Effect of recombinant human brain natriuretic peptide on acute kidney injury after coronary artery bypass grafting: a retrospective comparative cohort study

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Background: Acute kidney injury (AKI) is a common complication of coronary artery bypass grafting (CABG) that results in worse prognosis. Studies have shown that recombinant human brain natriuretic peptide (rh-BNP) reduces renal injury. However, its treatment effects for AKI in patients underwent cardiac surgery are unclear. This study sought to explore the efficacy of rh-BNP in patients with AKI after bypass surgery.

Methods: This study included patients with AKI diagnosed within 4 days after CABG during the period January 2016 to December 2020. AKI was defined according to the Kidney Disease Improving Global Outcomes (KDIGO) criteria. The clinical characteristics and outcomes were collected. Patients were divided into BNP and non-BNP groups according to whether rh-BNP was injected intravenously after the operation. Multivariable logistic regression was adjusted the confounding effects between clinical characteristics and rh-BNP. Propensity score matching (PSM) was used to perform a sensitivity analysis.

Results: A total of 395 patients, including 56 and 339 patients in the BNP and non-BNP groups, respectively, were included in this study. The decreasing trend of postoperative serum creatinine levels (P<0.001) and postoperative urine volume (P=0.001) within 4 days of surgery were independent associated with rh-BNP. From PSM, 175 patients, including 44 and 131 patients in the BNP and non-BNP groups, respectively, were included in this study. The decreasing trend of postoperative serum creatinine levels in the BNP group was significantly stronger than that in the non-BNP group (0.04±0.28 *vs.* –0.16±0.36, P=0.001). The postoperative urine volume within 4 days of surgery of the BNP group was higher than that of the non-BNP group (11.3±2.8 *vs.* 9.11±2.66, P<0.001). The cumulative dosage of diuretics after the procedure did not differ between the BNP and non-BNP groups {60 [40, 80] *vs.* 60 [40, 120], P=0.852}.

Conclusions: Rh-BNP can reduce creatinine levels and increases postoperative urine volume to improve renal function in patients.

Keywords: Recombinant human brain natriuretic peptide (rh-BNP); acute kidney injury (AKI); coronary artery bypass surgery (CABG surgery)

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Introduction

With an incidence of 20–30%, acute kidney injury (AKI) is one of the most frequent complications of cardiac surgery (1-3). Postoperative AKI can adversely affect patient outcomes in terms of increased short- and long-term mortality, prolonged intensive care unit (ICU) and hospital stays, and increased costs (4-7). It can also increase the risk of dialysis and end-stage renal disease (8,9). Thus, the prevention and treatment of AKI following coronary artery bypass grafting (CABG) are of great significance to the short-term and long-term prognosis of patients.

Recombinant human brain natriuretic peptide (rh-BNP) is a hormone produced using deoxyribonucleic acid recombination technology that has the same chemical structure composition and biological activity as endogenous BNP. It can induce diuresis, dilate blood vessels, inhibit the renin-angiotensin-aldosterone system (RAAS), reduce aldosterone secretion, resist myocardial hypertrophy and myocardial fibrosis, and affect the neuroendocrine system and secretion of inflammatory cytokines (10-13). Human atrial natriuretic peptide and human brain natriuretic peptide belong to the Natriuretic Peptides (NPs) family. Some studies have shown that human atrial natriuretic peptide (ANP), which has similar pharmacological effects with BNP, has achieved good clinical results in improving cardiopulmonary function and reducing acute renal injury after cardiac surgery (14-16). However, to date few studies have reported on the effect of BNP in AKI patients after cardiac surgery. This study sought to evaluate the efficacy of rh-BNP on renal function after CABG. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3727/rc).

