Venipuncture Versus Peripheral Catheter: Do Infusions Alter Laboratory Results?

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Introduction: Our aim was to evaluate the equivalence between analytic parameters from blood samples obtained from a saline solution lock device used for the infusion of drugs and those from venipuncture. In our emergency department, patients bearing a saline solution lock device have blood extracted by venipuncture to avoid possible contamination of the sample.

Methods: Adults from the emergency department with a saline solution lock device who required laboratory tests were selected as candidates for this cross-sectional observational study. Infusions were halted and flushed with 0.9% saline solution; 2 minutes later, 2 mL of blood was drawn and discarded, and the corresponding laboratory tubes were filled. Immediately after, another sample was withdrawn from the opposite extremity by venipuncture. Both samples were analyzed for hematology, biochemistry, venous blood gases, and coagulation parameters. Concordance was evaluated by use of the intraclass correlation coefficient with its 95% confidence intervals; Bland-Altman plots were used to illustrate the percentage of samples with differences exceeding 2 SDs. The mean differences were also checked to detect those exceeding the laboratory's systematic error.

Results: An intraclass correlation coefficient of over 0.9 was achieved for all parameters except for pH, partial pressure of carbon dioxide, and partial pressure of oxygen. Differences of over 2 SDs were found in fewer than 10% of all parameters. None of them exceeded 3 SDs, except for pH and venous blood gases. All parameters showed differences below the laboratory's accepted systematic error except for pH and venous blood gases.

Discussion: Blood samples extracted from a peripheral catheter with or without drug infusions are valid for the analysis of hematology, biochemistry, and coagulation parameters but not for venous blood gases. Nurses should know the benefits of using an existing peripheral catheter for drawing blood samples for laboratory analysis even when infusing commonly used drugs. Emergency nurses should consider collecting blood specimens from a venous access device regardless of the type of drug infusions administered, because it is a safe, simple, and fast technique, which is time efficient when treating patients with limited venous access sites. This procedure reduces patient discomfort and the risk of complications related to venipunctures.

Key words: Peripheral catheter; Laboratory results; Venipuncture; Saline lock device; Nursing; Blood extraction; Infusions

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Patients treated in our hospital's emergency department are subject to numerous laboratory tests to monitor different analytic parameters. The most common practice, which is not evidence based, is to obtain these blood samples by means of venipuncture, even though patients already have a peripheral venous access device (VAD) placed for the infusion of drugs and fluids. Nevertheless, this device is normally not used to obtain blood samples, because it is believed that the infusion of drugs and fluids alters the results.

Venipuncture is a painful and invasive technique that can cause bruising, hematomas, infections, vasovagal reactions, and in rare cases, peripheral nerve injury[1,2]; moreover, it also exposes nurses to the risk of an accidental needle stick.

Blood sampling from central venous and arterial lines is a common practice in intensive care units and has been proved to be efficient on numerous occasions[3,4]; similarly, previous studies have shown the efficiency of blood sam-

pling through peripheral venous catheters, which suggests that there are no significant differences between samples obtained from direct venipuncture and samples extracted from a VAD.[5-12]

Furthermore, during our literature review, we did not find articles on blood samples extracted from VADs with drug infusions other than 0.9% saline solution, 5% dextrose, isotonic glucosaline solution, lactated Ringer solution, and 2-mol/L potassium chloride.[7,8,13,14] We found that most studies compare different protocols and methods of extraction[15] but study a limited number of analytic parameters and, in general, use a small sample number (n < 100).

These circumstances made us consider whether it was possible to avoid painful procedures for blood specimen collection in patients with a VAD in our emergency department, despite the infusion of drugs. Our hypothesis was that blood samples extracted from a VAD did not differ from those extracted by venipuncture.

Our main aim was to evaluate the equivalence between analytic parameters from blood samples obtained from a VAD and those obtained by venipuncture. In addition, we wanted to observe the effect that the most commonly used drugs in the emergency department had on blood samples extracted from those same vascular devices.

