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SODIUM BICARBONATE INFUSION: TO PREVENT CARDIAC SURGERY ASSOCIATED ACUTE KIDNEY INJURY

Dr. Botta Vijayalakshmi[1*]
[1*]Associate Professor, Department of Cardiothoracic surgery, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India.
Corresponding Author: Dr. BottaVijayalakshmi
Associate professor, Department of Cardiothoracic surgery, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India.

Abstract

Introduction: Acute kidney injury (AKI) is a frequent and severe postoperative complication in patients undergoing cardiac surgery with an incidence varying from 36.3 to 52.0%. With increasing interest, this topic has been specifically referred to as cardiac surgery-associated acute kidney injury (CSA-AKI). CSA-AKI could contribute to increased in-hospital mortality, 5-year mortality, 30-day readmission, requirement for renal replacement therapy (RRT), ICU length of stay, and total postoperative cost.

Materials and Methods: Informed and written consent was obtained from all the patients. Study was done in the period of April 2023 to April 2024 at Department of Cardiothoracic surgery, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India. This study was a double-blind, randomized controlled trial designed to assess if the administration of sodium bicarbonate as a continuous infusion commenced prior to cardiopulmonary bypass would result in less postoperative acute renal dysfunction in patients undergoing cardiac surgery. This prospective study enrolled 70 consecutive patients who underwent on pump cardiac surgery. A Microsoft Excel based random-number generator was used to create the randomization list.

Results: The patients were distributed into two groups on the basis of either they received sodium bicarbonate or sodium chloride. No statistical difference between the groups was detected in terms of age (41.83 ± 13.742 vs 46.78 ± 13.250) days, P=0.331; age range, 18 year-80 years), weight (49.18 ± 10.415 vs 56.18 ± 17.668 kg, P =0.183, and duration of CPB (93.2857 ± 33.79913 vs 105.8429 ± 41.68955 minutes, P=0.270) and in cross clamp time (67.1143 ± 27.20110 vs 75.9143 ± 37.93539 minutes, P=0.079).

Conclusion: In patients at high risk of CSA-AKI, bicarbonate infusion alkalinized both blood and urine but did not result in a decrease in the prevalence of CSA-AKI. On this basis of these results, we have concluded that, the use of perioperative infusions of sodium bicarbonate may not reduce the CSA-AKI in this patient group.

Key Words: Acute kidney injury, cardiac surgery, sodium bicarbonate, cardiopulmonary bypass.

INTRODUCTION

Acute kidney injury (AKI) is a frequent and severe postoperative complication in patients undergoing cardiac surgery with an incidence varying from 36.3 to 52.0%. This topic has been specifically referred to as cardiac surgery-associated acute kidney injury (CSA-AKI).[1]CSA-AKI could contribute to increased in-hospital mortality, 5-year mortality, 30-day readmission, requirement for renal replacement therapy (RRT), ICU length of stay, and total postoperative cost. Considering the poor prognosis and increasing medical cost, prophylaxis of CSA-AKI is urgently needed. Many strategies have been tried to reduce the incidence of CSA-AKI effective methods to prevent CSA-AKI unfortunately remain to be established due to underpowered evidence and controversial conclusions.[2]

Evidence suggests that even minimal increase in serum creatinine is associated with poorer outcomes. AKI induces injury to distant organs such as lungs, heart and brain.[3] Many causes of cardio pulmonary bypass associated acute renal dysfunction have been proposed such as ischemia reperfusion, generation of reactive oxygen species, hemolysis and activation of inflammatory pathways. No safe, simple and effective intervention for prevention of cardiopulmonary bypass associated acute renal dysfunction has been found.[4]

The mechanism behind these observed protective effects is thought to relate to the ability ofbicarbonate to alkalinize the urine and to slow the Haber-weiss reaction that generate reactive oxygen species via iron-dependent pathways. Mechanism of action for sodium bicarbonate are supported by the findings from a large meta-analysis in contrast nephropathy, demonstrating a positive outcome.[5]

Accordingly we hypothesized that urinary alkalization might protect kidney function inpatients at increased risk of acute renal dysfunction undergoing cardiopulmonary bypass and conducted a randomized controlled trial with perioperative sodium bicarbonate infusion.