Methods

Study design and population

To be eligible for inclusion in this study, patients had to meet the following inclusion criteria: (I) have undergone a CABG and had postoperative AKI at The Affiliated Hospital of Qingdao University from 2016 to 2020; and (II) be aged >18 years. Patients were excluded from the study if they met any of the following exclusion criteria: (I) had a preoperative chronic renal injury; (II) had undergone intraoperative combined valve replacement (molding), macrovascular surgery, or re-exploration after a secondary operation; (III) had undergone an emergency surgery (i.e., surgical treatment within 24 hours of admission); (IV) had died within 7 days of surgery; and/or (V) had missing data. Based on the criteria, a total of 395 patients were included in this study (56 in the BNP group and 339 in the non-BNP group). Rh-BNP was pumped intravenously in patients to observe the trend of serum creatinine levels and changes in urine volume. The screening process is illustrated in *Figure 1*.

Use of rh-BNP and diuretics

All the patients underwent isolated CABG. Each patient was transferred to the ICU following the operation, after which the physicians administered rh-BNP according to each patient's specific situation and experience. The intravenous pumping dose was 0.0075–0.01 μg/(kg·min), and only patients who received intravenous pumping of rh-BNP within 4 days of surgery were included in the study. Diuretics were routinely used when patients develop AKI after CABG, and the amount of diuretics was determined based on each patient's postoperative urine volume and the physicians' experience.

Data collection

Clinical characteristics, demographic data, preoperative, and operative data were extracted from the database for each patient at The Affiliated Hospital of Qingdao University. All the laboratory data were the last recorded results before surgery. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study is a single-center retrospective study, and the study protocol was reviewed and approved by the Ethics Committee of The Affiliated Hospital of Qingdao University (No. QYFY WZLL 27256). The requirement of informed consent from participants was waived.

Definition of indicators

This study included a number of indicators. The first indicator was acute renal failure (or AKI), for which the Kidney Disease Improving Global Outcomes diagnostic criteria (17) were adopted. Under the KDIGO criteria, AKI was diagnosed if: (I) the creatinine value within 48 h of surgery increased to 1.3 times that of the baseline value or >26.5 μmol/L; (II) the creatinine value within

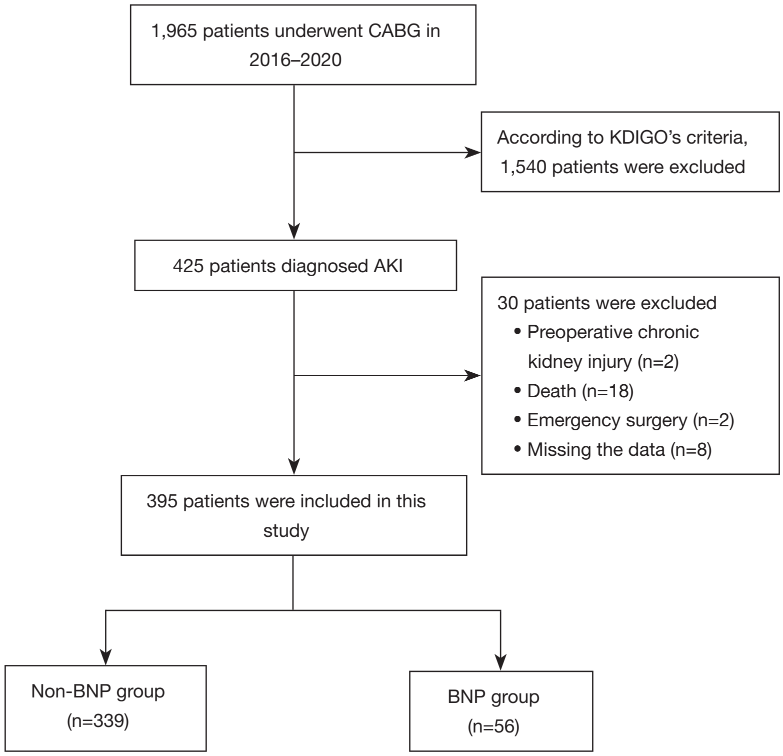

Figure 1 Study cohort. CABG, coronary artery bypass grafting; KDIGO, kidney disease improving global outcomes; AKI, acute kidney injury; rh-BNP, recombinant human brain natriuretic peptide.

