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Experimental Research of Blood Collected From the Peripheral Side of the Fluid Infusion Site That Is Not Affected by Fluid Infusion

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Abstract

Background: The objective of this study was to determine a safe blood sample collection site for clinical investigations, in patients with an *in situ* intravenous line, which would minimize distress to the patient and provide accurate blood data.

Methods: An intravenous line was established in the left upper limb for administration of Solita T3G (84 mL/h). After 5 min of infusion, two nurses simultaneously collected venous blood samples (vacuum blood collection method) from a site on dorsum of the left hand located 15 cm distal to the site of fluid infusion (the peripheral side), and the cubital fossa of the contralateral upper limb (the opposite side). The results obtained from the blood samples of the contralateral side served as the standard reference. Testing of 41 blood-cell tests and biochemical parameters were outsourced to a specialized company. Between-group differences in test results for the two locations were assessed using the paired *t*-test, with a significance level of < 5%.

Results: No significant differences in mean values (± standard deviation) of blood parameters were observed between the distal site and the contralateral side.

Conclusion: Blood samples collected from a venous site located 15 cm distal to the fluid-infusion site did not show any effect of fluid infusion on the results.

Keywords: Blood collection; Collection site; Fluid infusion; Nursing technique; Venous blood; Injection; Blood cell investigations; Biochemical investigations

Introduction

The blood circulates through the whole body, and there are various physical information. Therefore, blood tests are used for diagnosis of illness and therapeutic monitoring. Blood investigations including examination of blood corpuscles, biochemistry, and serological tests provide a rich variety of information and are particularly suitable as screening tests owing to their minimally invasive nature. Accuracy of blood investigations is important. Modalities of blood sample collection are critical to the accuracy of test results; moreover, certain components of blood are liable to change under different conditions, which may affect the accuracy. Change in the serum potassium levels caused by clenching of fist by the subjects is on record [1, 2]. It is also reported that the data of blood samples, which are collected in the proximal regions from the infusion sites, are affected by blood transfusions [3].

In patients who have undergone surgical procedures such as mastectomy with lymph node dissection or those with arteriovenous shunt for dialysis, future fluid infusions are usually administered on the contralateral limb. When a blood sample is collected from these patients, the affected side is not used for paracentesis during investigations. In addition, it is believed that blood samples should not be collected from an arm where a fluid infusion is being administered [4-7]. Therefore, in many medical institutions, a lower-limb vein is selected for blood sample collection; however, sample collection from the lower limb is painful and distressing to most patients. It is also a cause of concern for nurses. Furthermore, the blood collection guidelines and textbooks on nursing technique state that blood collection from the lower limbs should be avoided due to the risk of thrombosis [4, 6]. Therefore, the objectives of this research were to determine a safe site for blood sample collection that would not cause distress to the patient and to verify the accuracy of blood data from the new site, even during fluid infusion.

We previously reported an animal study on seven 20-week-old Japanese white male rabbits. Fluid infusion routes were secured via the left auricular veins. To simulate the scenario of a fasting patient who was receiving a 24-h fluid infusion, we used a type 3 fluid for infusion (brand name: Solita T3G), as this is the most common type in clinical use for such patients. The infusion was started after 5 min, and blood samples of 2 mL each were collected from sites 2 cm proximal and 2 cm distal to the infusion site, and from the contralateral side (the right auricular vein). The test results of blood samples from the opposite side were considered as the standard reference. For analysis, we measured 39 blood-cell tests and biochemical parameters. Serum levels of albumin, sodium, chlorine, calcium, and magnesium in the samples collected from the proximal site

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were significantly lower than those in samples collected from the distal as well as the contralateral side. Blood sugar and serum potassium levels in the sample collected from the proximal site were significantly higher than those from the peripheral and opposite sides. No statistically significant differences were observed for any other parameters.

Total protein, albumin, sodium, chlorine, calcium, and magnesium tests at the proximal site were significantly lower than that at the contralateral side; this may be because of the lower concentrations of these constituents in Solita T3G relative to blood. Conversely, blood sugar and potassium levels were higher at the proximal site due to their higher concentrations in the infused fluid. No significant difference between the distal site and contralateral side was found, since blood sample collected from the distal site is not affected by fluid infusion [3]. The finding that blood sample collected from a site distal to the site of fluid infusion site is not affected by fluid infusion needs to be verified in human subjects.

Methods

Study design

The present study was an experimental research for verification of causal hypothesis.

Study participants

Five men with nationally accredited healthcare qualifications participated in the study. Only men were selected to control for potential confounding effect of variables that may vary on account of sex difference.