MATERIALS AND METHODS

Informed and written consent was obtained from all the patients. Study was done in the period of April2023 to April 2024 at Department of Cardiothoracic surgery, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India. This study was a double-blind, randomized controlled trial designed to assess if the administration of sodium bicarbonate as a continuous infusion commenced prior to cardiopulmonary bypass would result in less postoperative acute renal dysfunction in patients undergoing cardiac surgery. This prospective study enrolled 140 consecutive patients who underwent on pump cardiac surgery. A Microsoft Excel based random-number generator was used to create the randomization list.

Allocation concealment to patients, anesthesiologists, cardiac surgeons, intensive carespecialists, bedside nurses, and investigators was ensured. Treatment allocation was only revealedafter the study had been completed, the database locked, and statistical analysis completed. ResearchRandomizer online random number generator was used to create the randomization. All the patientswere randomly divided in to two group. One was study group in all the patients were given NaHCO3and another group is control group in all the patients were given NaCL. NaHCO3 group of Patientsreceived a dose of 4 mmol/kg body weight over 24 hour. And NaCL group of patients received sameamount of NaCl.

Inclusion Criteria:

- Age >40 year.
- New York Heart Association class III/IV or impaired left ventricular function (left ventricular ejection fraction < 40%)
- Valvular surgery or concomitant valvular and coronary artery bypass graft surgery.
- Redo cardiac surgery.
- Insulin-dependent diabetes mellitus.

Exclusion Criteria:

- End-stage renal disease (plasma creatinine concentration > 3.4 mg/dL).
- Emergency cardiac surgery.
- Known blood-borne infectious disease.
- Planned off-pump cardiac surgery.
- Chronic inflammatory disease on immunosuppression.
- Age < 18 year.

The primary outcome measure was the number of patients who had postoperative AKI development. This was defined as an increase in plasma creatinine concentration greater than 25% from baseline to peak value at any time within the first 3 days after cardiopulmonary bypass.

Data collected included age (Days), weight (kilograms), sex, height, preoperative creatinine postoperative creatinine on day 1 day 2 and day 3 and its creatinine clearance. As well as mean arterial pressure, pH, urea and bicarbonate. CPB time, cross clamp time, mechanical ventilation time (hours), intensive care unit (ICU) stay (hours), and hospital stay also collected. Postoperative morbidity and mortality data were also collected.

The occurrence of specific adverse events including the prevalence of hypernatremia ([Na+] >150 mmol/L), hypokalemia ([K+] < 3.5 mmol/L), alkalemia (pH > 7.50), postoperative atrial fibrillation, and other postoperative arrhythmias (supraventricular arrhythmias, ventricular tachycardia and ventricular fibrillation) during the first 3 postoperative days were recorded.

The statistical analysis was performed using SPSS v20.0. The values were expressed as Mean±SD. To compare the data between two groups one sample t test were used. Independent sample t test were used to compare the categorical variables. 'p' <0.05 was considered statistically significant.

RESULTS

The patients were distributed into two groups on the basis of either they received sodium bicarbonate or sodium chloride. No statistical difference between the groups was detected in terms of age (41.83 ± 13.742 vs 46.78 ± 13.250) days, P=0.331; age range, 16 year-80 years), weight (49.18 ± 10.415 vs 56.18 ± 17.668 kg, P =0.183, and duration of CPB (93.2857 ± 33.79913 vs 105.8429 ± 41.68955 minutes, P=0.270) and in cross clamp time (67.1143 ± 27.20110 vs 75.9143 ± 37.93539 minutes, P=0.079) which is shown in Table.1, 3.

Significant differences in urinary pH and plasma pH from baseline to 48 hours were found between the two groups. Sodium bicarbonate infusion induced urinary alkalization 6 and 24 hours after commencement of study drug infusion which is shown in Figure (1, 2).

	With NaHCO3	**Without NaHCO3**	
	Mean ± SD	**Mean ± SD**	**P Value**
Age (year)	41.83 ± 13.762	46.78 ± 13.250	0.331
Gender	M=17, F=18	M=20, F=15	
Height (cm)	161.09 ± 8.686	160.00 ± 14.022	0.428
Weight (kg)	49.17 ± 10.413	56.17 ± 17.666	0.183