Methods

We designed a prospective, observational, cross-sectional study of equivalence between blood samples extracted by means of 2 different techniques: from a VAD and by routine venipuncture. The following laboratory panels were analyzed in the hospital's ED laboratory; glucose (in milligrams per deciliter), urea (in milligrams per deciliter), creatinine (in milligrams per deciliter), Na^+ (in millimoles per liter), K^+ (in millimoles per liter), Cl^- (in millimoles per liter), Ca^{2+} (in milligrams per deciliter), albumin (in grams per deciliter), amylase (in units per liter), creatin kinase (in units per liter), total bilirubin (in milligrams per deciliter), osmolality (milliosmoles per kilogram), pH, venous partial pressure of carbon dioxide (pCO_2) (mm Hg), venous partial pressure of oxygen (pO_2) (mm Hg), HCO_3^- (in millimoles per liter), troponin (in nanograms per milliliter), leucocytes (in cells per microliter), red blood cells (in cells per microliter), International Normalized Ratio, hemoglobin (in grams per deciliter), platelets (in cells per microliter), and activated plasma thromboplastin time (aPTT) (in seconds). Laboratory panels such as lactate or ammonium, which required a specific sampling technique, were not analyzed.

The study was approved by the hospital's Ethics in Biomedical Research Committee and conducted over a 7-month period in the emergency department of a university hospital that treats an average of 400 patients a day. Informed consent was offered consecutively to all aware adult patients with a double-lumen VAD and a laboratory test prescription.

We excluded patients who had anemia (hemoglobin level <9 g/dL), vascular disease, or coagulopathy; who were receiving anticoagulant treatment; who were immunocompromised; who had difficult venous access; and in whom venipunctures had to be minimized; as well as those who refused to participate (n = 1).

The quantity of blood for discard was double the dead space of the catheter (0.2 mL) plus the dead space of the catheter extension set (0.6 mL), which was in total 1.6 mL,[9,11,16] although we decided to round up the amount to 2 mL to facilitate the process.

Six qualified nurses with more than 3 years' ED experience were trained for the extraction of the samples according to the study's procedure. To collect the 2 blood samples, we proceeded to halt any infusions running and flush both catheter extension set lumens with 1 mL of 0.9% saline solution[17] each. Both lumens were clamped to minimize blood reflux. Two minutes later,[6,8,14] a tourniquet was placed proximal to the catheter, and the tip of the female Luer connector of 1 of the lumens was wiped with an alcohol pad; a syringe was then attached to it, and after unclamping the lumen, 2 mL of blood was drawn and discarded.

A Vacutainer Luer adapter with a collector (Becton, Dickinson and Company, Franklin Lakes, NJ) was attached to the connector, and 3 vacuum-prepared laboratory tubes and a blood gas syringe (Becton, Dickinson and Company–Diagnostics, Plymouth, England) were inserted and filled for analysis. The tourniquet was then removed, and both lumens were flushed with 1 mL of 0.9% saline solution each. Immediately thereafter, routine venipuncture was performed on the opposite arm using a 21-gauge butterfly needle attached to a Vacutainer system (Eclipse; Becton, Dickinson and Company) and the corresponding laboratory tubes filled for analysis. After this, the infusion was restarted.

Venipuncture and VAD blood specimens were sent to the ED laboratory, where the laboratory technicians processed them simultaneously.

The sample size was estimated over creatinine, a critical parameter in commercial control samples. Mean, SD, and admissible total error[18] for creatinine in our laboratory are 1.1 mg/dL, 0.725 mg/dL, and 13%, respectively, giving an estimated sample size of 250.