7 days of surgery was >1.5 times that of the baseline value; or (III) the urine volume within 6 h of surgery was <0.5 mL/kg/hour. The second indicator was a decrease in creatinine levels, which was defined as: (I) a decrease in postoperative serum creatinine levels that peaked within 4 days of surgery (i.e., peak creatinine – minimum creatinine after peak)/peak creatinine); (II) continuously elevated creatinine levels within 4 days of surgery (i.e., baseline creatinine value – peak creatinine)/peak creatinine; (III) a urine volume that equaled the total urine volume over 4 days after surgery; or (IV) a dosage of diuretics that equaled the total amount used within 4 days of surgery.

Statistical analysis

R4.1 and SPSS 26.0, were used for the data analysis. The continuous variables are expressed as the mean (standard deviation) or median (interquartile range) and were compared using the *t*-test or Mann-Whitney U test. The classification data are described by proportional counting, and the χ^2 test was used for the analysis. Logistic regression was adopted to reduce baseline information differences between the two groups to adjust the confounding effects. The associations between collected variables and rh-BNP were assessed with univariate logistic regression analysis, and variables with a P value <0.05 were entered into a multivariate regression model. Propensity score matching (PSM) was used to perform a sensitivity analysis. Since the use of rh-BNP is related to a patient's condition after surgery, the variables of the postoperative use of inotropic drugs were included in the PSM to balance the two groups. The control group was selected at a ratio of 1:4 according to the PSM method. When matching, the caliper value was 0.05, and the nearest neighbor method was used. R4.1 was used to verify the matched cohort. A P value <0.05 was considered statistically significant.

Results

A total of 1,965 patients underwent CABG at our hospital between 2016 and 2020, and 425 of those patients developed AKI. Based on the exclusion criteria, 395 patients were included in this study (56 in the BNP group and 339 in the non-BNP group) (see *Figure 1*). The preoperative, perioperative and postoperative characteristics of patients are presented in *Table 1* and *Table 2*. The preoperative left ventricular ejection fraction (LVEF), usage rate of preoperative angiotensin converting enzyme inhibitors (ACEI), dosages of postoperative adrenaline, perioperative intra-aortic balloon pumps (IABP), decreasing trend of serum creatinine levels and postoperative urine volume were statistically significant difference between BNP group and non-BNP group (P<0.05). All of the characteristics with clinical significance were included in the multivariate analysis for predicting independent correlations of rh-BNP. Multivariable logistic regression showed that the decreasing trend of serum creatinine levels (OR =15.209, 95% CI: 4.692–49.294, P<0.001) and postoperative urine volume (OR =1.0002, 95% CI: 1.0002–1.0003, P=0.001) were independently associated with rh-BNP. Besides, patients in BNP group tend to had lower value of LVEF (P=0.003), more usage rate of ACEI (P=0.005), more perioperative intra-aortic balloon pumps (P=0.009) than non-BNP group (*Table 3*).

In addition, PSM was applied to have sensitivity analysis (*Table 4,5*). Before PSM, the preoperative left ventricular ejection fraction of the BNP group was lower than that of the non-BNP group {56 [48, 60] *vs.* 60 [56, 61], P=0.001}. The dosages of postoperative adrenaline and noradrenaline were higher in the BNP group than the non-BNP group (25% *vs.* 9.7%, P=0.001 and 98.2% *vs.* 92.6%, P=0.005, respectively). Additionally, the history of drinking and the usage rate of preoperative angiotensin converting enzyme inhibitors and perioperative intra-aortic balloon pumps were higher in the BNP group than the non-BNP group (33.9% *vs.* 18.9%, P=0.011; 37.5% *vs.* 23%, P=0.021; 17.9% *vs.* 4.1%, P<0.001). The other clinical characteristics or demographic data did not differ significantly. After PSM, the differences in the variables became insignificant.

