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Comparing Two Kinds of Prime Solution between Ringer/Albumin and Ringer Lactate/Gelatin for Patients Undergoing Cardiopulmonary Bypass

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Abstract

Background: Use of Cardiopulmonary bypass system is commonly in open heart surgeries. Different prime solutions are used in cardiac surgery centers of world. In this study, we compared the level of bicarbonate and metabolic acidosis in both groups of patient's undergone CPB with two different prime solutions.

Materials and Methods: This is a retrospective cross-sectional-observational study. The Studied community is all the Adult patients with elective coronary artery bypass grafting since March 21st till September 22nd 2018. Patients were divided into two groups. Group A (Ringer and Albumin solution) and group B (Ringer lactate and gelatin solution).

Result: In total 203 patients were in the study. Group A (104 members) and group B (99 members) had the mean age of 61.32 ± 8.91 and 58.93 ± 9.88 years respectively. The prime volume (P-value<0.001) and consumed bicarbonate volume (P-value<0.001) in Group A was significantly more than group B. According to the statistics, each of the variables PH, HCO3, BE in Group B was significantly more than group A and Hb in Group A was significantly more than group B (P-value<0.001).

Conclusion: We can decrease metabolic acidosis and amount of consumed bicarbonate by decreasing the prime volume and using a different prime solution

Keywords: Metabolic acidosis; Cardiopulmonary bypasses; Crystalloid solutions

Introduction

Nowadays cardiopulmonary bypass pump is commonly used in cardiac surgeries, more than 200000 times per year in United States. The patients undergoing cardiac surgery face unique kind of dangers. Physiologic activities of under pump patient are totally different than other patient in any surgery except heart surgery. Actually it can be said that a patient under pump is never in a physiologic status this patient is in a pathologic condition. This pathologic state is most of the times accompanied by serious complications [1]. Hypo perfusion, increased acetate and gluconate level. Hyperchloremia and prime solutions are the main causes of metabolic acidosis during operation [2]. Prime solutions are one of the potential reasons of decreased PH due to decreased bicarbonate level and metabolic acidosis. During and post-operation, metabolic acidosis The causes of increasing the chance of arrhythmia, decreased cardiac contractile power, decreased sensitivity of body to catecholamine's, vascular vasodilation, effect on cerebrospinal fluid and oxygen transfer to tissues (+5). Different kind of primes is used around the world. Heparinized fresh blood used to be used as prime; due to difficult accessibility of fresh blood, infectious disease risk and a high hemoglobin level, fresh blood is no longer used [3-5]. Today crystalloids and colloids are used as prime solutions. Prime solutions have the same osmolality and electrolytes as plasma; decreasing blood viscosity, decreasing risk of air emboli, improving cellular oxygenation, improving microvascular blood circulation, decreasinghemolysis, decreasing chance of anaphylactic reactions, better bleeding of air from the pump and less cost are the advantages of prime solutions [6]. So we decided to compare the effect of Ringer and albumin solutions with ringer lactate and gelatin in patients undergone the cardiopulmonary bypass in metabolic acidosis.

Materials and Methods

This is a retrospective cross-sectional observational. Studied community is all of the patient's undergone coronary bypass surgery. Method of sampling is census and review of the files in directory. 203 patients were enrolled in the study. Considering the ethic committee regulations (IR.SUMS.RES.1398.228), 104 patients in group A and 99 patients in group B were studied. All the Adult patients with nonemergency coronary artery bypass grafting undergone CPB were enrolled in the study. Case excluding criteria were: Age less than 20 years, weight less than 50 and more than 100 kg, creatinine more than 1.5 mg/dl in men and more than 1.4 mg/dl in women, diabetes, pre-op metabolic acidosis (PH<7.35), pump time more than 120 min, hemoglobin less than 10 gr/dl and blood transfusion while operation. Solutions studied here are colloids and crystalloids each of which have their own advantages and disadvantages. [7-15] crystalloids are ringer and ringer lactate solutions. Colloids are albumin, Haemaccel (gelatin) and 20% mannitol. Data were collected by self-administered questionnaires in three parts of the demographic information, preoperative and during the operation. Demographic information included: Age (year), sex, height (cm), weight (kg) and body surface area. Pre-op data included past history diseases, pre-op acidosis, BUN, Cr, BS, HB, Hct. The during operation information included blood gas analysis pre and during operation in different minutes, pump time (min), prime volume and the volume of consumed sodium bicarbonate.

