ELMER PRESS

Original Article

J Hematol. 2018;7(2):51-56

Evaluation of Blood Collection From the Proximal Side of a Fluid Infusion Site

Shotaro Koike

Abstract

Background: We aimed to determine if blood data are unaffected by transfusion method when the blood is sampled from the proximal side of the infusion site under temporary suspension of transfusion.

Methods: In five 30-week-old Japanese white male rabbits, fluid infusion routes were secured via left auricular veins with a disposable plastic indwelling cannula (24-G needle). Solita T3 (22 mL/h) was administered to each animal using a syringe pump. Ten minutes after starting infusion, 2 mL blood was sampled from a distance of 2 cm on the central side of the infusion site with ongoing fluid infusion, from the opposite side (the right auricular vein), and from the central side of the infusion site with suspended fluid infusion. We cross-verified and compared results of 41 biochemical and blood cell examination items for samples collected from the central side with ongoing fluid infusion, from the central side with suspended fluid infusion, and from the opposite sides by comparison with Tukey's test.

Results: A significant difference was noted in tested items between blood samples collected from the proximal side with ongoing fluid infusion and those collected from the proximal side and from the contralateral side with suspended fluid infusion. Conversely, for all test items, no significant difference was noted in the test item data between blood samples collected from the proximal side with suspended fluid infusion and those collected from the contralateral side.

Conclusions: We successfully verified and demonstrated that blood samples collected from the proximal side of the infusion site remain unaffected by fluid infusion when drawn under the conditions of suspended fluid infusion.

Keywords: Blood cell; Cannula; Routes; Syringe pump; Transfusion

Introduction

The testing technology is advancing every day, and the accuracy of the testing is gaining increasing importance. Blood tests are performed for most of the routine testing procedures as blood specimens provide a sneak into the body's internal status [1]. Phlebotomists performing blood collection have an immense responsibility of performing correct and safe blood sampling. Recently, there is a greater emphasis on safe blood sampling to avoid the risk of infection spread while drawing blood, particularly from a diseased individual. For example, the rate of contamination with MRSA is 32 out of 131 cases (25%) because of tourniquets. An audit of hand hygiene practice revealed that phlebotomists' hand decontamination between sampling is inadequate and also that some wear wristwatches while collection [2]. To reduce the prevalence of blood contamination in such scenarios, Richard et al [3] recommended monitoring, surveillance, adherence to a pre-defined infection control protocol for maintaining point-of-care testing instruments [3], as well as monitoring the effect of changes in potassium concentrations in stored blood samples [4]. Another important subject that has been rarely studied includes the influence of transfusion on sampled blood.

Inappropriate transfusion methods have been reported to affect the quality of blood, necessitating adoption of corrective measures to avoid the effect of transfusion on the collected blood sample to obtain precise blood test results [5]. However, there is a lack of studies on drawing blood method to avoid the effect of transfusion. If the nurse chooses an arm that is not an ideal blood drawing site, blood data may get affected, for instance, in patients who have undergone surgical procedures, such as mastectomy, or those with arteriovenous shunt for dialysis. These patients are administered fluid infusions on the contralateral limb. When blood is collected from these patients, the affected side is not used for paracentesis during investigations. It is believed that results obtained from the arm where a fluid infusion is being administered may be incorrect. Therefore, in several medical institutions, a vein in the lower limb is preferred as the blood collection site. However, collecting blood from a lower limb carries the risk of infection and blood clotting [6]. The Clinical and Laboratory Standards Institute recommend that IV infusion be turned off for 2 min, after which the phlebotomist may apply the tourniquet between the IV and the venipuncture site to perform venipuncture. However, turning off transfusion for 2 min can result in the formation of blood clots in the transfusing needle, which renders this approach invalid. Moreover, there is no consensus on the recommended time of 2 min. Therefore, we hypothesized that collecting blood from the peripheral side of the transfusion site may be ideal because the transfusion flows to the central side

Manuscript submitted April 13, 2018, accepted April 30, 2018

Department of Nursing, Aomori University of Health and Welfare, Aomori, Japan. Email: s_koike@auhw.ac.jp

doi: https://doi.org/10.14740/jh403w

Table 1. Blood Date (n = 5)

