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Determining Optimal Waste Volume From an Intravenous Catheter

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Abstract

Waste is blood drawn from an intravenous (IV) catheter to remove saline before obtaining a blood sample. This study examines the minimum waste volume resulting in an undiluted sample. A repeated measures design was used. Investigators placed an IV catheter in 60 healthy adults and obtained samples at baseline and following waste volume ranging from 0.5 mL to 3 mL. A random effects mixed model was used to determine the stabilizing point. For sodium and glucose measurements, this stabilizing point was 1 mL of waste. Knowing that only 1 mL of waste is needed will prevent clinicians from obtaining extra waste and discarding blood needlessly.

Patients undergoing testing in a hospital setting often will have an intravenous (IV) catheter inserted. After an IV catheter is inserted, it is flushed with either normal saline or heparinized normal saline to ensure patency and flush blood out of the catheter. Before a blood sample is obtained from an IV catheter, a "waste" blood sample is drawn to remove the saline or heparin that was in the catheter. The purpose of this study is to investigate the minimum volume of waste required to be drawn from an IV catheter to obtain a subsequent undiluted blood sample.

BACKGROUND

Several studies have been conducted that compare lab values of blood drawn via IV catheters to lab values of blood obtained via venipuncture. The majority of these studies used a standard volume of waste, either 3 mL² or 5 mL,^{1,3–7} that was drawn from the IV catheter prior to drawing the blood samples. These studies demonstrated that there were no statistically significant differences between complete blood counts,³ hemoglobin,² hematocrit,^{1,7} electrolytes,¹ cardiac enzymes,¹ PT,⁴ aPTT,⁴ or serum chemistry⁶ when blood was obtained through an IV catheter following a standard waste draw, as opposed to venipuncture. While these studies provided important information about whether blood obtained from an IV catheter following a waste draw was comparable to blood drawn

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through venipuncture, they did not address the question of the minimum volume of waste necessary to obtain a subsequent undiluted sample.

Three studies examined the minimum volume of waste needed to be drawn after flushing an IV catheter with heparin to obtain accurate activated partial thromboplastin time, prothrombin, and partial thromboplastin times.^{8–10} While these studies are important in determining whether an IV catheter can be used to obtain reliable coagulation tests, they examined the effect that flushing IV catheters with heparin had on coagulation studies, not dilution of samples more broadly.

Four studies examined varying volumes of waste and the effect on the dilution of the subsequent blood sample. Yucha and DeAngelo¹¹ studied 9 healthy adults and compared hematocrit readings of blood obtained from an IV catheter following waste draws of 1 mL, 1.5 mL, and 2.5 mL to the average hematocrit readings obtained from blood drawn from an IV catheter following a draw of more than 2.5 mL of waste. They concluded that there was no difference in hematocrit readings between blood obtained following 1.5 mL of waste and each subject's true hematocrit reading, which they defined as the average of the hematocrit readings after at least 2.5 mL of waste was drawn. Davies, Mehr, and Morley¹² studied sodium levels of blood obtained through an IV catheter following waste draws of 0.6 mL, 0.9 mL, 1.3 mL, and 1.6 mL. These values were compared to a control sodium level that was obtained through the IV catheter following a 10-mL waste. They concluded that drawing 1.6 mL of waste prior to obtaining a blood sample was adequate to obtain sodium levels. These 2 studies examined varying volumes of waste; they did not, however, use a baseline sample that was drawn via venipuncture.

Zlotowski, Kupas, and Wood¹³ studied 33 healthy volunteers and compared 3 sources: venipuncture, an IV catheter with no waste drawn, and an IV catheter with 12 mL of waste drawn. They found that results from 16 of the 19 laboratory tests were similar. There were differences in potassium, bicarbonate, and glucose between the venipuncture sample and both the sample following no waste and the sample with 12-mL waste. Herr and colleagues¹⁴ studied 38 subjects and compared blood obtained via venipuncture to blood obtained from an IV catheter with no waste drawn first and then an IV catheter with 5 mL of waste drawn first. They analyzed the blood samples for CBC, electrolytes, BUN, creatinine, and glucose. They concluded that only bicarbonate values were clinically and statistically different between the 3 samples. These 2 studies compared blood obtained via venipuncture to blood obtained via IV catheters following varying volumes of waste (5 mL¹⁴ or 12 mL¹³). Neither of these studies examined blood drawn after smaller increments of waste draws. In addition, they both examined a blood sample that was relatively large (5 mL or 12 mL) and minimal dilution may not have altered lab values.