Concordance of paired results (samples obtained by venipuncture were considered as the gold standard) was evaluated by use of the intraclass correlation coefficient (ICC) with its 95% confidence intervals and Bland-Altman plots to illustrate the number and percentage of samples

TABLE 1
Concordance between results obtained by both methods of blood extraction (VAD and venipuncture)

	Overall			With infusions			Without infusions		
		95% CI			95% CI			95% CI	
Parameter	ICC	Lower	Upper	ICC	Lower	Upper	ICC	Lower	Upper
Glucose	0.99	0.99	0.99	0.99	0.99	0.99	0.98	0.97	0.99
Urea	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00
Creatinine	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00
Na^+	0.91	0.88	0.93	0.92	0.89	0.94	0.88	0.81	0.92
K^+	0.91	0.88	0.93	0.91	0.87	0.93	0.90	0.85	0.94
Cl^-	0.95	0.94	0.97	0.94	0.91	0.96	0.98	0.96	0.99
Ca^{2+}	0.93	0.91	0.94	0.91	0.88	0.94	0.96	0.93	0.97
Albumin	0.97	0.96	0.97	0.96	0.94	0.97	0.99	0.98	0.99
Amylase	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Creatin kinase	0.97	0.96	0.98	1.00	1.00	1.00	1.00	0.99	1.00
Bilirubin	1.00	0.99	1.00	1.00	1.00	1.00	0.99	0.98	0.99
pH	0.88	0.85	0.91	0.89	0.85	0.92	0.88	0.81	0.92
pCO_2	0.79	0.73	0.83	0.74	0.66	0.80	0.84	0.76	0.90
pO_2	0.54	0.44	0.63	0.55	0.43	0.66	0.51	0.31	0.67
HCO_3^-	0.92	0.90	0.94	0.91	0.88	0.94	0.93	0.90	0.96
Troponin	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Osmolality	0.92	0.87	0.95	0.91	0.85	0.95	0.94	0.86	0.98
Leucocytes	0.99	0.99	1.00	0.99	0.99	1.00	0.99	0.99	1.00
Red blood cells	0.98	0.98	0.99	0.98	0.98	0.99	0.98	0.97	0.99
Hemoglobin	0.99	0.99	0.99	0.99	0.98	0.99	1.00	0.99	1.00
Platelets	0.99	0.99	0.99	0.99	0.99	0.99	1.00	0.99	1.00
aPTT	0.95	0.93	0.96	0.96	0.94	0.97	0.93	0.89	0.95
INR	0.99	0.99	0.99	0.99	0.99	1.00	0.99	0.99	1.00

CI, Confidence interval; *ICC*, intraclass correlation coefficient; *INR*, International Normalized Ratio.

with differences exceeding 2 SDs. The mean differences, expressed as percentages, were also checked to detect those exceeding the laboratory's admissible systematic error.[18]

The parameters for which we did not have any reference data in our laboratory were obtained from Ricós et al.[19]

Associations between qualitative variables were made by use of the χ^2 test. A 2-sided *P* value of less than .05 was considered statistically significant. SPSS software (version 18; SPSS, Chicago, IL) was used to conduct the analyses.

Results

A total of 259 paired blood samples were collected. Concordance between results obtained by both methods of blood extraction is shown in Table 1. An ICC of over 0.9 was achieved for all parameters except for venous pCO_2 and venous pO_2.

Results of mean values, absolute mean differences, and differences expressed as percentages are shown in Table 2.[19] It can be seen that some parameters (creatinine, K^+, Ca^{2+}, albumin, bilirubin, hematologic cell counts, and aPTT, as well as blood gases) show a statistically significant mean difference, but clinically, this difference has no significance. Fewer than 10% of paired samples' differences exceeded 2 SDs (Bland-Altman scatter plot for amylase is shown in the Figure), all of which (expressed as percentage) were below the admissible systematic error included in our laboratory specifications; only pH and blood gases exceeded 3 SDs (data not shown).

We observed no significant differences between the percentage of hemolysis in samples extracted from the VAD and those from venipuncture ($P = 0.4$); in addition, different catheter sizes (18 and 20 gauge) had similar hemolysis rates (22% and 21%, respectively). Concordance

TABLE 2
Differences between laboratory test values depending on method of extraction, including number of values exceeding 2 SDs and calculated and admissible errors

