Preoperative Prophylactic Intraaortic Balloon Pump Reduces the Incidence of Postoperative Acute Kidney Injury and Short-Term Death of High-Risk Patients Undergoing Coronary Artery Bypass Grafting: A Meta-Analysis of 17 Studies

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This meta-analysis investigated the effects of preoperative prophylactic intraaortic balloon pump placement on postoperative renal function and short-term death of high-risk patients undergoing coronary artery bypass grafting. We found that preoperative prophylactic intraaortic balloon pump support reduced the incidence of coronary artery bypass grafting–associated acute kidney injury and short-term death and dramatically decreased the incidence of postoperative renal replacement therapy by 82% compared with high-risk patients without the procedure. This is the first meta-analysis to demonstrate significant beneficial effects of preoperative prophylactic intraaortic balloon pump on renal function in high-risk patients undergoing coronary artery bypass grafting.

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Current candidates for cardiac operations are often high-risk patients characterized by old age, multiple preoperative comorbidities, poor clinical conditions, and reduced left ventricular function [1]. The beneficial effects of improved surgical techniques appear not to substantially change short-term death in high-risk patients [1]. Previous studies showed that preoperative prophylactic intraaortic balloon pump (IABP) therapy exerted protective effects on high-risk patients undergoing coronary artery bypass grafting (CABG) operations [2–4].

During the off-pump CABG (OPCABG) procedure, avoidance of cardiopulmonary bypass (CPB) eliminates CPB-associated complications [5, 6]; however, displacement of the heart to expose the target vessels often causes hemodynamic deterioration [7, 8], particularly in high-risk patients [9]. It has been indicated that preoperative prophylactic IABP therapy might benefit the hemodynamics in high-risk patients undergoing OPCABG and thus improve prognosis and clinical outcomes [9].

Acute kidney injury (AKI), a common complication after CABG, affects 11% to 17% of patients undergoing CABG [10]. Previous studies showed that comorbidities, such as diabetes and chronic obstructive pulmonary disease, preoperative coronary disease, and poor preoperative renal function were associated with the development of AKI after CABG [11–14]. In particular, age, poor left ventricular ejection fraction, and high preoperative creatinine levels have been consistently shown as independent risk factors for developing postoperative AKI [11–14]. Several scoring systems to estimate the risk of postoperative AKI have been developed, such as the AKI following cardiac surgery prognostic score system [13]. Thakar and colleagues [11] also developed a scoring model to predict AKI after cardiac operations by incorporating the effects of all major risk factors for AKI, including gender, congestive heart failure, left ventricular ejection fraction of less than 0.35, comorbidities, type of operation, and preoperative creatinine levels.

Postoperative AKI is considered as an independent predictor of short- and long-term death in patients undergoing cardiac operations [15]. Postoperative renal replacement therapy (RRT), which is frequently used to treat AKI, is also associated with an increased death and hospitalization cost [15, 16] and requires intensive nursing care and continuous anticoagulation [17, 18]. Thus, reducing the incidence of postoperative AKI and RRT is essential to improve the clinical outcome of patients undergoing CABG. However, whether preoperative prophylactic IABP can exert protective effects on renal function in high-risk patients undergoing CABG remains unclear. This current meta-analysis was initiated to fill the knowledge gaps. The aim of this study was to examine the effects of preoperative prophylactic IABP on the incidence of postoperative AKI and short-term death in high-risk patients undergoing CABG, particularly in

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high-risk patients undergoing OPCABG. The high-risk patients in this study were at high risk of death. This study also analyzed the effect of risk factors for postoperative AKI on the association of preoperative prophylactic IABP and the incidence of postoperative AKI by meta-regression.

Material and Methods

Literature Search and Selection Criteria

This systematic review and meta-analysis were conducted and reported in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [19]. A computerized and manual search for relevant English articles was conducted using the PubMed, CENTRAL (Cochrane Central Register of Controlled Trials), ISI Web of Science, Directory of Open Access Journals, and the Cochrane Library electronic databases. All of the selected articles focused on a comparison of the incidence of postoperative AKI and short-term death in high-risk patients receiving vs not receiving prophylactic IABP before CABG.