A total of 44 and 131 patients were included in the BNP and non-BNP groups, and the data of 12 patients in the BNP group were missing after PSM. Decreasing trends in serum creatinine levels, urine volume, and diuretics usage were the primary outcome indicators within 4 days of CABG. The postoperative serum creatinine of the BNP group decreased by 4% in 4 days, while that of the non-BNP group increased by 16%, and the difference between the two groups was significant (P=0.001). Additionally, within 4 days of surgery, the urine volume of the BNP group was significantly higher than that of the observation group (11.3 *vs.* 9.11 L, P<0.001), and there was no significant difference in the postoperative diuretics usage between the two groups (P=0.852). Details of the outcomes are presented in *Table 6*. The study cohort after PSM is shown in *Figure 2*.

Discussion

The natriuretic peptide family includes ANP, BNP, and C-type natriuretic peptide (18). Studies have shown that the intravenous injection of recombinant human ANP (rh-ANP) and rh-BNP effectively reduces pulmonary arterial pressure and blood pressure, protects renal function, and decreases the occurrence of arrhythmia (15,19-22). A meta-analysis showed that plasma BNP levels can be used as a diagnostic and predictive factor for pulmonary hypertension, heart failure, myocardial fibrosis, atrial fibrillation, and metabolic diseases (10).

Due to insufficient circulating blood volume during surgery, the activity of humoral factors (e.g., the RAAS system and catecholamines) and the sympathetic nervous system can be enhanced to strengthen the inflammatory response and coagulation function. The kidney contracts its glomerular arterioles to decrease the glomerular filtration rate and reduce urine output, which enables it to supply blood volume to important organs; however, these changes may have adverse effects on the kidneys (23,24). Rh-BNP acts directly on the renal tubules (exhibiting a diuretic effect) to increase urinary sodium excretion, thereby maintaining the electrolyte balance and avoiding renal parenchymal damage caused by high-dose diuretics and may reduce damage to renal function after surgery (25,26).

From clinical reports, it remains unclear whether rh-BNP has a protective function in the kidneys. Several studies have shown that the effect of rh-BNP on renal function is not obvious (27-29). However, a prospective study by Mentzer *et al.* (30) revealed that the 24-h urine volume of patients in the rh-BNP group was significantly higher than that of patients in the control group. The peak plasma creatinine concentration and absolute decline in glomerular filtration rate in the rh-BNP group decreased significantly within 14 days of hospitalization. Similarly, a meta-analysis showed that the infusion of any peptide increased the urine volume and creatinine clearance or the glomerular filtration rate, and reduced the dose of diuretics and serum creatinine levels (31).

Table 1 Univariate analysis of preoperative clinical variables for rh-BNP after CABG