Parameter	Mean VAD	Mean VP	Difference in mean values	95% CI		SD	n >2 SDs	n >2 SDs (%)	SE	
				Lower	Upper				Calculated	Admissible
Glucose	121.42	120.76	0.66	–0.32	1.64	7.58	8.00	3.46	0.5485	2.2
Urea	41.84	41.89	–0.05	–0.30	0.20	1.84	16.00	7.66	–0.1262	5.5
Creatinine	1.07	1.09	–0.01	–0.02	–0.01	0.07	7.00	3.02	–1.3781	5.1
Na^+	138.46	138.35	0.11	–0.13	0.34	1.80	9.00	3.90	0.0780	1.0
K^+	3.86	3.92	–0.05	–0.08	–0.02	0.22	11.00	5.14	–1.3687	1.8
Cl^-	105.21	104.88	0.33	0.09	0.56	1.43	9.00	6.34	0.3130	1.0
Ca^{2+}	8.73	8.81	–0.08	–0.10	–0.05	0.18	14.00	6.51	–0.8573	3.8
Albumin	3.45	3.50	–0.05	–0.07	–0.04	0.12	15.00	6.64	–1.5328	2.0
Amylase	51.87	52.41	–0.54	–0.92	–0.17	2.74	4.00	1.96	–1.0382	11.1
Creatin kinase	157.01	152.97	4.04	–7.90	15.99	85.69	1.00	0.50	2.6436	11.5
Bilirubin	0.66	0.67	–0.01	–0.02	–0.01	0.06	10.00	5.59	–1.9750	10.0
pH	7.40	7.39	0.01	0.00	0.01	0.02	4.00	1.78	0.0933	1.0
pCO_2	42.01	43.80	–1.78	–2.33	–1.24	4.17	15.00	6.52	–4.0721	1.8
pO_2	45.56	38.55	7.01	5.31	8.71	12.80	20.00	9.09	18.1818	5.52
HCO_3^-	25.97	26.60	–0.63	–0.82	–0.44	1.47	16.00	6.93	–2.3824	1.8[a,b]
Troponin	1.12	1.08	0.04	–0.04	0.12	0.27	1.00	2.00	3.6770	10.0
Osmolality	292.24	292.82	–0.58	–1.72	0.57	5.01	2.00	2.63	–0.1977	0.7
Leucocytes	8.99	9.06	–0.07	–0.13	–0.02	0.44	15.00	6.20	–0.7862	5.6[a]
Red blood cells	4.27	4.30	–0.03	–0.05	–0.01	0.13	9.00	3.73	–0.6997	1.7[a]
Hemoglobin	12.56	12.67	–0.11	–0.14	–0.07	0.27	17.00	7.00	–0.8415	1.8[a]
Platelets	206.91	209.25	–2.34	–3.48	–1.20	8.98	16.00	6.61	–1.1177	5.9[a]
aPTT	32.41	33.04	–0.63	–0.92	–0.35	2.19	20.00	8.66	–1.9194	2.3[a]
INR	1.16	1.17	–0.01	–0.02	0.00	0.06	6.00	2.58	–0.8118	2.0[a,c]

CI, Confidence interval; *INR*, International Normalized Ratio; *SE*, systematic error; *VP*, venipuncture.
[a]Data were obtained from Ricós et al[19] (1999).
[b]Carbon dioxide data.
[c]Prothrombin time data.

between VAD samples, with and without infusions, and venipuncture samples was similar.