The following search terms were used: ("preoperative prophylactic intra-aortic balloon pump" [All Fields] *or* "preoperative prophylactic intra-aortic balloon counterpulsation" [All Fields]) *and* ("30-day mortality" [All Fields] *or* "in-hospital mortality"); ("preoperative prophylactic intra-aortic balloon pump" [All Fields] *or* "preoperative prophylactic intra-aortic balloon counterpulsation" [All Fields]) *and* ("acute kidney injury" [All Fields] *or* "acute renal failure" [All Fields] *or* "renal replacement therapy" [All Fields]).

The last search was conducted on July 8, 2015. Two investigators (J.W. and W.Y.) performed the initial search separately, deleted duplicate records, screened titles and abstracts for relevance, and identified relevant articles for further full-text assessment. The references of the retrieved articles were also reviewed to identify additional eligible studies. Studies meeting the following criteria were included:

1. Population: study subjects were high-risk patients undergoing CABG. The articles that did not clearly specify a complete inclusion of high-risk patients in the Method section were excluded. The high-risk definition of each included article is reported in Table 1. Also excluded were studies that included patients undergoing other cardiac operations or CABG accompanied with other cardiac operations, including valve operation, aneurysm repair, or cardiac major vascular operation.
2. Intervention: preoperative prophylactic IABP.
3. Comparison: patients receiving preoperative prophylactic IABP vs patients without preoperative prophylactic IABP (including patients who never received any IABP in the hospital and patients who did not receive preoperative prophylactic IABP but received intraoperative and postoperative obligatory IABP).
4. Outcome: AKI, short-term death (in-hospital or 30-day postoperatively), requirement of postoperative RRT, IABP-associated complications, acute myocardial infarction, low cardiac output syndrome, atrial fibrillation, respiratory complications, stroke, infection, and prolonged ventilatory support (>24 hours).
5. Design: randomized controlled trials (RCTs) and observational studies (prospective or retrospective cohort studies).

Data Extraction and Quality Assessment

Two reviewers (J.W. and W.Y.) independently extracted the following information from the eligible studies: first author, year of publication, country, study design, patient characteristics, number of patients enrolled, intervention, and outcome data. When the same patients were reported in several publications, only the largest study was retained to avoid duplication of information. The Cochrane risk of bias tool was adopted to assess the risk of bias for each RCT [31]. Observational studies were evaluated using the Newcastle-Ottawa Scale [32].

Study End Points and Definitions

The primary end point of this meta-analysis was the incidence of postoperative AKI of high-risk patients undergoing CABG. Because a consensus definition of AKI is not available [33], to include sufficient patients, we not only considered the RIFLE (Risk of renal dysfunction, Injury to the kidney, Failure of kidney function, Loss of kidney function, End-stage kidney disease) and Acute Kidney Injury Network (AKIN) criteria but also referred to the AKI definitions in the studies that were published before RIFLE and AKIN criteria were developed. Thus, AKI was defined as meeting one or more of the following criteria [34, 35]:

1. AKIN stage 1: increase in serum creatinine of 0.3 mg/dL or higher or exceeding 50% during any 48-hour period;
2. RIFLE-Risk (RIFLE-R): increase in serum creatinine of 50% or more or a decrease in the estimated glomerular filtration rate of 25% or more during any 48-hour period;
3. AKIN stages 2 and 3 (identical to RIFLE-Injury [RIFLE-I] and -Failure [RIFLE-F]): doubling of serum creatinine or an increase in serum creatinine of 0.5 mg/dL or more to a level of 4 mg/dL or more during any 48-hour period;
4. Serum urea exceeding 9 mmol/L and serum creatinine exceeding 125 μmol/L for patients with normal preoperative values.

AKIN stage 3 also included new-onset RRT. Comparisons of RRT incidence and short-term death (including deaths in the hospital and at 30 days postoperatively) in patients receiving preoperative prophylactic IABP vs patients without the procedure were analyzed.

The secondary study end points were short-term mortality, incidences of atrial fibrillation, stroke, any infection, acute myocardial infarction, low cardiac output syndrome, respiratory failure, prolonged ventilatory support (>24 hours), and IABP-related complications,