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The effect of Substituting blood sampling through routine direct venipuncture with intravenous cannulation on the accuracy of hematologic results in children

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Abstract

Background: In pediatric care settings, intravenous cannulation (IVC) is usually needed for diverse purposes. Considering the painfulness and invasiveness of sampling by direct venipuncture (DVP), using a painless and less invasive method would be promising. Therefore, this study aimed to compare the effect of substitution of routine DVP with direct blood sampling through IVC on the accuracy of hematologic results.

Materials and Methods: This was a cross-sectional study conducted on 5-14-year-old children admitted to the emergency ward of 17th Shahrivar Pediatric Hospital in Rasht, north of Iran. After discarding only one ml of blood, paired-samples were taken from IVC and DVP and analyzed for 30 most frequently requested electrolytes, hematologic, and blood gas tests. The similarity of the obtained results by the two methods indicated the probability of substituting DVP with IVC and was defined by the absence of significant statistical difference ($P>0.05$).

Results: The comparison between the mean of hematologic factors by two methods showed significant similarity between groups regarding all parameters ($P>0.05$) except the mean of red blood cell count in the two groups ($P<0.05$). Assessing the level of electrolytes by two collection methods showed that there was a significant similarity between the mean of all parameters ($P>0.05$) except for phosphorus ($P=.002$). Furthermore, assessing the level of electrolytes showed a significant similarity between the potential of hydrogen, partial pressure of carbon dioxide, bicarbonate, and buffer base in the two groups ($P>0.05$). However, there was a significant difference between partial pressure of oxygen, base excess, and O_2 saturation in the two collection methods ($P<0.05$).

Conclusion: Based on the promising results obtained in this study, it seems that these methods could be interchangeably used, and IVC can be an alternative method for DVP by discarding the minimum amount of blood and less invasiveness in children.

Keywords: Child, Catheterization, Hematology, Venipuncture

Introduction

Several laboratory tests are needed for hospitalized patients (1). Direct Venipuncture (DVP) is a common process of intravenous blood sampling (2). It is one of the most painful interventions in childhood (3, 4) that induces anxiety and distress (5). It is an invasive method that can produce infection, hematoma, bruising, vasovagal reactions, and peripheral nerve injury (6, 7). Although intravenous cannulation (IVC) is a routine measure that is used for diverse purposes such as administration of fluids, drugs, chemotherapy, and transfusion of blood products (8), it seems that obtaining blood samples using IVC can be an alternative method for DVP (9). In recent years, studies have been conducted on adults to compare differences between results of blood tests obtained by IVC and DVP (1, 8-11). Previous studies revealed the partial concordance between these two methods in diverse laboratory parameters (10-16). Although Hambelton et al. revealed that extracted blood samples from IVC with or without drug infusions is a valid method for assessing hematology, biochemistry, and

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coagulation parameters, they reported that it was not appropriate for blood gas assessments (8). According to the limited similar studies in the pediatric field, it seems that IVC may be an appropriate alternative for DVP due to less pain and anxiety for children (17-19). Furthermore, IVC may have some benefits for health care personnel by spending less time for insertion of venous access and less risk of accidental needle stick (9, 19). To the best of our knowledge, relatively few studies have been assessed the utility of IVC in obtaining laboratory samples in children (17-19). Considering the painfulness and invasiveness of sampling by DVP for diagnostic purposes, using a painless and less invasive method would be promising. Therefore, the authors aimed to perform a study on more comprehensive laboratory parameters in children and compare the effect of substitution of routine DVP with blood sampling through IVC on the accuracy of hematologic results.

