Section: Cardiothoracic & Vascular Surgery

Research

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

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Abstract

Background: 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:** Study was done in the period of February 2019 to February 2020 at Super speciality hospital GMC Nagpur
. 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 (Microsoft Corp., Redmond, WA) random-number generator was used to create the randomization list. Allocation concealment to patients, anesthesiologists, cardiac surgeons, intensive care specialists, bedside nurses, and investigators was ensured. Treatment allocation was only revealed after the study had been completed, the database locked, and statistical analysis completed. **Result:** No statistical difference between the groups was detected in terms of age (41.84 ± 13.762 vs 46.77 ± 13.249) days, P=0.331; age range, 16 year -80 years), weight (49.17 ± 10.413vs 56.17 ± 17.666 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. **Conclusion:** Perioperative alkalization of blood and urine using an infusion of sodium bicarbonate did not result in a decrease in the incidence of acute kidney injury in patients undergoing cardiac surgery.

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).[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. Although many strategies have 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]

The pathogenesis of CSA-AKI is multifactorial, including ischemia and reperfusion injury, inflammation, oxygen free radicals, oxidative stress, and free hemoglobin.[3] An experimental study demonstrated that urinary alkalinization with sodium bicarbonate (SBIC) could prevent oxidant injury to the kidney by eliminating oxygen species. Accordingly, a randomized double-blind trial involving 100 patients suggested that intravenous SBIC could also effectively reduce the incidence of AKI in patients undergoing on-pump cardiac surgery.[4]

The mechanism behind these observed protective effects is thought to relate to the ability of bicarbonate to alkalinize the urine and to slow the

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Haber-weiss reaction that generate reactive oxygen species via iron-dependent pathways.[5] Mechanism of action for sodium bicarbonate are supported by the findings from a large meta-analysis in contrast nephropathy (Another form of acute kidney injury), demonstrating a positive outcome.[6] Accordingly we hypothesized that urinary alkalization might protect kidney function in patients at increased risk of acute renal dysfunction undergoing cardiopulmonary bypass and conducted a randomized controlled trial with perioperative sodium bicarbonate infusion.

MATERIALS AND METHODS

Study Design: A double-blind, randomized controlled trial.
Study Location: Super speciality hospital GMC Nagpur
Study Duration
Study was done in the period of February 2019 to February 2020.
Sample Size: 70 patients

Study was done in the period of February 2019 to February 2020 at Super speciality hospital GMC Nagpur. 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 (Microsoft Corp., Redmond, WA) random-number generator was used to create the randomization list. Allocation concealment to patients, anesthesiologists, cardiac surgeons, intensive care specialists, bedside nurses, and investigators was ensured. Treatment allocation was only revealed after the study had been completed, the database locked, and statistical analysis completed. Research Randomizer online random number generator was used to create the randomization. All the patients were randomly divided in to two group. One was study group in all the patients were given NaHCO3 and another group is control group in all the patients were given NaCL. NaHCO3 group of Patients received a dose of 4 mmol/kg body weight over 24 hour. And NaCL group of patients received same amount of NaCl.

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.
Statistical Analysis: 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.

RESULTS

No statistical difference between the groups was detected in terms of age (41.84 ± 13.762 vs 46.77 ± 13.249) days, P=0.331; age range, 16 year -80 years), weight (49.17 ± 10.413vs 56.17 ± 17.666 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 1-3] patients from each group needed renal replacement therapy but they died during hospital stay due to multi organ dysfunction.

Table 1: Patient demographics

	With NaHCO3 Mean ± SD	Without NaHCO3 Mean ± SD	P Value
Age (years)	41.84±13.76	46.77±13.24	0.331
Male	17	20	
Female	18	16	
Height (cm)	161.08±8.65	160.12±14.10	0.428
Weight (kg)	49.17±10.412	56.17±17.66	0.183

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Table 2: Primary variables

	With NaHCO3 Mean ± SD	Without NaHCO3 Mean ± SD	P Value
Creatinine baseline (mg/dl)	0.908±0.340	0.9001 ± 0.25	0.24
Creatinine day 1 (mg/dl)	0.967±0.345	1.047±0.428	0.102
Creatinine day 2 (mg/dl)	0.8682±0.34	0.947±0.384	0.158
Creatinine day 3 (mg/dl)	0.830±0.35	0.874±0.43	0.736
Creatinine clear baseline (ml/min)	76.21±33.70	77.35±22.45	0.076
Creatinine clear day 1 (ml/min)	70.73±28.43	71.43±26.64	0.773
Creatinine clear day 2 (ml/min)	79.69±31.35	78.51±30.29	0.327
Creatinine clear day 3 (ml/min)	83.73±34.87	83.50±26.86	0.299
Urea baseline (mg/dl)	31.73±16.35	29.55±13.34	0.209
Urea day 1 (mg/dl)	37.00±16.92	38.89±18.63	0.741
Urea day 2 (mg/dl)	35.77±19.32	41.68±21.28	0.158
Urea day 3 (mg/dl)	35.87±23.88	38.08±23.18	0.786
Urine output day 1 (mg/dl)	1.713±744	1.66±711	0.789
Urine output day2 (mg/dl)	1.947±609	1.755±620	0.460
Urine output day 3 (mg/dl)	1.761±614	1.715±576	0.279

Table 3: Secondary variables

	With NaHCO3 Mean ± SD	Without NaHCO3 Mean ± SD	P Value
MAP preop (mmHg)	81.40±11.16	80.54±15.94	0.158
MAP at ICU admission (mmHg)	80.74±13.28	82.12±14.72	0.590
MAP 12 hr ICU admission (mmHg)	78.94±10.11	78.75±13.18	0.054
MAP 24 hr ICU admission (mmHg)	75.45±13.18	78.98±10.22	0.998
CPB duration (min)	93.28±33.79	105.84±41.16	0.270
X clamp duration (min)	67.11±27.20	75.91±37.93	0.079
Duration of mechanical ventilation (hr)	8.47±5.296	8.14±5.78	0.317
Duration of ICU stay (days)	3.67±1.271	3.83±1.085	0.341
Duration of hospital stay (days)	19.71±7.410	18.47±5.11	0.124

DISCUSSION

AKI is not only a frequent complication in cardiac surgical patients but has also been associated with morbidity and mortality independently. Unfortunately, there is not much progress within the last years in the development of strategies to reduce the incidence and improve the prognosis of this complication. Recently, Haase and coworkers have elegantly 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 typically observed during rhabdomyolysis. Since alkalization of the urine is among the best treatment option available to treat rhabdomyolysis they used this concept successfully as a strategy for the prevention of CSA-AKI in a small pilot trial.[7]

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.[8,9]

Previous single-center double-blind controlled study demonstrated that sodium bicarbonate administration may reduce CSA-AKI, However this was not confirmed in our study. It is interesting to note that the use of sodium bicarbonate to prevent CIN has shown positive results in several small single-centre studies, but these also have not been replicated consistently in larger studies.[10]

This study demonstrates that there is no reduction of CSA-AKI in patients who are administered sodium bicarbonate despite achieving adequate plasma and urinary alkalization. Therefore, we cannot recommend the routine prophylactic use of this therapy in patients undergoing cardiac surgery.

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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