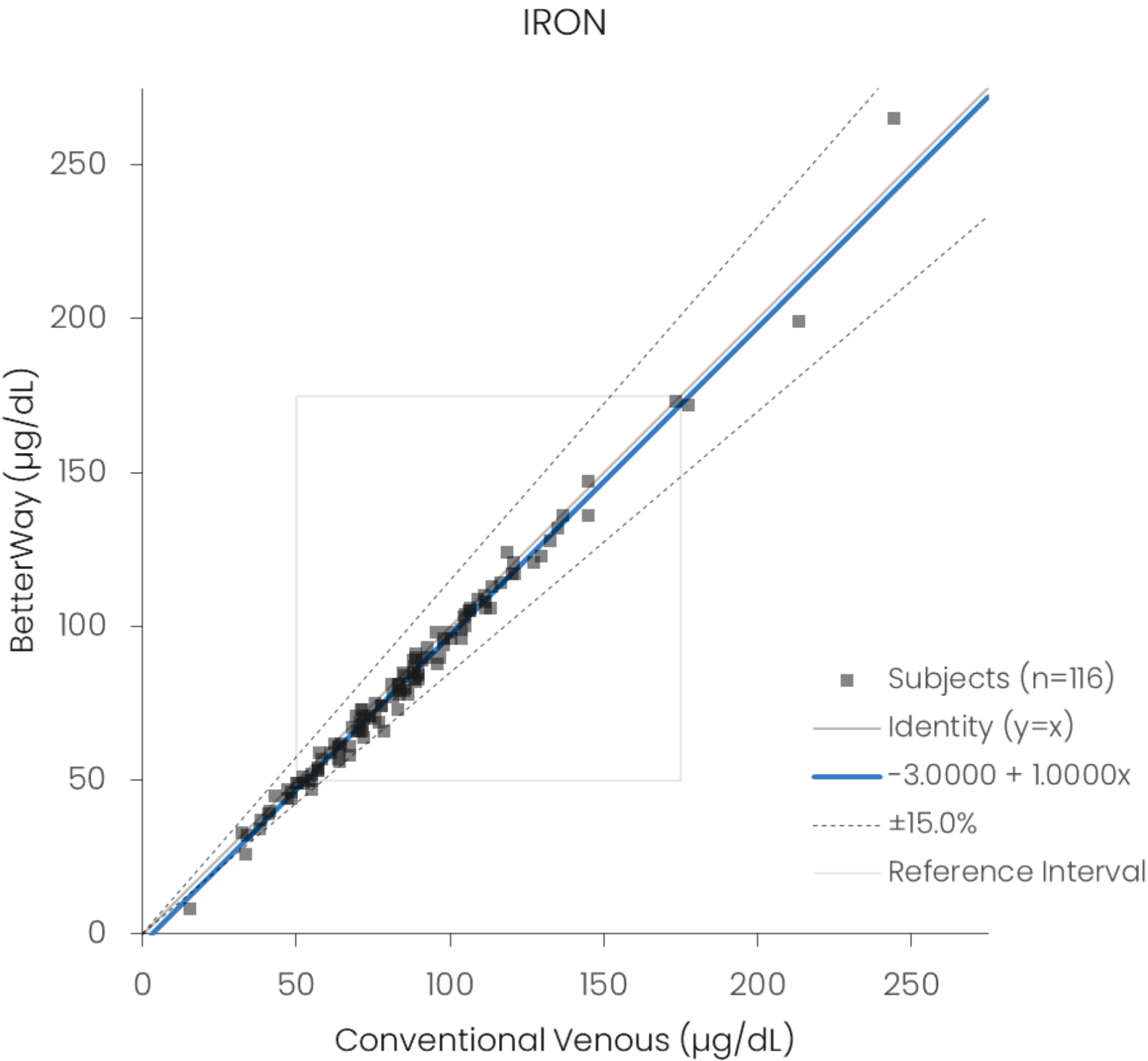


Figure 4



Conclusions

Capillary blood samples collected using the BD MiniDraw and Babson Sample Preparation Device produce venous-equivalent hemolysis levels, and this sample quality is sufficient to produce venous-equivalent iron test results.