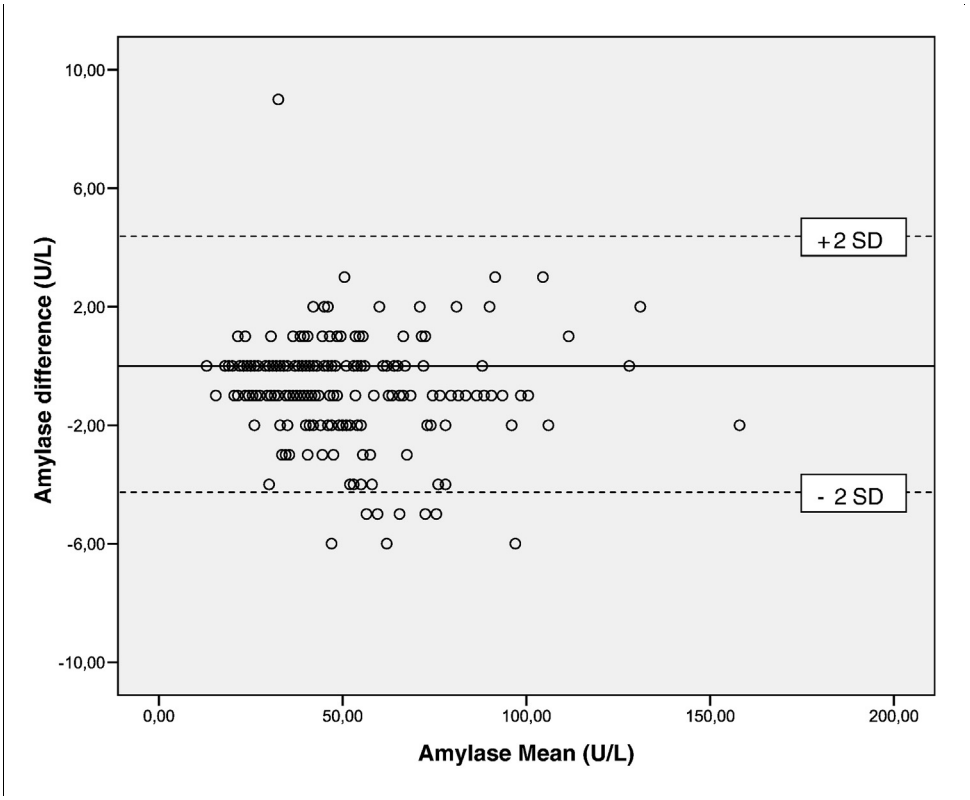
Discussion

Our study confirms the reliability of using VADs for the extraction of blood samples for the analysis of glucose, urea, creatinine, Na^+, K^+, Cl^-, Ca^{2+}, albumin, amylase, creatin kinase, total bilirubin, osmolality, troponin, leucocytes, red blood cells, hemoglobin, platelets, International Normalized Ratio, and aPTT, as shown by the ICCs of over 0.9 and no samples with differences exceeding 3 SDs. Na^+, K^+, and osmolality yielded an inferior limit of the ICC, below 0.9, but we consider the concordance with lower limits of 0.88, 0.88, and 0.87, respectively, to be very good.

Potassium is especially sensitive to hemolysis. Authors who registered altered K^+ values observed a higher incidence of hemolysis in samples from catheters smaller than 18 gauge because of greater difficulty in extraction.[8,20,21] On the contrary, we observed no differences in the extraction related to the size of the catheters used (18 and 20 gauge).

Granados Gámez et al[7] in their study relate the alteration of K^+ with the difficulty of extraction and the need to apply a tourniquet; we found it necessary to use one to ensure a correct sampling, which could have had a positive influence on our results for K^+.

Our findings support the results obtained by authors who studied biochemistry, coagulation, and hematology



FIGURE

Bland-Altman scatter plot for amylase. Blood samples were obtained through venipuncture and from a VAD.

parameters,[6,7] as well as, specifically, coagulation[5,9,10,12] and biochemistry values[11] altogether; these researchers also found no significant differences between both samples.

Mohler et al[13] studied biochemistry and hematology parameters and found divergent results for liver enzymes and electrolytes, but their number of participants was very scarce (n = 8) and samples from the VAD and venipuncture were obtained within 1 hour of each other.

Zlotowski et al,[14] with a larger sample size (n = 62) than Mohler et al,[13] analyzed similar parameters and obtained discordant results for K^+, HCO_3^-, and glucose, even after discarding 12 mL of blood. The infusion of a bolus of 200 mL of 0.9% saline solution and the short waiting period for the extraction (2 minutes), according to the authors,[14] could have caused hemodilution with the resulting alteration of these parameters.