The present study seeks to address current gaps in the literature by comparing blood drawn at baseline through venipuncture to blood drawn from an IV catheter following different volumes of waste in small increments. This study enrolled 60 healthy adults, constituting the largest study of blood waste from an IV catheter reported in the literature. The ultimate goal of the present study was to provide evidence for a standard minimum waste volume to be drawn from an IV catheter. This will impact nursing practice in multiple patient populations.

METHODS

The present study used a repeated-measures design in which the dependent variables were blood sodium and glucose levels, and the independent variable was the amount of blood waste drawn. The authors evaluated the quality of blood samples obtained at baseline and blood samples obtained following waste samples of various volumes (0 mL, 0.5 mL, 1 mL,

1.5 mL, 2 mL, 2.5 mL, and 3 mL). At each time point, 0.5 mL of blood was drawn and analyzed for sodium. Serum sodium was measured on a Vitros 950 (Ortho Clinical Diagnostics). The Vitros 950 has a within-lab coefficient of variance (CV) of 0.9%, based on 86 observations over 23 days. The “within day” standard deviation (SD) for serum sodium values is 0.7 mmol/L, and the “within lab” SD is 1.1 mmol/L. These precision data are based on a serum sodium value of 121 mmol/L. This specific test was selected because, between each blood draw, the nurse flushed the IV catheter with normal saline. In addition, among a subset of the sample, the authors tested fasting glucose levels on the blood. By examining glucose measurements (a substance not present in the flush solution) in addition to the sodium measurements, the authors added validity to their findings.

A total of 60 healthy adult subjects were enrolled in the study. Potential subjects were excluded if they were younger than 18 years of age or if they had a diagnosed renal disease, diabetes, or other diagnosis that could affect their sodium or glucose levels. After obtaining consent, investigators obtained the subject’s age, race/ethnicity, gender, height, and weight. Subjects were asked if they had fasted for at least 8 hours before the study visit. Next, a nurse placed a 22-gauge IV catheter into the subject’s arm, forearm, or hand connected to a 6-inch extension tube with IV cap. Immediately upon insertion of the catheter and before flushing the catheter, 0.5 mL of blood was obtained (baseline sample). Since the baseline sample was obtained before the IV catheter had been flushed with normal saline, it served as the reference for subsequent samples. After obtaining the baseline blood sample, the catheter was flushed with 2 mL of normal saline. The nurse waited approximately 5 minutes after flushing the IV, drew a specified volume of waste, which was discarded, and then immediately drew the next 0.5 mL sample for determination of the sodium and glucose levels. Then the catheter was flushed with 2 mL of normal saline, and the nurse waited approximately 5 minutes before repeating the procedure with the next waste amount. During this process, the amount of waste drawn was in random order for each subject. The randomization schedule was created by the study biostatistician prior to the start of the study. The order of the draw volumes was not known until the study subject had signed informed consent. The code was kept in a sealed opaque envelope designated with a unique subject identification number. In total, 7 samples were drawn following blood waste volumes of 0 mL, 0.5 mL, 1 mL, 1.5 mL, 2 mL, 2.5 mL, and 3 mL. The sample drawn without drawing any waste first (ie, waste volume of 0 mL) was expected to result in a dilute sample with an elevated sodium level and decreased glucose level. This expected dilute sample was drawn to validate that the researchers would be able to detect dilution in samples.

DATA ANALYSIS

The study design required 8 blood samples: baseline and 1 sample obtained after drawing 0 mL, 0.5 mL, 1 mL, 1.5 mL, 2 mL, 2.5 mL, and 3 mL of waste for each study subject. To allow for this repeated-measures design, a generalized mixed-model approach was used for analysis, incorporating an autoregressive covariance structure, with post-hoc testing of each level against baseline and each subsequent volume. This allowed determination of the point at which the difference from baseline becomes undetectable.

RESULTS

The researchers enrolled 60 healthy subjects in the study; demographics are shown in Table 1. On average, the subjects were 34.3 years of age, 34 (57%) were female, 55 (92%) Caucasian, 3 (5%) African American, and 2 (3%) Asian. The order of amount of waste drawn was randomized with 7 distinct sequences. The randomization was set up a priori, and researchers opened the sealed envelopes after consent was obtained. No statistically

significant differences between the randomization order schemes were found for baseline sodium ($P=.32$), baseline glucose ($P=.79$), or weight, used as a surrogate for total blood volume ($P=.27$) (Table 2).

The statistically significant stabilizing point for both sodium and glucose measurements was 1 mL of waste. The means and associated standard errors by draw volume are shown in Table 3. Secondary analyses adjusting for weight and body mass index (BMI) did not affect the interpretation of the results.