Characteristics	BNP (N=56)	Non-BNP (N=339)	Overall (N=395)	P value
Age (years)	66 (9.2)	63.8 (8.7)	64.1 (8.8)	0.085
Male, n (%)	43 (76.8)	238 (70.2)	281 (71.1)	0.316
BMI (kg/m^2)	25.7 (3.8)	25.8 (3.4)	25.8 (3.5)	0.297
Smoking, n (%)	30 (53.6)	141 (41.6)	171 (43.3)	0.096
Drinking, n (%)	21 (37.5)	78 (23.0)	99 (22.5)	0.058
Hypertension, n (%)	41 (73.2)	244 (72.0)	285 (72.2)	0.848
Diabetes mellitus, n (%)	21 (37.5)	142 (41.9)	163(41.3)	0.537
LVEF (%)	56 [48, 60]	60 [56, 61]	56.3 [55, 61]	0.001
PVD, n (%)	0 (0)	8 (2.4)	8 (2.0)	0.999
COPD, n (%)	2 (3.6)	4 (1.2)	6 (1.5)	0.197
HF, n (%)	4 (7.1)	14 (4.1)	18 (4.6)	0.323
ACS, n (%)	54 (96.4)	332 (97.9)	386 (97.7)	0.489
Coronary stent, n (%)	4 (7.1)	31 (9.1)	35 (8.9)	0.626
Stroke, n (%)	8 (14.3)	28 (8.3)		0.152
OMI, n (%)	4 (7.1)	19 (5.6)	23 (5.8)	0.65
Preoperative blood results				
Scr (μmol/L)	65 [55, 82]	57 [73, 91]	71 [57, 90]	0.438
LDLC (mmol/L)	2.7 (1.04)	2.6 (0.9)	2.6 (0.92)	0.283
Triglycerides (mmol/L)	1.4 [1, 2.35]	1.4 [1.1, 1.9]	1.4 [1.1, 2]	0.349
Uric acid (mmol/L)	331.1 (91.7)	346.6 (106.0)	347 (104.2)	0.219
Hemoglobin (g/L)	130 [123, 143]	132 [120, 144]	132 [120, 144]	0.752
Platelet (10^9/L)	222 [189, 249]	216 [177, 260]	216 [179, 258]	0.854
Preoperative medication, n (%)				
ACEI	19 (33.9)	64 (18.9)	83 (21)	0.012
ARB	17 (30.4)	126 (37.2)	143 (36.2)	0.327
CCB	18 (32.1)	120 (35.4)	138 (34.9)	0.636
BRB	42 (75.0)	240 (70.8)	282 (71.4)	0.52
Statin	43 (76.8)	258 (76.1)	301 (76.2)	0.912
Diuretics	25 (44.6)	148 (43.7)	173 (43.8)	0.891
Inotropic drugs	7 (12.5)	32 (9.4)	39 (9.9)	0.478

The data are shown as n (%) or as mean (standard deviation) or as median [interquartile range; 25th–75th percentile]. rh-BNP, recombinant human brain natriuretic peptide; CABG, coronary artery bypass grafting; BMI, body mass index; LVEF, left ventricular ejection fraction; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; ACS, acute coronary syndrome; OMI, old myocardial infarction; Scr, serum creatinine; LDLC, low-density lipoprotein cholesterol; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; CCB, calcium channel blockers; BRB, β receptor blocker; BNP, brain natriuretic peptide.

Table 2 Univariate analysis of perioperative and postoperative clinical variables for rh-BNP after CABG

Characteristics	BNP (N=56)	Non-BNP (N=339)	Overall (N=395)	P value
IABP, n (%)	10 (17.9)	14 (4.1)	24 (6.1)	<0.001
Operative time (min)	281.5 (73.5)	267.2 (83.0)	269 (81.8)	0.226
CPB, n (%)	2 (3.6)	22 (6.5)	24 (6.1)	0.404
Postoperative adrenaline, n (%)	14 (25.0)	33 (9.7)	47 (11.7)	0.002
Postoperative noradrenaline, n (%)	55 (98.2)	314 (92.6)	369 (93.4)	0.152
Postoperative dopamine, n (%)	56 (100.0)	296 (87.3)	354 (89.1)	0.997
Decreasing trend of Scr (%)	0.02 (0.28)	–0.16 (0.27)	–0.14 (0.28)	<0.001
Urine volume (L)	11.3 (2.87)	9.47 (2.96)	9.73 (3.02)	<0.001
Postoperative diuretic (mg)	60 [40, 80]	60 [40, 120]	60 [40, 96.1]	0.881

The data are shown as n (%) or as mean (standard deviation) or as median [interquartile range; 25th–75th percentile]. rh-BNP, recombinant human brain natriuretic peptide; CABG, coronary artery bypass grafting; IABP, intra-aortic balloon pump; CPB, cardiopulmonary bypass; Scr, serum creatinine.

Table 3 Multivariate analysis of independent factors associated with rh-BNP after CABG

Characteristics	β-coefficient	OR	95% CI	P value
LVEF (%)	-0.06	0.942	0.906–0.979	0.003
ACEI, n (%)	1.021	2.755	1.366–5.635	0.005
IABP, n (%)	1.373	3.948	1.418–10.991	0.009
Postoperative adrenaline, n (%)	0.543	1.721	0.748–3.959	0.201
Decreasing trend of Scr (%)	2.722	15.209	4.692–49.294	<0.001
Urine volume (L)	0.0002	1.0002	1.0002–1.0003	0.001

rh-BNP, recombinant human brain natriuretic peptide; CABG, coronary artery bypass grafting; LVEF, left ventricular ejection fraction; ACEI, angiotensin converting enzyme inhibitor; IABP, intra-aortic balloon pump; Scr, serum creatinine.