Materials and Methods

This was a cross-sectional study conducted on 5-14-year-old children admitted to the emergency ward of 17th Shahrivar Pediatric Hospital in Rasht, north of Iran. The inclusion criteria were age between 5 to 14 years, no need for pediatric intensive care unit admission or history of any special drug use, hemodynamic stability, and no clear history of anemia, cardiovascular disease, respiratory distress, and coagulative abnormalities. Patients were excluded from the study if they were unwilling to participate or because of unsuccessful sampling. The catheter was inserted for all of the patients before administering drugs and close to the time of admission. After infusion of at least 100 ml of fluid through a peripheral catheter, infusion stopped for 30 seconds and a tourniquet was closed above the intravenous line. Then, 1 ml of blood was discarded and a 2 ml blood sample was drawn slowly into a 2 ml syringe (IVC) to decrease the probability of hemolysis. Concurrently, another intravenous blood sample of 2 ml was taken by DVP from the opposite hand by a 23-gauge needle connected to a 2 ml syringe. After sampling, the tourniquet was released, the peripheral catheter was irrigated by 2 ml of normal saline and infusion started again. The excess air was removed from the syringes. Blood samples were taken to the laboratory and tested in terms of 30 most frequently requested electrolytes, hematologic, and blood gas tests. The blood gas, electrolytes, and hematologic tests were analyzed by AVL compact 3, EasyLyte, Sysmex k21 devices, respectively. To prevent observer bias, all samplings were done by single personnel and according to a well-specified protocol.
Parameters included blood sugar (BS), blood urea nitrogen (BUN), creatinine (Crea), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALK-P), sodium (Na), potassium (K), calcium (Ca), phosphorus (P), and chloride (Cl). Hematologic tests were white blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), Platelet (PLT), Polymorpho-nuclear leukocytes (Poly), Lymphocytes (Lymph), Monocytes (Mono), and Eosinophils (Eos). The venous blood gas (VBG) included the potential of hydrogen (PH), partial pressure of carbon dioxide (PCO2), partial pressure of oxygen (PO2), bicarbonate (HCO3), base excess (BE), BB (buffer base), and O2 saturation (O2 sat). The similarity of the obtained results by the two methods for each parameter indicated the probability of substituting DVP with IVC.

Ethical consideration

Ethical committee of the Vice-Chancellor of Research, Guilan University of Medical Sciences approved this research proposal. (Code: 1930596716, 2015-02-24). The informed consent letters were obtained from patient’s guardians.

Statistical analysis

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Data were collected, and reported by descriptive statistics (mean, standard deviation, frequency, and percent). The normality of quantitative data was analyzed by Kolmogorov-Smirnov. If there was a normal distribution, the paired T-test was applied. In non-normal distribution, the Mann-Whitney-U test was used. The similarity of the obtained results by the two methods indicated the probability of substituting DVP with IVC and was defined by the absence of significant statistical difference ($P>0.05$).

Results

Forty-six children aged 5 to 14 years were enrolled. Six patients were excluded from the study because of the inability of personnel to take the samples that could be associated with the small-sized catheter, presence of clot, or inappropriate site of sampling. Finally, 40 children consisting of 22 (55 %) boys and 18 (45 %) girls participated in this study. Assessing the level of electrolytes by two collection methods showed that there was a significant similarity between the mean of all parameters including BS, BUN, Crea, AST, ALT, ALK-P, Na, K, Ca, and Cl by DVP and IVC ($P>0.05$, shows the lack of significant difference between the two groups) except for P ($P= 0.002$). Results showed a higher level of P in IVC than in the DVP group (Table I). The comparison between the mean of hematologic factors by two methods showed significant similarity between groups regarding WBC, Hb, HCT, MCV, MCH, MCHC, PLT, Poly, Lymph, Mono, and Eos ($p>0.05$, shows the lack of significant difference between the two groups). As Table II shows, results indicated that only the mean level of RBC was different in the two groups ($P<0.05$). As Table III indicates, assessing the level of electrolytes by two collection methods showed a significant similarity between PH, PCO2, HCO3, and BB in the two groups ($P>0.05$, shows the lack of significant difference between the two groups). However, there was a significant difference between PO2, BE, and O2 sat in the two collection methods ($p<0.05$).