Analytes	Unit	Blood collection	Mean	SD	P
Alkaline phosphates	U/L	Central side with ongoing fluid infusion	80.4	58.3	
		Central side with suspended fluid infusion	268.8	34.4	*
		Contralateral side	274.2	31.9	#
Aspartate aminotransferase	U/L	Central side with ongoing fluid infusion	8.4	6.5	
		Central side with suspended fluid infusion	27.8	5.6	*
		Contralateral side	29.4	5.0	#
Alanine aminotransferase	U/L	Central side with ongoing fluid infusion	14.6	11.2	
		Central side with suspended fluid infusion	46.4	2.8	*
		Contralateral side	48.4	2.5	#
Lactate dehydrogenase	U/L	Central side with ongoing fluid infusion	133.6	85.2	
		Central side with suspended fluid infusion	458.6	91.5	*
		Contralateral side	525.2	96.5	#
Gamma-glutamyl transpeptidase	U/L	Central side with ongoing fluid infusion	3.0	2.0	
		Central side with suspended fluid infusion	9.4	0.5	*
		Contralateral side	9.6	0.5	#
Leucine aminopeptidase	U/L	Central side with ongoing fluid infusion	32.2	24.7	
		Central side with suspended fluid infusion	100.4	3.9	*
		Contralateral side	102.4	5.0	#
Total protein	g/dL	Central side with ongoing fluid infusion	1.7	1.3	
		Central side with suspended fluid infusion	5.2	0.3	*
		Contralateral side	5.5	0.3	#
Albumin	g/dL	Central side with ongoing fluid infusion	0.7	0.5	
		Central side with suspended fluid infusion	2.1	0.1	*
		Contralateral side	2.2	0.1	#
Urea nitrogen	mg/dL	Central side with ongoing fluid infusion	6.8	5.2	
		Central side with suspended fluid infusion	15.0	2.3	*
		Contralateral side	15.2	2.0	#

Tukey's test. *P < 0.05, central side with ongoing fluid infusion versus central side with suspended fluid infusion. #P < 0.05, central side with ongoing fluid infusion versus contralateral side.

of the fluid infusion site and therefore, blood collection from the peripheral side of the infusion site may only minimally affect test data. Based on this working hypothesis, we conducted both basic and applied research. Our experiments revealed that data from a blood sample collected at a distance of 15 cm from a fluid infusion site on the peripheral side were unaffected by the fluid infusion and accurately reflected biological functions of the subject. A site at a distance of 15 cm on the peripheral side is thus deemed suitable for blood collection [7]. However, when the vein on the forearm is the transfusion site, the distance of 15 cm away from the fluid infusion site is at the back of the hand. In general, the preferred site for venipuncture is the antecubital fossa, located anterior to the elbow. Major veins on the antecubital fossa are the median cubital vein and cephalic vein. The median cubital vein is the preferred vein for transfusion because it is larger and does not move when punctured. Conversely, the cephalic vein is usually more difficult to locate, except possibly in plumper patients, and has greater tendencies to move. The cephalic vein is, therefore, the second choice, considered only when the median cubital is inaccessible in both arms. These blood collection sites and veins are reasonable basics of drawing blood. The next choice for blood collection site is the dorsal venous network on the back of the hand. The veins on back of the hand are smaller and less well anchored, making the punctures more painful for the patients [4]. Therefore, if possible, the dorsal venous network on the back of the hand is avoided as the blood collection site. Therefore, even when the patients' forearm is used for transfusion, it is important that the phlebotomist chooses a site below the bend of the elbow. To the best of our knowledge, no previous studies have reported these associations, and therefore, there is no further evidence for this view. As an alternative to obtain blood sample without exposing it to the influence of transfusion, we believed that stopping the transfusion process when

Table 2. Blood Date (n = 5)