Currently, rh-ANP is widely used in Japan and has effects similar to those of rh-BNP (18,32,33). Some studies have shown that rh-ANP has a positive effect on long-term renal protection. In a randomized controlled trial of 303 patients with chronic kidney disease who underwent CABG, the dialysis-free rate at 1 year was 98.6% in the carperitide group and 91.6% in the placebo group (34). A prospective study in which patients undergoing CABG were divided into two groups (i.e., the intravenous drip of rh-ANP and placebo groups) showed that the non-dialysis rate of the rh-ANP group was significantly higher than that of the placebo group at 1, 5, and 10 years (35). However, Saito *et al.* (36) found that a low-dose infusion of rh-ANP did not reduce creatinine and increase urine output during hospitalization. However, it should be noted that Saito *et al.* conducted a retrospective study. To avoid the bias of observation indicators caused by patients' conditions, numerous creatinine values reveal the efficacy of rh-ANP on renal function better than a single creatinine value. Additionally, the use of diuretics can also affect patients' urine output during treatment. However, in Saito *et al.* study, they did not appear to mention this, which may have caused bias and affect the outcome indicators.

Rh-BNP is widely used in patients with acute and chronic heart failure and cardiac insufficiency in China; however, there are relatively few reports on the protective effect of rh-BNP on renal function after CABG. As patients with AKI after bypass surgery were included in this cohort, this experiment was able to observe the prognosis of rh-BNP in patients with postoperative renal dysfunction.

Table 4 Baseline characteristics of patients before surgery according to rh-BNP

Characteristics	Patients with AKI before PSM (N=395)			Patients with AKI after PSM (N=175)		
	BNP (N=56)	Non-BNP (N=339)	P value	BNP (N=44)	Non-BNP (N=131)	P value
Patient characteristics						
Age (years)	66 (9.2)	63.8 (8.7)	0.084	65.6 (9.2)	64.3 (7.8)	0.344
Male, n (%)	43 (76.8)	238 (70.2)	0.315	32 (72.7)	90 (68.7)	0.616
BMI (kg/m^2)	25.7 (3.8)	25.8 (3.4)	0.784	25.3 (3.7)	25.6 (3.5)	0.493
Smoking, n (%)	30 (53.6)	141 (41.6)	0.094	23 (52.3)	60 (45.8)	0.458
Drinking, n (%)	21 (37.5)	78 (23.0)	0.021	12 (27.3)	36 (27.5)	0.979
Hypertension, n (%)	41 (73.2)	244 (72.0)	0.848	32 (72.7)	105 (80.2)	0.303
Diabetes mellitus, n (%)	21 (37.5)	142 (41.9)	0.537	20 (45.5)	62 (47.3)	0.83
LVEF (%)	56 [48, 60]	60 [56, 61]	0.001	58 [51, 60]	58 [55, 60]	0.27
PVD, n (%)	0 (0)	8 (2.4)	0.246	0 (0)	0 (0)	–
COPD, n (%)	2 (3.6)	4 (1.2)	0.176	1 (2.3)	1 (0.8)	0.416
HF, n (%)	4 (7.1)	14 (4.1)	0.317	2 (4.5)	7 (5.3)	0.836
ACS, n (%)	54 (96.4)	332 (97.9)	0.485	43 (97.7)	129 (98.5)	0.742
Coronary stent, n (%)	4 (7.1)	31 (9.1)	0.626	3 (6.8)	7 (5.3)	0.716
Stroke, n (%)	8 (14.3)	28 (8.3)	0.147	5 (11.4)	10 (7.6)	0.446
OMI, n (%)	4 (7.1)	19 (5.6)	0.649	3 (6.8)	9 (6.9)	0.991
Preoperative blood results						
Scr (μmol/L)	65 [55, 82]	57 [73, 91]	0.085	64 [55, 86]	68 [54, 86]	0.745
LDLC (mmol/L)	2.7 (1.04)	2.6 (0.9)	0.284	2.7 (0.93)	2.6 (0.92)	0.622
Triglycerides (mmol/L)	1.4 [1, 2.35]	1.4 [1.1, 1.9]	0.649	1.39 [1, 2.3]	1.37 [1.1, 1.9]	0.83
Uric acid (mmol/L)	331.1 (91.7)	346.6 (106.0)	0.219	334.2 (95.4)	326.8 (105.0)	0.68
Hemoglobin (g/L)	130 [123, 143]	132 [120, 144]	0.992	132 [122, 144]	132 [120, 144]	0.728
Platelet (10^9/L)	222 [189, 249]	216 [177, 260]	0.735	230 [196, 255]	228 [173, 274]	0.97
Preoperative medication, n (%)						
ACEI	19 (33.9)	64 (18.9)	0.011	13 (29.5)	36 (27.5)	0.792
ARB	17 (30.4)	126 (37.2)	0.326	13 (29.5)	51 (38.9)	0.265
CCB	18 (32.1)	120 (35.4)	0.636	17 (38.6)	52 (39.7)	0.901
BRB	42 (75.0)	240 (70.8)	0.52	33 (75.0)	103 (78.6)	0.618
Statin	43 (76.8)	258 (76.1)	0.912	33 (75.0)	107 (81.7)	0.339
Diuretics	25 (44.6)	148 (43.7)	0.891	19 (43.2)	54 (1.2)	0.82
Inotropic drugs	7 (12.5)	32 (9.4)	0.477	5 (11.4)	16 (12.2)	0.881