Finally, venous blood gases (pO_2 and pCO_2) in our study showed a poor concordance (ICCs of 0.54 and 0.79, respectively). These differences are probably because of the difficulty in obtaining samples free from environmental air contamination, with the resulting increase in pCO_2 and loss of pO_2. The studies of Corbo et al[6] and Herr et al[8] only showed differences for HCO_3^-, which was ascribed, in the case of Herr et al, to the under-filling of the laboratory tubes and, in the case in Corbo et al (although the differences had no clinical relevance), to a longer time of tourniquet application for samples from the VAD. Zlotowski et al[14] also associate HCO_3^- alteration with the use of syringes for obtaining the samples and transferring them to the laboratory tubes, which could have given rise to a certain loss of carbon dioxide and, consequently, lower values of HCO_3^-. Further research should be done on this matter, improving the standardization of the procedures. In our hospital laboratory, HCO_3^- is calculated from carbon dioxide, which is why all alterations derived from sample contamination affected HCO_3^- values.

In this study, samples nearly triplicate those provided by other authors.[7] Until now, most have analyzed, specifically, biochemistry[11] or hematologic parameters.[5,9,10,12] We have extended the number of biochemistry and hematology values according to what is most commonly prescribed in our emergency department.

Studies that evaluate the effect on blood samples obtained from saline solution lock devices when infusing

medication are scarce, except for a few with infusions limited to 0.9% saline solution, 5% dextrose, glucosaline, lactated Ringer solution, and 2-mol/L potassium chloride. In this study, samples were drawn from catheters with these types of infusions and others, such as amoxicillin, metamizole, 1-mol/L bicarbonate, paracetamol, metoclopramide, omeprazole, furosemide, insulin, dexketoprofen, and 1-mol/L sodium bicarbonate. The limited number of samples with each of the infusions makes it difficult to draw conclusions on whether a specific medication alters any of the laboratory parameters. Further research should be done on this aspect, although we found that samples from VADs with infusions yielded better ICCs than those without (Table 1), which can be interpreted as a valid blood sampling technique applicable to patients bearing VADs with drug infusions.

Regarding the amount of blood that has to be discarded, findings vary from one author to another; few authors specify the dead space of the device,[9,16] which makes it difficult to know what criteria are used for deciding the amount to be discarded.

On the basis of the findings of Powers,[9] we decided to discard 2 mL of blood (double the dead space of the catheter and the extension set), which is a small amount but an important aspect to be considered in frail patients or patients with anemia. In addition, the time at which the infusion needs to be halted is brief (2 minutes), which does not interfere either in the patient's clinical progress[6,8,14] or in the nurse's regular organization. Finally, we used safety devices such as Vacutainer systems to reduce the risk of needle-stick injury but found few researchers who made use of them in their studies.[6,11,14,21]

Limitations

Our results cannot be extrapolated to patients who have anemia, who are immunocompromised, who are receiving anticoagulant treatment, or who have difficult venous access, who were excluded for ethical reasons. The Vacutainer system did not guarantee the extraction of samples for blood gases free from environmental air. Further research should be conducted to improve the standardization of the procedure. Finally, we did not record the number of patients who were excluded because of lack of blood reflux from the VAD; however, this number was small (around 5%) and would not have affected our results.

Implications for Emergency Nurses

This study has proven that applying a standardized procedure for collecting blood specimens from a VAD, regardless of the type of drug infusions administered, is a valid method for the analysis of the most commonly studied laboratory parameters in the emergency department. This procedure also allows each nurse to discard the minimum amount of blood regardless of the type of VAD and extension set, which are in continuous evolution, by calculating the dead space volume of the VAD and catheter extension set and discarding twice the dead space volume.

Applying the theory of evidence-based practice, emergency nurses should consider collecting blood specimens from a VAD regardless of the type of drug infusions administered as a first option, because it is a safe, simple, and fast technique, which is time efficient when treating patients with limited venous access sites. In addition, this technique has a direct positive impact on the patient's health because it avoids unnecessary painful procedures and reduces the risk of complications related to venipunctures. In overcrowded emergency departments with high workloads, nurses performing venipunctures are exposed to an unnecessary higher risk of needle-stick injury.

Conclusions

The extraction of blood from a saline solution lock device with or without infusions of medication is a valid method for the analysis of a large number of hematology, biochemistry, and coagulation parameters. The number of venipunctures can be significantly reduced to prevent patient discomfort and complications resulting from this technique.

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