Analytes	Unit	Blood collection	Mean	SD	P
Creatinine	mg/dL	Central side with ongoing fluid infusion	0.3	0.2	
		Central side with suspended fluid infusion	0.7	0.0	*
		Contralateral side	0.7	0.0	#
Glucose	mg/dL	Central side with ongoing fluid infusion	2,782.8	1,075.9	
		Central side with suspended fluid infusion	140.6	76.3	*
		Contralateral side	49.0	11.4	#
Total cholesterol	mg/dL	Central side with ongoing fluid infusion	5.8	3.6	
		Central side with suspended fluid infusion	19.6	2.2	*
		Contralateral side	20.4	2.9	#
Triglyceride	mg/dL	Central side with ongoing fluid infusion	22.2	13.0	
		Central side with suspended fluid infusion	81.2	17.1	*
		Contralateral side	95.2	21.6	#
HDL-cholesterol	mg/dL	Central side with ongoing fluid infusion	3.8	2.7	
		Central side with suspended fluid infusion	11.6	1.3	*
		Contralateral side	11.8	1.3	#
LDL-cholesterol	mg/dL	Central side with ongoing fluid infusion	1.4	0.9	
		Central side with suspended fluid infusion	3.8	0.8	*
		Contralateral side	4.0	1.0	#
Phospholipid	mg/dL	Central side with ongoing fluid infusion	19.4	12.6	
		Central side with suspended fluid infusion	59.8	5.3	*
		Contralateral side	64.4	5.8	#
Creatine phosphokinase	U/L	Central side with ongoing fluid infusion	687.2	561.5	
		Central side with suspended fluid infusion	2,354.0	674.9	*
		Contralateral side	2,565.6	527.8	#

Tukey's test. *P < 0.05, central side with ongoing fluid infusion versus central side with suspended fluid infusion. #P < 0.05, central side with ongoing fluid infusion versus contralateral side.

drawing the blood and not collecting it in the blood collection tube should work. In this study, we intend to discuss whether the blood sample remains unaffected by transfusion when obtained by turning off the transfusion on the central side of the infusion site.

Materials and Methods

An experimental research was undertaken to verify the causal hypothesis by enrolling five 30-week-old Japanese white male rabbits (body weight: approximately 3.5 kg). The ears of rabbits have long auricular veins. Rabbits were considered suitable for the study because their long auricular veins allow puncturing at three places in the same vein.

The rabbits were sedated with isoflurane using an anesthetic device for small animals. Fluid infusion routes were secured via the left auricular veins using a disposable plastic indwelling cannula with a 24-G needle (length: 19 mm, outer diameter: 0.7 mm, inner diameter: 0.47 mm). To simulate the scenario in a fasting patient receiving a 24-h fluid infusion, a type 3 fluid (Solita T3; AY Pharmaceuticals Co., Japan) was used for infusion as it is the most common fluid type in clinical use for animals. Solita T3 contains 35 mEq/L Na^+, 20 mEq/L K^+, 35 mEq/L Cl^-, and 20 mEq/L L-lactate$^-$.

The animals required 100 - 150 mL/kg/day fluid transfusion, i.e., 3.5 kg × 150 mL/24 h, which comes to 21.8 mL/h. Therefore, the administration of Solita T3 was started at 22 mL/h using a syringe pump.

After the infusion was started for 10 min, blood samples of 2 mL each were collected from 2 cm on the central side of the infusion site while being put on a drip and from the opposite side (the right auricular vein), and the central side of the infusion site that turned off a drip by 21 G needle. The test results for the blood sampled from the opposite side were considered as standard for comparison purpose.

Data obtained were analyzed using SPSS Statistics for Windows (version 19.0). A total of 32 biochemical test and blood cell test items were analyzed, and data obtained from the central side with ongoing fluid infusion, from the central side with suspended fluid infusion, and from the opposite sides were compared using the Tukey's test. The biochemi-

Table 3. Blood Date (n = 5)