The data are shown as n (%) or as mean (standard deviation) or as median [interquartile range; 25th–75th percentile]. rh-BNP, recombinant human brain natriuretic peptide; BMI, body mass index; LVEF, left ventricular ejection fraction; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; ACS, acute coronary syndrome; OMI, old myocardial infarction; Scr, serum creatinine; LDLC, low-density lipoprotein cholesterol; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; CCB, calcium channel blockers; BRB, β receptor blocker; AKI, acute kidney injury; PSM, propensity score matching; BNP, brain natriuretic peptide.

Table 5 Baseline characteristics of patients during and after surgery according to rh-BNP

Characteristics	Patients with AKI before PSM (N=395)			Patients with AKI after PSM (N=175)		
	BNP (N=56)	Non-BNP (N=339)	P value	BNP (N=44)	Non-BNP (N=131)	P value
IABP, n (%)	10 (17.9)	14 (4.1)	<0.001	2 (4.5)	8 (6.1)	0.7
Operative time (min)	281.5 (73.5)	267.2 (83.0)	0.226	284.3 (76.4)	275.4 (80.5)	0.522
CPB, n (%)	2 (3.6)	22 (6.5)	0.398	2 (4.5)	8 (6.1)	0.7
Postoperative adrenaline, n (%)	14 (25.0)	33 (9.7)	0.001	8 (18.2)	15 (11.5)	0.254
Postoperative noradrenaline, n (%)	55 (98.2)	314 (92.6)	0.005	44 (100.0)	131 (100.0)	–
Postoperative dopamine, n (%)	296 (87.3)	56 (100.0)	0.119	44 (100.0)	127 (96.9)	0.242

The data are shown as n (%) or as mean (standard deviation). rh-BNP, recombinant human brain natriuretic peptide; IABP, intra-aortic balloon pump; CPB, cardiopulmonary bypass; AKI, acute kidney injury; PSM, propensity score matching.