Table I: The mean of the electrolyte by two collection methods.

Parameters*	groups	Mean± SD	P-Value
BS (mg/dL)	IVC	135.25±80.67	0.55
	DVP	130.45±71.67	
BUN (mg/dL)	IVC	11.15±3.23	0.06
	DVP	11.37±3.38	
Crea (mg/dL)	IVC	0.59±0.1	0.07
	DVP	0.61±0.1	
Na (mEq/L)	IVC	138.37±3.80	0.30
	DVP	153.87±94.31	
K (mEq /L)	IVC	3.92±0.3	0.47
	DVP	3.95±0.3	
Ca (mg/dL)	IVC	8.83±0.42	0.07
	DVP	8.90±0.41	
P (mg/dL)	IVC	4.02±0.56	0.002
	DVP	3.94±0.54	
Cl (mEq/L)	IVC	100.27±3.05	0.49
	DVP	99.87±3.56	
AST (U/L)	IVC	28.92±14.84	0.96
	DVP	28.95±14.78	
ALT (U/L)	IVC	19.52±14.45	0.73
	DVP	19.40±14.68	
ALK-P (IU/L)	IVC	491.82±257.05	0.10
	DVP	502.27±260.20	

*Blood sugar (BS), blood urea nitrogen (BUN), creatinine (Crea), sodium (Na), potassium (K), calcium (Ca), phosphorus (P), chloride (Cl), aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALK-P).

Table II: Comparing the results of hematologic factors by two collection methods.

Parameters*	Groups	Mean ± SD	P-Value
WBC ($10^3/mm^3$)	IVC	10843.58±5127.72	0.36
	DVP	10974.35±5379.82	
RBC ($10^3/mm^3$)	IVC	4.42 ± 0.32	0.02
	DVP	4.49 ± 0.32	
Hb (g/dL)	IVC	11.94 ± 0.84	0.19
	DVP	12.92 ± 4.9	
HCT (%)	IVC	43.4± 50.56	0.35
	DVP	35.98± 2.27	
MCV (fL)	IVC	80.61±4.41	0.22
	DVP	81.18±5.12	
MCH (pg)	IVC	27.24± 2.00	0.19
	DVP	27.35 ±1.98	
MCHC (g/ dL)	IVC	32.68 ±1.33	0.86
	DVP	33.64±1.89	
PLT ($10^3/mm^3$)	IVC	256300 ± 104167.32	0.11
	DVP	263750 ± 114428.51	
Poly ($\%/mm^3$)	IVC	73.1 ± 13.26	0.27
	DVP	74.25 ± 11.98	
Lymph ($\%/mm^3$)	IVC	20.50 ± 11.27	0.44
	DVP	21.10 ±11.12	
Mono ($\%/mm^3$)	IVC	2.40 ±1.25	0.78
	DVP	2.45 ±1.28	
Eos ($\%/mm^3$)	IVC	1.02 ±0.89	0.78
	DVP	1.05 ±0.87	

*White blood cell (WBC), red blood cell (RBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), Platelet (PLT), Polymorpho-nuclear leukocytes (Poly), Lymphocytes (Lymph), Monocytes (Mono), and Eosinophils (Eos)

Table III: Comparing blood gas analysis in two collection methods.

Parameters*	Groups	Mean± SD	P-Value
PH (num)	IVC	7.41±0.053	0.32
	DVP	7.41±0.051	
PCO_2 (mmHg)	IVC	38.83±7.35	0.25
	DVP	39.83±7.14	
PO_2 (mmHg)	IVC	52.31±2279	0.0001
	DVP	41.35±14.35	
HCO_3 (nmol/L)	IVC	24.71±3.56	0.14
	DVP	25.21±2.972	
BE (num)	IVC	3.56±1.31	0.01
	DVP	2.83±2.16	
BB (num)	IVC	48.50±3.69	0.42
	DVP	48.77±3.40	
O_2 sat (mmHg)	IVC	80.40±10.41	0.001
	DVP	70.91±13.39	

* potential of hydrogen (PH), partial pressure of carbon dioxide (PCO2), partial pressure of oxygen (PO2), bicarbonate (HCO3), base excess (BE), BB (buffer base), and O2 saturation (O2 sat).