CONCLUSION

In the literature, to date, there are many studies that demonstrate the agreement between lab values of blood obtained via venipuncture and lab values of blood obtained via an IV catheter following a standard waste sample. There are fewer studies (4) that examine the minimum volume of waste required to be drawn from an indwelling peripheral IV catheter to provide a subsequent undiluted blood sample. Two of the studies compared lab values obtained following waste samples of varying volumes to either an average lab value drawn from the same IV catheter¹¹ or to a lab value drawn from the same IV catheter following a large waste volume.¹² The assumption made by these investigators is that an average of the lab values of all samples obtained with greater than 2.5 mL of waste¹¹ or the lab value obtained following 10 mL¹² are accurate estimations of true undiluted lab values. The remaining 2 studies did not examine waste volumes less than 5 mL.^{13,14} The present study addressed these current gaps in the literature by comparing blood drawn at baseline through venipuncture to blood drawn from an IV catheter following different volumes of waste in small increments.

Nurses obtaining blood samples from a 22-gauge IV catheter with a 6-inch extension tube should draw a minimum of 1 mL of waste prior to obtaining the sample for testing. Drawing 1 mL of waste will prevent clinicians from obtaining extra waste and discarding blood needlessly. Additionally, there are times when drawing blood from an IV is difficult. In these cases, the minimum amount of waste necessary would be useful knowledge to potentially prevent the patient from undergoing another venipuncture to obtain the sample. Finally, there are times when multiple blood samples are needed and the total volume of blood removed approaches the maximum amount that can safely be removed from a patient. In these cases, knowing the minimum amount of waste that needs to be drawn can help reduce the total amount of blood drawn and potentially increase the number of samples that safely can be drawn.

A limitation of this study is that only 22-gauge IV catheters were studied. While the present study provided important information about 22-gauge IV catheters with 6-inch extension tubing, additional research is needed to examine minimum waste volumes necessary when IV catheters of a different gauge are used.

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Table 1

Demographic Characteristics

Variable	
Age at visit (years)	34.3 $\pm$ 1.3 [19.1, 59.1]
Female	34 (56.7%)
Race	
Caucasian	55 (91.7%)
African American	3 (5.0%)
Asian	2 (3.3%)
Hispanic	0 (0%)
Height (cm)	171.7 $\pm$ 1.4 [150.0, 201.9]
Weight (kg)	75.6 $\pm$ 2.3 [48.7, 141.3]
BMI (kg/m ²)	25.6 $\pm$ 0.7 [17.4, 54.5]
Baseline sodium (mEq/L)	138.5 $\pm$ 0.2 [134.0, 143.0]
Baseline glucose (mg/dL)	80.7 $\pm$ 2.4 [41.5, 107.0]

Data expressed as mean $\pm$ standard error [range] or n (%).

Abbreviation: BMI, body mass index.

Table 2

Baseline Sodium and Glucose by Randomization Scheme (N=60)

Random order group	n/ random order group	Sodium (mEq/L)	Glucose (mg/dL)	Weight (kg)
B	9	138.2 ± 0.7	80.3 ± 5.0	75.0 ± 4.5
C	9	139.1 ± 0.7	79.9 ± 4.2	77.5 ± 5.1
D	8	139.0 ± 0.4	81.6 ± 4.6	87.9 ± 9.4
E	9	139.0 ± 0.8	86.4 ± 8.1	72.4 ± 4.7
F	9	137.7 ± 0.4	80.2 ± 2.7	74.6 ± 7.0
G	8	137.6 ± 0.7	83.5 ± 2.9	78.0 ± 3.3
H	8	139.1 ± 0.6	70.2 ± 14.8	64.0 ± 6.8

Data expressed as mean ± standard error.

Table 3

Mean Sodium and Glucose by Draw

	Sodium (mEq/L)	<i>P</i> value	Glucose 1 (mg/dL)	<i>P</i> value
Baseline/ Venipuncture	138.5 ± 0.21		80.6 ± 1.92	
Volume of Waste				
0 mL	142.5 ± 0.22	<.001 *	44.6 ± 1.97	<.0001 *
0.5 mL	138.3 ± 0.22	.91 *	77.7 ± 1.98	.31 *
1.0 mL	137.8 ± 0.22	.01 **	81.3 ± 1.97	.02 **
1.5 mL	137.8 ± 0.22	1.00 **	80.9 ± 1.96	1.00 **
2.0 mL	137.8 ± 0.22	1.00 **	80.3 ± 1.97	1.00 **
2.5 mL	137.9 ± 0.22	1.00 **	79.0 ± 1.99	.93 **
3.0 mL	137.8 ± 0.22	.99 **	81.4 ± 1.99	.16 **

Data expressed as mean ± standard error.

*
difference from baseline

**
difference from previous volume measurement