Table 6 Outcome characteristics according to rh-BNP (N=175)

Characteristics	BNP (N=44)	Non-BNP (N=131)	P value
Decreasing trend of Scr (%)	0.04 (0.28)	–0.16 (0.36)	0.001
Urine volume (L)	11.3 (2.80)	9.11 (2.66)	<0.001
Postoperative diuretic (mg)	60 [40, 80]	60 [40, 120]	0.852

The data are shown as mean (standard deviation) or as median [interquartile range; 25th–75th percentile]. rh-BNP, recombinant human brain natriuretic peptide; Scr, serum creatinine.

Serum creatinine is a significant diagnostic indicator for AKI (37), and has been shown to be positively associated with hospital mortality and lengths of ICU stay, and even a slight increase in serum creatinine can alter patient outcomes (38). Monitoring the dynamic trend of serum creatinine values after CABG better reflects the change in renal function than a single creatinine value index. We found that rh-BNP enhanced the decreasing trend in creatinine levels and improved renal function, which is consistent with the above report.

Additionally, considering that both postoperative diuretics and rh-BNP had an effect on postoperative urine volume, we separately counted the total amount of diuretics in the two groups within 4 days of surgery to avoid bias in the experimental process. The results showed that there was no significant difference in the doses of diuretics administered between the two groups after surgery (P=0.852), and the urine volume of the rh-BNP group was much higher than that of the non-BNP group (P<0.001). Rh-BNP is commonly used clinically in the treatment of patients with heart failure. From this study, we can conclude that intravenous rh-BNP can also increase their urine volume and improve their renal function. These findings may provide clinical guidance for the treatment of patients with cardio-renal syndrome after cardiac surgery.

This study had some limitations. As a retrospective study, it may have had a bias because it was performed at a single center. Thus, future prospective studies are required to further verify our findings. Second, there is still the possibility of insufficient matching information after passing through the PSM to adjust for the difference between the two groups; thus, studies with larger sample sizes and multicenter prospective studies are needed.

Conclusions

Rh-BNP strengthens the rate of creatinine decline and increases urine output in patients with AKI and thus protects their renal function.

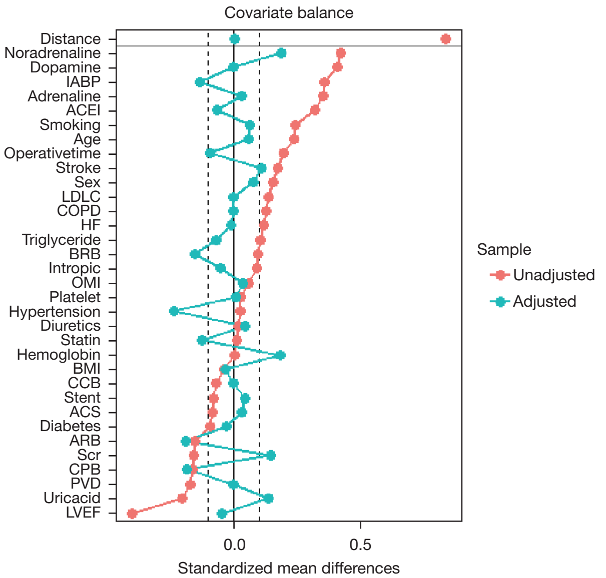

Figure 2 The evaluation of PSM. IABP, intra-aortic balloon pump; ACEI, angiotensin converting enzyme inhibitor; LDLC, low-density lipoprotein cholesterol; COPD, chronic obstructive pulmonary disease; HF, heart failure; OMI, old myocardial infarction; BMI, body mass index; CCB, calcium channel blocker; ACS, acute coronary syndrome; ARB, angiotensin receptor blocker; Scr, serum creatinine; CPB, cardiopulmonary bypass; PVD, peripheral vascular disease; LVEF, left ventricular ejection fraction; PSM, propensity score matching.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-3727/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-3727/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study is a single-center retrospective study, and the study protocol was reviewed and approved by the Ethics Committee of The Affiliated Hospital of Qingdao University (No. QYFY WZLL 27256). The requirement of informed consent from participants was waived.

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