Analytes	Unit	Blood collection	Mean	SD	P
Sodium	mEq/L	Central side with ongoing fluid infusion	73.6	27.4	
		Central side with suspended fluid infusion	145.0	0.7	*
		Contralateral side	145.4	0.5	#
Potassium	mEq/L	Central side with ongoing fluid infusion	15.0	4.2	
		Central side with suspended fluid infusion	4.6	0.6	*
		Contralateral side	4.8	0.7	#
Chloride	mEq/L	Central side with ongoing fluid infusion	54.0	16.7	
		Central side with suspended fluid infusion	97.0	2.3	*
		Contralateral side	97.8	2.9	#
Calcium	mEq/L	Central side with ongoing fluid infusion	4.7	3.6	
		Central side with suspended fluid infusion	14.0	0.5	*
		Contralateral side	14.1	0.6	#
Inorganic phosphorus	mg/dL	Central side with ongoing fluid infusion	2.1	1.3	
		Central side with suspended fluid infusion	6.9	0.7	*
		Contralateral side	7.8	1.0	#
Magnesium	mg/dL	Central side with ongoing fluid infusion	1.2	0.8	
		Central side with suspended fluid infusion	3.3	0.1	*
		Contralateral side	3.5	0.2	#
Serum iron	µg/dL	Central side with ongoing fluid infusion	75.2	55.4	
		Central side with suspended fluid infusion	217.0	15.0	*
		Contralateral side	222.6	16.0	#
Total iron binding capacity	µg/dL	Central side with ongoing fluid infusion	91.4	69.2	
		Central side with suspended fluid infusion	269.4	24.8	*
		Contralateral side	282.8	27.1	#

Tukey's test. *P < 0.05, central side with ongoing fluid infusion versus central side with suspended fluid infusion. #P < 0.05, central side with ongoing fluid infusion versus contralateral side.

cal test items included tests for alkaline phosphates, aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase, gamma-glutamyl transpeptidase, leucine aminopeptidase, total protein, albumin, urea nitrogen, creatinine, glucose, total cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, phospholipid, creatine phosphokinase, sodium, potassium, chloride, calcium, inorganic phosphorus, magnesium, and serum iron levels; total iron binding capacity; unsaturated iron binding capacity; and serum amylase. The blood cell tests included determination of the counts of leukocytes, red blood cells, hemoglobin, hematocrit, and platelets.

The research ethics committee at the Aomori University of Health and Welfare approved the study protocol.

Results

For all test items examined (Tables 1-4), a significant difference in the test item data was observed between blood samples collected from the proximal side with ongoing fluid infusion and those collected from the proximal side with suspended fluid infusion. A significant difference was also observed between blood samples collected from the proximal side with ongoing fluid infusion and those collected from the contralateral side. Conversely, for all test items, no significant difference in test item data was observed between blood samples collected from the proximal side with suspended fluid infusion and those collected from the contralateral side.

Discussion

Animal experiments were conducted to elucidate whether blood samples remain unaffected by fluid infusion when collected from the proximal side of the infusion site by suspending the infusion process during the sampling.

Our experimental results confirmed that blood sample data are unaffected by fluid infusion when the blood is obtained from the proximal side of the infusion site under the conditions of suspended fluid infusion during the blood sampling process. Existing guidelines on blood sampling techniques and nursing recommend that sampling blood from the extremity where flu-

Table 4. Blood Date (n = 5)

Analytes	Unit	Blood collection	Mean	SD	P
Unsaturated iron binding capacity	μg/dL	Central side with ongoing fluid infusion	17.4	13.4	
		Central side with suspended fluid infusion	52.4	16.0	*
		Contralateral side	60.2	14.9	#
Serum amylase	U/L	Central side with ongoing fluid infusion	97.8	74.2	
		Central side with suspended fluid infusion	295.8	16.7	*
		Contralateral side	309.4	19.1	#
Leukocytes	/μL	Central side with ongoing fluid infusion	2,012.0	1,312.3	
		Central side with suspended fluid infusion	5,450.0	143.7	*
		Contralateral side	5,742.5	376.1	#
Red blood cells	$\times 10^4$/μL	Central side with ongoing fluid infusion	312.2	129.9	
		Central side with suspended fluid infusion	659.2	17.4	*
		Contralateral side	667.8	49.2	#
Hemoglobin	dL	Central side with ongoing fluid infusion	6.9	2.9	
		Central side with suspended fluid infusion	14.2	0.5	*
		Contralateral side	14.5	1.1	#
Hematocrit	%	Central side with ongoing fluid infusion	22.4	9.5	
		Central side with suspended fluid infusion	48.5	1.2	*
		Contralateral side	48.6	3.7	#
Platelets	$\times 10^4$/μL	Central side with ongoing fluid infusion	12.7	5.5	
		Central side with suspended fluid infusion	23.4	4.0	*
		Contralateral side	22.8	4.5	#

