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CONTRAST-INDUCED NEPHROPATHY

Prevention of Contrast-Induced Nephropathy by Central Venous Pressure–Guided Fluid Administration in Chronic Kidney Disease and Congestive Heart Failure Patients

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ABSTRACT

OBJECTIVES This study aimed to explore the hemodynamic index-guided hydration method for patients with congestive heart failure (CHF) and chronic kidney disease (CKD) to reduce the risk of contrast-induced nephropathy (CIN) and at the same time to avoid the acute heart failure.

BACKGROUND Patients at moderate or high risk for CIN should receive sufficient hydration before contrast application.

METHODS This prospective, randomized, double-blind, comparative clinical trial enrolled 264 consecutive patients with CKD and CHF undergoing coronary procedures. These patients were randomly assigned to either central venous pressure (CVP)-guided hydration group ($n = 132$) or the standard hydration group ($n = 132$). In the CVP-guided group, the hydration infusion rate was dynamically adjusted according to CVP level every hour. CIN was defined as an absolute increase in serum creatinine (SCr) >0.5 mg/dl (44.2 μmol/l) or a relative increase >25% compared with baseline SCr.

RESULTS Baseline characteristics were well-matched between the 2 groups. The total mean volume of isotonic saline administered in the CVP-guided hydration group was significantly higher than the control group (1,827 ± 497 ml vs. 1,202 ± 247 ml; $p < 0.001$). CIN occurred less frequently in CVP-guided hydration group than the control group (15.9% vs. 29.5%; $p = 0.006$). The incidences of acute heart failure during the hydration did not differ between the 2 groups (3.8% vs. 3.0%; $p = 0.500$).

CONCLUSIONS CVP-guided fluid administration can safely and effectively reduce the risk of CIN in patients with CKD and CHF. (Central Venous Pressure Guided Hydration Prevention for Contrast-Induced Nephropathy; NCT02405377) (J Am Coll Cardiol Intv 2016;9:89–96) © 2016 by the American College of Cardiology Foundation.

Incidence of contrast-induced nephropathy (CIN) is reported to be more than 20% in chronic kidney disease (CKD) complicated with congestive heart failure (CHF) (1–3), and CIN is a significant risk factor for long-term mortality and renal events after coronary angiography (4,5). Patients at moderate or high risk for CIN should receive sufficient hydration before and after application of contrast (6). Hydration

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ABBREVIATIONS AND ACRONYMS

CHF = congestive heart failure

CIN = contrast-induced nephropathy

CKD = chronic kidney disease

CVP = central venous pressure

eGFR = estimated glomerular filtration rate

LVEF = left ventricular ejection fraction

SCr = serum creatinine

is the cornerstone for prevention of CIN, because hydration could increase the renal flow, reducing the contraction of renal vessels and the formation of urinary casts (7–9). The guidelines recommend controlling the hydration rate in patients with CHF to avoid acute pulmonary edema. However, inadequate hydration markedly increases the incidence of CIN in patients with CKD (9). We expect to explore an individual hydration method for CKD-complicated CHF patients to reduce the incidence of CIN and, at the same time, to prevent acute heart failure.

METHODS

The study was a prospective, randomized, double-blind clinical trial, conducted in China from February 2014 to February 2015. This trial was registered with ClinicalTrials.gov (NCT02405377). The study was approved by the institutional review board of the Chinese People's Liberation Army General Hospital and performed in conformity with the Helsinki Declaration of 1975, as revised in 2000. The ethical committee of our institution approved the protocol. Written informed consent was provided by all patients before enrollment.

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STUDY POPULATION. We enrolled patients from February 2014 to December 2014. The principal inclusion criteria included: 1) CHF: left ventricular ejection fraction (LVEF) by echocardiography <50% and with a typical attack of congestive left heart failure in the past 1 year, which presented with paroxysmal nocturnal dyspnea or orthopnea with obvious rales or wheezes in lungs; 2) CKD: estimated glomerular filtration rate (eGFR) from 15 to 60 ml/min/ 1.73 m^2, calculated via the Modification of Diet in Renal Disease study equation (10); and 3) patients scheduled to undergo diagnostic cardiac angiography or percutaneous coronary intervention. The principal exclusion criteria included: dialysis-dependent patients; age <18 years; pregnancy; lactation; emergency cardiac catheterization (e.g., primary percutaneous coronary intervention for ST-segment elevation myocardial infarction); exposure to radiographic contrast media within the previous 7 days; acute decompensated heart failure; and cardiogenic shock. We randomly assigned eligible patients at a 1:1 ratio to either central venous pressure (CVP)-guided hydration or standard hydration protocol. Eligible patients were assigned with sealed blinded envelopes that contained a computer-generated randomization number. Patients were not told to which group they were randomly allocated. The cardiologists performing the angiogram also had no knowledge of each patient's group assignment.

PROCEDURES. We used 0.9% sodium chloride hydration in all patients. We monitored the CVP level by placing a 5-F catheter in the jugular vein and recorded initial CVP level in both groups. Patients in the CVP-guided hydration group were divided into 3 subgroups according to initial CVP level, group 1 (CVP <6 cm H_2O), group 2 (CVP 6 to 12 cm H_2O), and group 3 (CVP >12 cm H_2O). The rate of fluid administration was guided by CVP as follows: 3 ml/kg/h for group 1, 1.5 ml/kg/h for group 2, and 1 ml/kg/h for group 3. The intravenous infusion rate was dynamically adjusted according to the level of CVP per hour during hydration. If the CVP of patients experienced a rise among the groups, (for example, if CVP increased from 8 cm H_2O to 13 cm H_2O, the patient would change from group 2 to group 3), this would necessitate a reduction in the intravenous infusion rate from 1.5 ml/kg/h to 1 ml/kg/h. If the patient's CVP increased from 8 cm H_2O to 12 cm H_2O, the fluid rate remained 1.5 ml/kg/h. The control group was hydrated at the rate of 1 ml/kg/h. Hydration continued from 6 h before the procedure to 12 h post-procedure, thus both study groups received intravenous fluids for the same duration but at different rates. All study participants received iodixanol (320 mg I/ml; Visipaque, GE Healthcare, Chalfont St. Giles, United Kingdom) as the contrast medium.

ENDPOINTS AND DEFINITION. The primary endpoint of the study was CIN, defined as the peak increase in serum creatinine (SCr) concentration either ≥25% or ≥0.5 mg/dl (44.2 μmol/l) over baseline during the first 72 h post-procedure, and we further analyzed the proportion of patients with a peak SCr increase ≥50% or ≥1.0 mg/dl (88.4 μmol/l) over baseline in the initial 72 h post-procedure. Urine output, SCr, blood urea nitrogen, and serum electrolytes were also evaluated at baseline, the day of coronary angiography and each day for the following 3 days and at hospital discharge for assessment of acute kidney injury severity and indication of dialysis. Secondary endpoints were major post-procedure adverse clinical events including acute pulmonary edema, myocardial infarction, all-cause death, and CIN requiring renal replacement therapy. Myocardial infarction was defined as a creatine kinase-myocardial band enzyme elevation 3 times the upper normal value with or without new Q waves on the electrocardiogram. The risk score of CIN was assessed on the basis of the patients' clinical and laboratory conditions (1,3). Each