The sample size was determined on the basis of sodium concentration in the infusion fluid used. The mean reference range in blood data was set at ± 2 standard deviation (SD), which corresponded to 140 ± 5 mEq/L with an SD of ± 2.5 for sodium. When the value was calculated with G*Power software using *t*-test with α error of 0.05, 1 - β error of 0.8, and sample size of 5, the effect size was 1.36. The difference to be detected was 1.36 × SD (2.5), which was equal to 3.4. Since this study was intended for clinical application, it was required to detect a clinically significant difference. Thus, a statistically significant difference of 1 - 2 units between mean sodium levels may not be caused by the influence of infusion fluids but rather due to the variation in blood sampled from different sites. Therefore, a sample size (n) of 5 was required to detect difference in sodium levels of approximately ± 3.4 with an SD of ± 1.

Fluid infusion and blood sampling

Study participants were not allowed to eat or exercise 2 h prior to the fluid infusion and blood sampling. The sampling was performed in a clinical setting. Administration of Solita T3G was initiated at the rate of 84 mL/h via the forearm of the left upper limb by a disposable plastic indwelling cannula with 24 G needle (length was 19 mm, outer diameter was 0.7 mm, and inner diameter was 0.47 mm). After 5 min, two nurses simultaneously collected blood samples using the vacuum blood collection method from the dorsum of the hand, which was 15 cm distal to the fluid infusion site (the peripheral side), and the cubital fossa of the upper limb on the opposite side (the opposite side) by a 23 G winged needle (length: 19 mm).

Data analysis

A battery of 41 blood-cell and biochemical investigations was outsourced to a specialized company. The tests included total bilirubin, direct bilirubin, thymol turbidity test, zinc sulfate turbidity test, alkaline phosphates, aspartate aminotransferase, alanine aminotransferase, lactate dehydrogenase, gamma-glutamyl transpeptidase, leucine aminopeptidase, cholinesterase, total protein, albumin, urea nitrogen, uric acid, creatinine, blood glucose, total cholesterol, triglycerides, HDL-cholesterol, LDL-cholesterol, phospholipids, creatine phosphokinase, sodium, potassium, chloride, calcium, inorganic phosphorus, magnesium, serum iron, total iron binding capacity, unsaturated iron binding capacity, serum amylase, leukocytes, red blood cell count, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and platelet counts.

Between-group differences in results of investigations between any two locations were assessed using the paired *t*-test, with a significance level of < 5%.

Ethical consideration

Data collection site

Blood collection and infusion are invasive procedures that involve needle puncture conducted by a skilled nurse. Therefore, it was considered favorable to collect data at a medical institution in the presence of a physician and a nurse. The investigator requested the use of the facility at a clinic located in the same city as the university the investigator belonged to. The study plan and details were shared with the director of the clinic and the chief nursing officer and a written approval was obtained.

Open recruitment of subjects

Volunteers were enrolled using an open recruitment strategy, referring to a notice displayed at the work place of the investigator to prevent enforced participation. For displaying the notice, the outline of the study was explained to the head of the work site using the study plan and due permission was obtained. The study objectives and method of intervention were explained orally and in writing to the potential subjects. They were informed about their right to withdraw from the study at any time without incurring any disadvantages. A written consent was obtained using an informed consent form. Healthcare

Table 1. Blood Parameters From Samples Collected From the Site Distal to Site of Intravenous Infusion and on the Contralateral Side (n = 5)

