Research Journal of Medical Sciences 10 (4): 191-193, 2016
ISSN: 1815-9346

The Effect of Various Amount of Heparin on Analysis of Arterial Blood Gas in Adult Patients Undergoing Open Heart Surgery

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Abstract: There are still questions regarding the effect of heparin on the accuracy of blood gas determination. The different dilutions of heparin may affect arterial blood gas analysis differently. The aim of the present study is to assess the effects of the different volumes of heparin added to blood sample of patients undergoing Coronary Artery Bypass Graft (CABG) surgery or valvular surgery. This randomized clinical trial was performed on 70 patients who were candidates for elective cardiac procedures including CABG surgery orvalvular surgery. From each patient three simultaneous blood samples were collected each with one of the three amounts of heparin (50, 200 and 500 units) by using a 1-cc blood sample with a 5-cc syringe. There was no significant differences in the three groups receiving the different amounts of heparin in terms of PH ($p = 0.629$), PaO_2 ($p = 0.711$) and O_2 saturation ($p = 0.965$) while the three indices of $PaCO_2$ ($p = 0.008$), HCO_3 ($p = 0.001$) and base excess ($p = 0.001$) all reduced by the increase in heparin volume in the syringes. Laboratory parameters such as serum sodium (Na) gradually increased ($p = 0.004$) by increasing in syringe the volume of heparin in the syringe while serum potassium (K), serum hemoglobin and serum hematocrit significantly decreased ($p<0.05$). Lactate level was independent to of the volume of heparin in the syringe ($p = 0.231$).

Key words: Lactate level, blood, imbalance, significant, Iran

INTRODUCTION

Heparin belongs to a family of complex carbohydrates named glycosaminogly cans that are natural anticoagulants in all mammalian species (Yamada *et al*., 2011). Heparinacts through preventing prevents blood from clotting because of its avid binding to anti thrombin III (Olson *et al*., 2010). Despite its anti coagulation effect, the liquid dilution with heparin led to a potential error in estimating arterial blood gas analysis (Ordog *et al*., 1985; Beaulieu *et al*., 1999). In fact, this potential error is due to the considerable difference in PH, $PaCO_2$ and PaO_2 of liquid heparin compared with that of arterial blood (Beaulieu *et al*., 1999). Approximate values for heparin solution are PH of 6.4; $PaCO_2$ of 7.5 mmHg and PaO_2 of 160 mmHg, reflecting its nature as an acidotic solution in equilibrium with air. However, a number of studies (Hamilton *et al*., 1978; Dake *et al*., 1984; Hutchinson *et al*., 1983; Gayed *et al*., 1992) have examined the effect on measured blood PH, $PaCO_2$ and PaO_2 of increasing sample dilution with heparinand could demonstrate that measured PH is resistant to this dilution effect presumably due to the buffering capacity of blood. Similarly, PaO_2 may be also relatively resistant to the dilution effect (Higgins, 2007). The $PaCO_2$ resistance to the dilution is directly dependent to on dilution percentage. In other words, as long as dilution is <10%, $PaCO_2$ is not significantly affected, but dilutions above 10% are associated with an increasingly significant decline in $PaCO_2$ values (Higgins, 2007). However, it also seems that the dilutional effect of heparinmay not be due to heparin per se butto the fact that liquid is being added to the blood, as seen when adding saline to blood (Higgins, 2007).

In total, there are stillquestions about the effects of heparin on the accuracy of blood gas determination. In fact, it is now hypothesized that much sodium heparin affects the PH of the results to the acidotic side. The different volumes of heparin may affect arterial blood gas analysis differently.

The aim of the present study is to assess the effects of the different volumes of heparin added to blood sample in of patients undergoing CABG surgery or valvular surgery.

MATERIALS AND METHODS

This randomized clinical trial was performed on 70 patients who were candidate for elective cardiac procedures including coronary artery bypass grafting surgery or valvular surgery. The baseline characteristics

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and clinical data including demographic characteristics, medical history and laboratory parameters were collected by referring the recorded hospital files. Rule out criterias for this study included emergency open heart surgery and patients candidatedfor off-pump open heart surgery. Regarding effects of different volumes of heparin added to the blood, from each patient, three simultaneous blood samples were collected, each with one of the three amounts of heparin (50, 200 and 500 units) by using a 1-cc blood sample with a 5-cc syringe. The study endpoint was to compare laboratory indices as well as arterial blood gas parameters after blood sample collection with the pointed schedules.

Statistical analysis: For statistical analysis, results were presented as mean±Standard Deviation (SD) for quantitative variables and were summarized by absolute frequencies and percentages for categorical variables. Normality of data was analyzed using the Kolmogorov-Smirnoff test. Categorical variables were compared using Chi-Square test. Quantitative variables were also compared with ANOVA test or Kruskal-Wallis H test. For the statistical analysis, the statistical Software SPSS version 16.0 for windows (SPSS Inc., Chicago, IL) was used. The p values of 0.05 or less were considered statistically significant.