Clinical management

CABG was done regarding local standards. Anesthesia induction was done by sufentanil 2 µg/kg and pancuronium 0.1 mg/kg. Anesthesia while the operation was maintained by isoflurane 0.5%-1%, atracurium 0.1 mg/kg/h, fentanyl 1 µg/kg^{-2}/µg/kg and midazolam 0.5 mg/kg-1 mg/kg. All the patients received 300 u/kg of heparin before operation; so that Active Coagulation Time (ACT) would be more than 480 sec. Extra heparin was also used to reach the target ACT. After withdrawing the patient from the pump, each 100 units of heparin was neutralized by 1 mg protamine sulfate; so that ACT changes to 80 lit/min-120. 2 lit/min O_2(FiO_2=70%) was administered for all the patients.

Statistical analysis: Data were analyzed by means of SPSS 25 software. For quantitative variables, independent t-test and for qualitative variables, chi-square tests were used. For quantitative variables in two groups in different times of measurement, repeated measurement of variances were used.

Result

This is a retrospective cross-sectional observational study. 203 patients undergoing CPB entered the study, 104 patients in group A and 99 patients in group B. Mean age was in group A 61.32 (Confidence interval ± 8.91 years) and group B 58.93 (confidence interval ± 9.88 years). The difference between age in the two groups was not significant (p-value=0.072). Mean weight between the two groups was also not significant (group A 72.95 ± 10.04. group B 73.04 ± 12.56, p-value=0.956). Mean height was significantly more in Group A (168.85 ± 6.94) than group B (166.35 ± 8.68). (P-value=0.024) Mean Body Surface area was 1.82 ± 0.15 and 1.79±0.18 in group A and B respectively; the difference was not significant. (P-value=0.302). Group A had 86 (82.7%) male and 18 (17.3%) female patients. There were 77 (77.77%) male and 22 (22.22%) female patients in group B. Sex did not show a significant difference in the two groups. (P-value=0.379) (Table 1).

Mean pump time in Group A 61.65 (15.877) and Group B 69.14 (19.222) was in Group B was significantly more than group A (P=0.003). Mean prime volume in Group A 2476.92 (345.978) and Group B 2114.19 (385.384) was in Group A was significantly more than group B (P ≤ 0.001). Mean prime volume in Group A 77.30 (27.597) and Group B 36.11 (58.599) was in Group A was significantly more than group B (P ≤ 0.001) (Table 2).

Parameter	Groups	Number/ Range	Mean	SD	P
Gender (F/M)	A	18/86(17.3%/ 82.7%)			0.379
	B	22/77(22.22%/77.77%)			
Age (years)	A	39-80	61.32	8.91	0.072
	B	40-83	58.93	9.88	
Wight (kg)	A	52-00	72.95	10.04	0.956
	B	50-100	73.04	12.56	
Height (cm)	A	150-187	168.85	6.94	0.024
	B	145-188	166.35	8.68	
BSA (m^2)	A	1.82		0.15	0.302
	B	1.79		0.18	

Table 1: Demographics of the Participants. F: Female; M: Male; BSA: Body Surface Area; SD: Standard Deviation; P: P value; kg: Kilogram; cm: centimeter; m^2: Square meter.

Parameter	Groups	Mean	SD	P
CPB time (min)	A	61.65	15.87	0.003
	B	69.14	19.22	
Prime Volume (ml)	A	2476.92	345.97	<0.001
	B	2114.19	385.38	
$NaHCo_3$ Volume (ml)	A	77.3	27.59	<0.001
	B	36.11	58.59	

Table 2: Operative outcomes of patients. SD: Standard Deviation; P: P value; min: minute; ml: milliliter; CPB: Cardio Pulmonary Bypass; $NaHCo_3$: Sodium bicarbonate

PH (Hydrogen Ion Concentration) was measured in both groups in 4 different times (pre-op, minute 10, 30 and 60). We figured out that PH has different behavior in the two groups and the amount of PH in group B was more than group A. (p-value<0.001) (Figure 1).