Analytes	Unit	Distal side		Contralateral arm		*t*-test
		Mean	SD	Mean	SD	
Total bilirubin	mg/dL	0.62	0.5	0.66	0.6	n.s.
Direct bilirubin	mg/dL	0.22	0.2	0.24	0.2	n.s.
Thymol turbidity test	U	1.86	0.8	1.88	0.8	n.s.
Zinc sulfate turbidity test	U	4.56	1.1	4.9	1.5	n.s.
Alkaline phosphates	U/L	207	28.7	209	27.6	n.s.
Aspartate aminotransferase	U/L	21.4	3.3	21.2	2.6	n.s.
Alanine aminotransferase	U/L	24.8	9.3	25.4	9.6	n.s.
Lactate dehydrogenase	U/L	184	8.8	186	13.3	n.s.
Gamma-glutamyl transpeptidase	U/L	33.2	9.4	34.0	9.0	n.s.
Leucine aminopeptidase	U/L	49.0	4.0	49.8	4.7	n.s.
Cholinesterase	U/L	416	25.0	421	22.7	n.s.
Total protein	g/dL	7.2	0.1	7.3	0.2	n.s.
Albumin	g/dL	4.5	0.2	4.6	0.3	n.s.
Urea nitrogen	mg/dL	12.5	3.9	12.4	3.9	n.s.
Uric acid	mg/dL	6.6	1.1	6.4	0.8	n.s.
Creatinine	mg/dL	0.82	0.1	0.83	0.1	n.s.
Glucose	mg/dL	96.2	10.3	94.8	11.4	n.s.
Total cholesterol	mg/dL	186	32.0	189	31.4	n.s.
Triglyceride	mg/dL	160	79.9	163	79.5	n.s.
HDL-cholesterol	mg/dL	41.8	6.3	42.4	7.4	n.s.
LDL-cholesterol	mg/dL	121	22.0	123	23.8	n.s.
Phospholipid	mg/dL	199	32.5	202	33.2	n.s.
Creatine phosphokinase	U/L	159	68.5	161	69.8	n.s.
Sodium	mEq/L	141	1.0	141	0.4	n.s.
Potassium	mEq/L	4.14	0.3	4.22	0.2	n.s.
Chloride	mEq/L	105	1.6	104	1.3	n.s.
Calcium	mg/dL	8.98	0.2	9.04	0.3	n.s.
Inorganic phosphorus	mg/dL	3.60	0.2	3.54	0.2	n.s.
Magnesium	mg/dL	2.18	0.1	2.16	0.1	n.s.
Serum iron	μg/dL	70.8	32.2	71.8	31.0	n.s.
Total iron binding capacity	μg/dL	304	23.9	308	27.5	n.s.
Unsaturated iron binding capacity	μg/dL	234	36.5	237	35.8	n.s.
Serum amylase	U/L	60.6	7.1	62.0	7.7	n.s.
Leukocytes	/μL	7,654	746.2	7,604	849.3	n.s.
Red blood cells	$\times 10^4/\mu L$	501	329	500.8	340	n.s.
Hemoglobin	dL	14.9	1.3	14.9	1.4	n.s.
Hematocrit	%	43.7	3.1	43.9	3.1	n.s.
Mean corpuscular volume	fL	87.4	2.2	87.8	1.8	n.s.
Mean corpuscular hemoglobin	pg	29.7	1.0	29.7	1.0	n.s.
Mean corpuscular hemoglobin concentration	%	34.0	0.9	34.0	1.0	n.s.
Platelets	$\times 10^4/\mu L$	27.0	4.7	27.9	4.3	n.s.

professionals with nationally accredited healthcare qualifications were recruited because they had already understood the risks associated with infusion and blood collection and were likely to adequately understand the explanation provided by the investigator on topics they were previously unaware of.

Blood sample collection and securing the infusion line

Blood sample collection and intravenous infusion was administered by a nurse with a level 3 experience, which is the highest level assigned to nurses according to the "Guideline for practicing intravenous injection by nurses" stipulated by the Japanese Nursing Association [8].

Financial compensation for the subjects in case of complications

In case of any unforeseen complications among the subjects, the medical expenses for the same were to be paid by the investigator. The investigator obtained two insurances: "Will & e-kango" from the Japan Nursing School Benefit Association and "Nursing Professional Liability Insurance Program" from the Japanese Nursing Association, to promptly respond to financial issues concerned with medical expenses and compensation.

Approval of the ethics committee

The study protocol was approved by the research ethics committee at the Aomori University of Health and Welfare, Iwate Prefectural University.

Results

General characteristics of the participants

Mean age (± SD) of subjects was 39.2 (± 6.5) years (range, 32 - 49), mean height (± SD) was 172.0 (± 4.9) cm (range, 163 - 177), mean weight (± SD) was 71.4 (± 2.8) kg (range, 68.0 - 76.4), and mean body mass index (± SD) was 24.2 (± 1.3) kg/m^2 (range 22.5 - 26.5).

Comparison of test results from samples collected from distal site and contralateral side

No significant difference in blood test results were observed between the two groups (Table 1).

Discussion

In this study, we compared 41 blood parameters on samples collected from a site 15 cm distal to the fluid infusion site and those from the opposite side in normal human subjects.

The comparison of the data for these samples showed no significant differences in any items, and the means and SDs were similar and there is no change in each individual. Thus, it was believed that accurate data cannot be obtained from the arm where a fluid infusion is being administered, but we demonstrated that the data of blood samples, which are collected in the 15-cm distal regions from the infusion sites, are not affected by blood transfusions and that they are accurately correlated with biological conditions of the patients. For patients who have undergone surgical procedures such as mastectomy combined with lymph node dissection, or the creation of arteriovenous shunt for dialysis, and an intravenous line for fluid infusions on the unaffected side, a lower-limb vein is used for blood sample collection. Our study suggests that a site 15 cm distal to the fluid infusion site can be used for blood sample collection. This would avert the risk of pain and thrombosis in case the blood sample is collected from a lower-limb vein.

Our results do not support the previous reports, which suggested that blood sample should not be collected from the arm where a fluid infusion is being administered [4-7].

We found that the blood sample collection from a site 15 cm distal to the site of fluid infusion was not affected by the infusion. It needs to be clarified whether blood sample collection from a site located < 15 cm distal to the site of fluid infusion provides accurate results.

Conclusion

Blood sample collected from a site 15 cm distal to the fluid-infusion site did not show any effect of the fluid infusion on the results and can be safely used.

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