Discussion

Blood sampling for laboratory assessments is a common intervention for hospitalized patients (20). It was estimated that about ten blood samplings are needed for each hospitalized patient per week (21). Based on the necessity of blood sampling during hospitalization and the induced pain and distress by DVP especially in childhood, in this study, diverse parameters have been assessed to compare the similarity or difference of results obtained by DVP and IVC to assess whether these two methods can be used interchangeably or not? Based on the promising results and significant similarity between the two methods for electrolytes, hematologic, and blood gas parameters and some negligible differences regarding parameters such as P, RBC, PO2, BE, and O2 sat, it seems that IVC can be considered as an appropriate method of sampling in children. It is noteworthy that despite different statistical levels of P and RBC, it was not clinically meaningful and had no considerable impact on patients' treatment plans.

In the study by Taghizadeganzadeh et al. who assessed 60 adult patients hospitalized in the Internal Medicine ward, the levels of Na, K, urea, and Crea were compared in two groups of patients. Their results showed that despite a significant difference between IVC and DVP in terms of Na and K in the first blood sampling, there was no significant difference regarding the biochemical parameters in the second sampling (18). In addition, in a systematic review on IVC and DVP, they reported IVC as a reasonable method for obtaining hematology and biochemistry blood samples. They believed that IVC should not be used for blood gas analysis (22).

Regarding the limited similar investigations in children, Berger et al. determined the possibility of substituting DVP with IVC in a study on 47 children aged 1-16 years. They assessed 14 parameters including Complete blood count (CBC) and basic chemical indices including Na, K, BS, Cl, and Urea. Their results showed considerable similarity between parameters except for BS that was attributed to technical problems. They concluded that using IVC for blood sampling might significantly decrease emotional and physical distress in the hospitalized children and can be indicated as an alternative for DVP (17).

In the current study, there was a significant difference regarding PO2 in two methods that was consistent with the previous investigations (8-9). Maybe this difference occurred due to the venous sampling method.

Baker et al. aimed to determine the optimal volume of discarded blood, Na, and BS values in healthy subjects. They showed that during sampling without discarding blood, statistically significant results were obtained; but discarding 0.5 - 3 ml of blood resulted in no meaningful difference. They suggested that withdrawing at least 1 ml of blood is necessary before sampling (23). Although results from previous studies with a higher amount of discarded blood were approximately consistent with the present investigation (10, 19), clinicians should consider the minimum amount of discarded blood, especially in children. Since sampling in the present study after discarding only 1 ml of blood showed significant similarity, it seems that withdrawing 1 ml of blood before sampling is sufficient.

This study had some strengths and limitations. The similarity of the results obtained from both methods in most of the parameters is promising and can be mentioned as the most important strength point. The main difference of the current study is the assessment of more parameters compared to the previous similar investigations. In the current study, investigators assessed 30 parameters of CBC, electrolytes, and VBG indices. Besides, finding an alternative method of sampling for pediatrics who cannot tolerate painful interventions is mandatory and this study showed successful results. The main limitations of this study were the small

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sample size, and missing patients under 5 years old. As the investigators assessed both methods on each patient simultaneously, they were unable to compare the pain severity or the imposed distress from each method.

Conclusion

Based on the promising results obtained in this study, it seems that these methods could be interchangeably used, and IVC can be an alternative method for DVP by discarding the minimum amount of blood and less invasiveness in children. Future studies on different age groups, with larger sample size, and more hematological and biochemical variables are strongly recommended.

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Conflict of interest

The authors declared no conflict of interest.

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