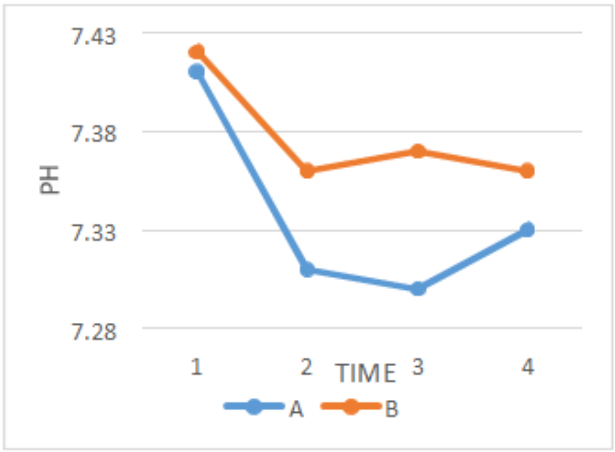

Figure 1: PH analysis (1: pre-op; 2: minute 10; 3: minute 30; 4: minute 60).

Consumed $NaHCo_3$(Sodium bicarbonate) in both groups was studied in 4 different times. (Pre-op, minutes 10, 30 and 60) We figured out that consumed bicarbonate has different behavior in the two groups and the amount of bicarbonate in group B was more than group A (p-value<0.001) (Figure 2).

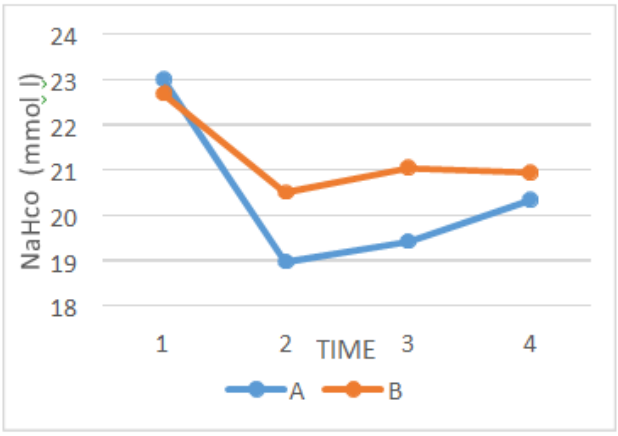

Figure 2: $NaHCo_3$ analysis (1: pre-op, 2: minute 10, 3: minute 30, 4: minute 60), Mmol/l: Mill moles per liter.

BE (Base Excess) in both groups was measured in 4 different times. (Pre-op, minutes 10, 30 and 60) It was understood that base excess has different behavior in the two groups and amount (level) of base excess in group B was more than group A (p-value<0.001) (Figure 3).

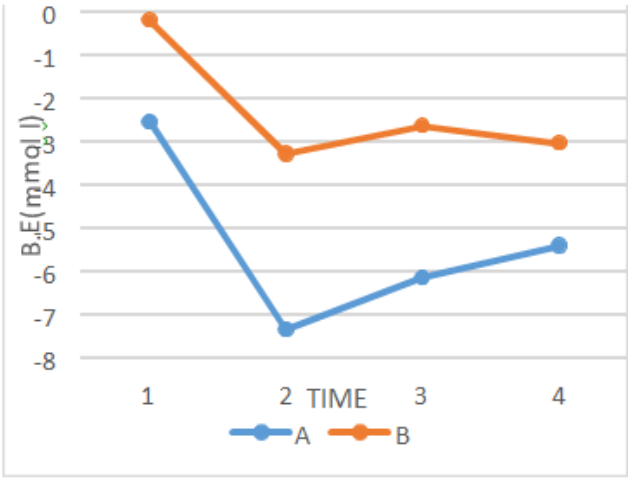

Figure 3: BE analysis (1:pre-op, 2: minute 10, 3: minute 30, 4: minute 60) Mmol/l: Millimoles per Liter.

HB (Hemoglobin) in both groups was studied in 4 different times. (Pre-op, minutes 10, 30 and 60) We figured out that hemoglobin has different behavior in the two groups the amount of hemoglobin in group A more than group B (p-value<0.001) (Figure 4).