Tukey's test. *P < 0.05, central side with ongoing fluid infusion versus central side with suspended fluid infusion. #P < 0.05, central side with ongoing fluid infusion versus contralateral side.

id infusion is being conducted should be avoided [8, 9]; however, our results suggest that blood samples remain unaffected by fluid infusion when obtained from the proximal side of the infusion site if the proposed method is used. Our proposal contributes to the expansion of the blood sampling site options in patients who are undergoing fluid infusion. Generally, fluid infused via a vein in the forearm and the cubital fossa, which is the first choice for blood sampling [4], can be selected even when fluid infusion is being conducted. Because blood vessels at the cubital fossa are thicker and more elastic than those at other sites, it involves lower risk of blood sampling failure. Thus, it is not only easier for a nurse to sample blood and reduce the risk of sampling failure but also the discomfort experienced by the patient is reduced by the proposed method. We expect this research to be applicable to the following situations wherein there is no choice but to select the proximal side of the upper extremity where fluid infusion is being conducted as a blood sampling site: 1) when no thick and elastic blood vessel suitable for blood sampling is available in the cubital fossa opposite to the fluid infusion site, 2) when fluid infusion is being conducted for both the limbs, and 3) when the patient has undergone mastectomy with lymph node dissection or has undergone shunt creation in the upper extremity opposite to the fluid infusion site.

Our study has some limitations. First, if fluid infusion is stopped for an extended period, it is possible for a thrombus to form in the indwelling needle, which can prevent precise fluid infusion when resumed. In such a situation, the indwelling needle would have to be inserted again, causing discomfort to the patient. In addition, even if fluid infusion can be resumed, there is a possibility that the thrombus formed inside the indwelling needle will enter and move through the venous circulatory system. If this occurs, there is a risk of pulmonary embolism and cerebral infarction. There is no experimental study on how long an interruption in fluid infusion can cause thrombus formation; this needs to be examined in the future. Second, this research was conducted on animals; therefore, application in humans would require human trials. Nevertheless, our animal experiments confirmed that blood sample data remain unaffected by fluid infusion when the blood is collected from the proximal side of the infusion site by temporarily suspending the fluid infusion. In the future, we plan to conduct a proof-of-concept study in humans as it is significantly valuable for clinical application.

Conclusion

We successfully verified our hypothesis and demonstrated that blood samples remain unaffected by fluid infusion when blood

is collected from the proximal side of the infusion site under the condition of suspended fluid infusion.

Acknowledgments

We would like to thank all participants of this study.

Grant Support

This study was supported by JSPS KAKEN (grant number JP16K20717 (2016-2017)).

References

1. Barbara K. Vernoski BK. Effect of blood collection practices on emergency department blood specimen rejection rates. UNF Graduate Theses and Dissertations. 2013.
2. Leitch A, McCormick I, Gunn I, Gillespie T. Reducing the potential for phlebotomy tourniquets to act as a reservoir for meticillin-resistant Staphylococcus aureus. J Hosp Infect. 2006;63(4):428-431.
3. Louie RF, Lau MJ, Lee JH, Tang Z, Kost GJ. Multicenter study of the prevalence of blood contamination on point-of-care glucose meters and recommendations for controlling contamination. Point of Care. 2005;4(4):158-163.
4. Strasinger SK, Di Lorenzo MS. The Phlebotomy Textbook. In: Davis FA, eds. Philadelphia, 2011:196-198.
5. Garza D, Becan-McBride K. Phlebotomy Handbook, Pearson education. USA, 2015:319-325.
6. Di Lorenzo MS, Strasinger SK. Blood Collection. In: Davis FA, eds. Philadelphia, 2010:46-50.
7. Koike S, Takeda T. Experimental research of blood collected from the peripheral side of the fluid infusion site that is not affected by fluid infusion. J Hematol. 2017:6(1):1-5.
8. Christensen BL, Kockrow EO. Foundations of Nursing. Mosby, St. Louis. 2006:506-511.
9. Strasinger SK, Di Lorenzo MS. The Phlebotomy Textbook. In: Davis FA, eds. Philadelphia, 2011:227-230.