Table 1: Patient demographics

	With NaHCO3 Mean ± SD	**Without NaHCO3 Mean ± SD**	**P Value**
Creatinine baseline (mg/dl)	0.9091 ± 0.34020	0.9002 ± 0.25230	0.24
Creatinine day1(mg/dl)	0.9671 ± 0.34453	1.0470 ± 0.42861	0.101
Creatinine day 2 (mg/dl)	0.8783 ± 0.34365	0.9574 ± 0.38440	0.159
Creatinine day 3 (mg/dl)	0.8404 ± 0.36251	0.8846 ± 0.44745	0.735
Creatinine clear baseline (ml/min)	76.2226 ± 33.73187	77.4189 ± 22.57714	0.076
Creatinine clear day1 (ml/min)	70.7476 ± 28.48894	71.5380 ± 26.64827	0.773
Creatinine clear day 2 (ml/min)	79.7992 ± 31.35400	78.6197 ± 30.29545	0.327
Creatinine clear day 3 (ml/min)	83.7348 ± 34.87537	83.5094 ± 26.86457	0.299
Urea baseline (mg/dl)	31.8303 ± 16.35761	29.6560 ± 13.44579	0.209
Urea day1 (mg/dl)	37.1034 ±	38.9937 ± 18.63299	0.741

	16.92377		
Urea day 2 (mg/dl)	35.8780 ± 19.32018	41.7833 ± 21.28555	0.158
Urea day 3 (mg/dl)	35.9784 ± 23.98313	38.1890 ± 23.28158	0.786
Urine output day1 (mg/dl)	1.7132 ±.74410	1.6648 ±.71119	0.789
Urine output day2 (mg/dl)	1.9575 ±.61983	1.7650 ±.63096	0.460
Urine output day 3 (mg/dl)	1.7718 ±.61321	1.7253 ±.57512	0.279

Table 2: Primary variables

	With NaHCO3 Mean ± SD	**Without NaHCO3 Mean ± SD**	**P Value**
MAP preop (mmHg)	81.5000 ± 11.16724	80.6429 ± 15.84982	0.158
MAP at ICU admission (mmHg)	80.7529 ± 13.29035	82.1486 ± 14.74641	0.590
MAP 12 hr ICU admission (mmHg)	78.9529 ± 10.11798	78.7671 ± 13.17159	0.054
MAP 24 hr ICU admission (mmHg)	75.4671 ± 13.18397	78.9957 ± 10.22003	0.998
CPB duration (min)	93.2957 ± 33.79913	106.8529 ± 41.68955	0.270
X clamp duration (min)	67.2143 ± 27.20110	76.9143 ± 37.93539	0.079
Duration of mechanical ventilation (hr)	8.47 ± 5.296	8.14 ± 5.787	0.317
Duration of ICU stay (days)	3.68 ± 1.271	3.84 ± 2.085	0.341
Duration of hospital stay (days)	19.72 ± 7.410	18.48 ± 5.115	0.124

Table 3: Secondary Variables

DISCUSSION

AKI is not only a common consequence of cardiac surgery, but it has also been linked to morbidity and mortality on its own. Efforts to limit the occurrence and improve the prognosis of this complication have been made in recent years.[6]Recently, Haase and colleagues delineated a pathophysiological line of evidence that the severity of the renal insult induced by on-pump cardiac surgery may, at least in part, be related to the degree of hemoglobinuria: the histological features of CSA-AKI resemble the pigment nephropathy commonly seen during rhabdomyolysis.[7] Because alkalization of urine is one of the greatest therapy options known to treat rhabdomyolysis, they effectively applied this notion as a strategy for the prevention of CSA-AKI in small pilot trial.[8]

A positive recommendation to use hydration and bicarbonate to reduce the nephrotoxic effects of myo- and hemoglobinuria.[9]

We conducted a double-blind, randomized controlled trial to investigate whether perioperative sodium bicarbonate infusion to achieve urinary alkalization could attenuate the creatinine rise associated with cardiopulmonary bypass in cardiac surgical patients. In this randomized controlled trial, we found that the infusion of sodium bicarbonate commencing before cardiopulmonary bypass and continuing postoperatively for a total of 24 hours achieved serum and urinary alkalization but did not reduce kidney damage, defined as a rise in serum creatinine during the first three postoperative days.[10]

CONCLUSION

In patients at high risk of CSA-AKI, bicarbonate infusion alkalinized both blood and urine but did not result in a decrease in the prevalence of CSA-AKI. On this basis of these results, we have concluded that, the use of perioperative infusions of sodium bicarbonate may not reduce the CSA-AKI in this patient group.

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