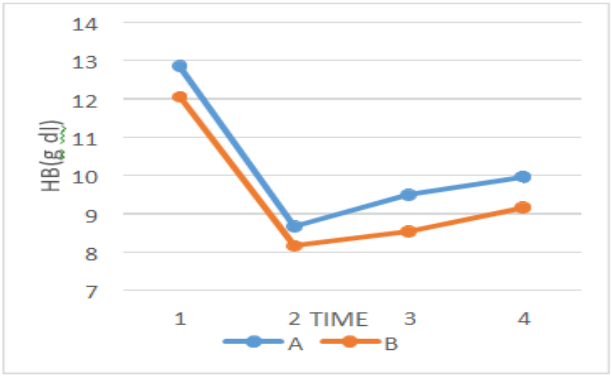

Figure 4: HB analysis (1:pre-op, 2: minute 10, 3: minute 30, 4: minute 60), g/dl: grams per decilitre.

Discussion

In this study, we compared two different prime solutions in degree of metabolic acidosis.

Considering the classic concept of dilution, infusing a high volume of fluid to systemic blood circulation causes bicarbonate level to decrease due to hemodilution. This would lead to hemodilution related acidosis at the beginning of CBP use [16-18].

At the beginning of the CPB, both groups (A and B) show a severe reduction in PH.

Regarding different kind and volume of primes in the groups, this decreasing is significantly more severe in group A (p-value<0.001). This shows more severe acidosis in the prime group A than B.

At the beginning of the CPB, both groups show a severe reduction bicarbonate level.

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At the beginning of the CPB, both groups show a severe reduction in B.E regarding different kind and volume of primes in the groups, this decrease is significantly more severe in group A (p-value<0.001).

Due to the reduction of PH level in group A, we have a more severe metabolic acidosis in this group than the other one.

HB level decreases at the beginning of the CPB due to hemodilutionwhich causes hypoperfusion. Leading to decreased tissues oxygenation, hypoperfusion can cause metabolic acidosis.

the amount of HB in this study was investigated And there was a significant difference between the two groups (p-value<0.001)

All over the time period, HB in group A was higher than B but metabolic acidosis in group A was more severe than B, This could be a sign of the greater effect of prime solution in HB on metabolic acidosis in this study.

High pump time is another reason of metabolic acidosis. Mean pump time in group A (61.65 ± 15.87) was significantly less than group B (69.14 ± 19.222) (p-value=0.003).

Regarding more pump time in group B than group A and less metabolic acidosis in group B, This could be a sign of the greater effect of prime solution in pump time on metabolic acidosis in this study.

According to a study performed by Johanna Katharina in 2014, infusing excessive volume of fluid to systemic circulation, causing hemodilution, leads to acidosis at the beginning of CBP work and a decrease in PH and BE [18]. These findings are in accordance with ours.

Another study was done by R Peter Alston et al. Statedthat Hartman solution which is so similar to ringer lactate was used instead of ringer. Hartman was shown to decrease metabolic acidosis [7]. These results are in accordance with ours.

According to the study performed by Liskaser et al. metabolic acidosis is due to hypoalbuminemia.

The acidosis in ringer-haemaccel group was hyperchloremic and appeared faster and had a later disappearance, so that at the end of the operation it was still present. It was like our study. Due to having acetate and gluconate that both- like lactate- can change to bicarbonate, acidosis in plasmalyte group was detected sooner and disappeared faster.

The soon appearance here was similar to our group B prime. So lactate in group B can prevent severe metabolic acidosis and its early presence [12]. Our results confirmed this study.

According to the study performed by Alston et al. metabolic acidosis while cardiopulmonary bypass is due to hemodilution which causes a decrease in concentration of albumin, protein and serum weak acids and hypoperfusion which leads to increased serum lactate level.

This fact is in accordance with our finding that group A with a significant hemodilution than B showed a more severe acidosis [8].

Conclusion

It is possible to decrease metabolic acidosis and consumed bicarbonate while cardiopulmonary bypass operation by changing the prime solution and decreasing its volume.

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