RESULTS

In total, 70 patients were assessed who were candidates for elective CABG or valvular surgery. The mean age of patients was 52.70±10.42 years ranged 23-64 year and 75.7% were male. Regarding surgical procedures, the majority of cases candidated for CABG (64.3%), while 14.3% underwent isolated mitral valve replacement, 12.9% underwent isolated aortic valve replacement, 4.3% underwent mitral plus tricuspid valves replacement, 2.9% underwent mitral plus aortic valves replacement and only 1.4% underwent triple valve replacement. Regarding cardiovascular risk factors, 30.0% were hypertensive, 20.0% were diabetic and 10.0% were dyslipidemic. There was no difference in the three groups receiving the different volumes of heparin in terms of PH ($p = 0.629$), PaO2 ($p = 0.711$) and O2 saturation ($p = 0.965$) while the three indices of PaCO2 ($p = 0.008$), HCO3 ($p = 0.001$) and base excess ($p = 0.001$) all reduced by the increase in heparin volume in the syringes (Table 1). Regarding laboratory parameters serum sodium (Na) gradually increased ($p = 0.004$) by increasing the volume of heparin in the syringe while serum potassium (K), serum hemoglobin and serum hematocrit significantly decreased ($p<0.05$). Lactate level was independent to the volume of heparin in the syringe ($p = 0.231$) (Table 2).

Table 1: Arterial blood gas analysis in three groups

	Heparin (units)			
Parameters	50	200	500	p-values
PH	7.43±0.050	7.42±0.070	7.42±0.040	0.629
PaO_2	72.50±10.74	73.24±10.53	74.04±11.80	0.711
O_2 saturation	94.21±2.630	94.33±2.620	94.30±2.660	0.965
$PaCO_2$	34.97±5.220	33.99±5.090	32.20±5.510	0.008
HCO_3	23.04±3.090	22.27±3.380	20.93±3.520	0.001
Base excess	0.14±2.990	-0.53±3.190	-1.85±3.310	0.001

Table 2: Laboratory parameters in three groups

	Heparin (units)			
Parameters	50	200	500	p-values
Serum Na	144.54±4.67	146.20±5.39	147.51±5.47	0.004
Serum K	3.80±0.52	3.62±0.51	3.36±0.50	<0.001
Serum Hb	14.43±1.63	14.12±1.79	13.70±1.83	0.049
Serum HCT	47.23±5.53	46.20±6.11	44.50±6.12	0.025
Serum lactate	0.85±0.41	0.77±0.39	0.74±0.39	0.231

DISCUSSION

As clearly shown in our research by increasing the in volume of heparin in syringes containing patients' blood samples, a significant decrease in PCO_2, HCO_3 as well as base excess was expected while no significant change was revealed in PH, PO_2 and arterial O_2 saturation. Furthermore, byan increase in heparin volume led to an increase in serum Na level as well as a decrease in serum K, hemoglobin and hematocrit. Additionally, the increase in heparin solution in the syringe containing blood may lead to a blood gas instability as well as electrolytes imbalance that is very vital in patients who undergoing major cardiac surgeries like CABG and valvular surgery.

Both early and recent studies could demonstrate potential effects of various amounts of heparin added to the blood sample on arterial blood gas indices as well as serum biomarkers leading potential errors in blood gas analysis. In an animal study by Hopper *et al.* (2005), the dilution of a 1 mL blood sample with liquid heparin 3.9%, 9.4%, 18.8% and 34.1% dilutions significantly changed the measured values of $PaCO_2$, PaO_2 and base deficit and concentrations of electrolytes and lactate. In an earlier study by Ordoghttp://www.ncbi.nlm.nih.gov/pubmed/term=Ordog%20GJ%5BAuthor%5D&cauthor=true&cauthor_uid=3919622, Wasserberger, Balasubramaniam (1985), the increase in liquid heparin statistically decreased the $PaCO_2$, PaO_2, HCO_3 and base excess while the pH remained unchanged that was similar to our observation. As shown by Hamilton *et al.* (1978), the addition of heparin produced errors in all three parameters tested including PaO_2, $PaCO_2$ and PH. The $PaCO_2$ value was most affected, a 12% decrease being introduced into a 1.5 mL blood sample. They showed that small but statistically significant errors were also produced in PaO_2 and pH by this heparin concentration. In another study by Karendal (1975), the dilutional effect of heparin on blood $PaCO_2$ was fully explained with lower $PaCO_2$ and thus the correction of the heparin solution to pH 7.40 and PCO_2 40 mmHg eliminated the effect on PCO_2, pH and a standard bicarbonate.

In total, the change in the components of blood gas as well as serum electrolytes following an increase in heparin volume can be explained by some a number of reasons. Some studies could show that the effect of the various amounts of heparin on blood gas analysis may be due to the clotting process in the serum samples (Boidin and Jorna, 1984). Some studies link these changes to the binding of heparin to other serum electrolytes such as serum calcium ion (Jiang, 1992). In other words, the main source of potential errors arises as a result of the calcium-binding property of heparin in that heparin binding of calcium artefactually reduces the ionized calcium concentration, the magnitude of the reduction being directly proportional to the heparin concentration (Toffaletti, 1994; Sachs *et al.*, 1994).

In total, balancing blood volume and heparin amount in syringe is very vital because the decrease in heparin dilution can increase the risk for coagulation while the increase in heparin may cause blood gas potential errors. In other word, both inadequate and excessive mixing of specimen with heparin is usually the problem needing accurate selection of heparin dilution to achieve optimal balance.

CONCLUSION

Inappropriate selection of heparin dilution in syringe containing patients' blood may lead to a significant change in arterial blood gas components as well as a serum electrolytes imbalance.

ACKNOWLEDGEMENTS

Acknowledgments of people, grants, funds, etc. should be placed in separate section before the reference list. The names of funding organizations should be written in full.

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