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# Postoperative AKI and blood product transfusion after synthetic colloid use during cardiac surgery

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## Abstract

**Objectives—**This study assesses the effect of two types of hydroxyethyl starches (HES) on renal integrity and blood transfusion in cardiac surgery patients.

**Design—**Retrospective investigation.

**Setting—**Patients from a single tertiary medical center.

**Participants—**Inclusion criteria included coronary artery bypass graft and/or valve surgeries that underwent cardiopulmonary bypass with aortic cross clamping.

**Interventions—**Intraoperative HES volumes and blood product administration

**Measurements and Main Results—**1,265 patients met inclusion and exclusion criteria. 70% of these patients received HES and of those, 47% received <1000mL and 53% received ≥1000mL. There was no difference in the development of AKI between the two groups. Parsimonious propensity model for colloids showed combined CABG and valve surgeries were less likely associated with HES administration than CABG alone (OR 0.68; CI 0.46–0.97; P= 0.04). IABP use was less likely associated with HES (OR 0.57; CI 0.38–0.86; P=0.007). CKD Stages 3–5 were less likely to receive HES with OR 0.56 (CI 0.38–0.84; P=0.004), OR 0.51 (CI 0.20–1.33; P= 0.170), and OR 0.23 (CI 0.12–0.44; P<0.0001) respectively. No difference was noted in red blood cell transfusion. However, fresh frozen plasma, cryoprecipitate, and platelets transfusions were

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**DISCLOSURES**

None.

significantly higher in larger volumes of HES with OR 2.03 (CI 1.64–2.52; P<0.001), 1.60 (CI 1.30–1.97; P<0.000) and 1.62 (CI 1.21–2.15; P=0.006) respectively. No differences in operative mortality was found between colloid and non-colloid group.

**Conclusions—**This study showed no association in postoperative AKI and red blood cell transfusion between colloid and non-colloid group. Although complication rate was higher with HES, there was no difference in operative mortality between the two groups.

### Keywords

synthetic colloid; hydroxyethyl starch; acute kidney injury; cardiopulmonary bypass; blood products

## INTRODUCTION

Since their introduction in the 1960s hydroxyethyl starches (HES) continue to be used as volume expanders in conjunction with crystalloids[1]. Due to some studies highlighting increased AKI and overall adverse effects with HES in the critically ill population, the choice of fluids in septic patients has become important[2–4]. HES' safety in perioperative setting, specifically in cardiovascular surgery, remains unclear due to few small, single outcome studies, and conflicting results[5–8]. Cardiopulmonary bypass (CPB) surgery in particular is prone to large fluid shifts necessitating aggressive fluid resuscitation. Colloids such as HES have become an efficient and affordable adjunct to crystalloids in maintaining intravascular volume and tissue perfusion.

Incidence of AKI after coronary artery bypass graft (CABG) surgery can be as high as 54% depending on the definition and is associated with 60% mortality which inevitably leads to higher healthcare costs[9–12]. CPB also interferes with coagulation due to platelet dysfunction, decrease in coagulation factors, and increased fibrinolytic activity[13]; therefore, the colloid choice used to maintain intravascular volume must not compound the bleeding risk that pre-exists in cardiac surgery.

HES is derived from potato starch or waxy maize. To suit our evolving understanding of these products' pharmacodynamics and pharmacokinetics, manufacturers have changed HES production from pentastarches with higher MMW (≥ 200kD), molar substitution, and hydroxyethylation ratios to newer generation tetrastarches with lower MMW (130kD), molar substitution, and hydroxyethylation ratios[14]. Higher molar substitution and hydroxyethylation ratio are believed to be linked with slow degradation[15] which then may result in accumulation of HES in plasma, interstitial space, reticuloendothelial system, and epithelial cells leading to impaired coagulation, nephrotoxicity, and pruritus[16,17]. Clinical studies have shown significantly higher concentration of HES 200/0.5 remaining in plasma compared to HES 130/0.4 after 24 hours[18].

Studies comparing HES products during cardiac surgery have yielded conflicting results. The lack of data quality has occurred due to small cohorts, predominantly single HES type (i.e. 130/0.4), and assessment of single primary end points such as either renal failure or bleeding. At least three meta-analyses on the effect of HES on surgical population have been

published in the last four years[5,6,19], but two concentrate only on kidney function[5,19], and all include heterogeneous groups including cardiac, abdominal, orthopedic, etc. To further complicate the results, several surgical studies including cardiac surgery have been retracted after scientific misconduct[20]. Recently, there were a few new observational studies on hydroxyethyl starch and AKI in non-cardiac surgeries[7,8]. Our goal was to look specifically at cardiac surgical population due to the unique physiological changes that CPB predisposes and compare two different types of 6% HES and their effects on the development of postoperative AKI and the need for blood product transfusion in comparison to patients who did not receive HES.

## METHODS

### Study Design

With permission from the University of California Davis Institutional Review Board (IRB), patients who underwent cardiac surgery were identified from the institutional Society of Thoracic Surgeons (STS) Database, and medical records from July 01, 2007 to June 30, 2013 were located. Inclusion criteria included adult patients who underwent CPB with aortic cross clamping, CABG, valve, or combination surgery. Exclusion criteria included patients that did not undergo CPB, pediatric population, emergency surgery, and deep hypothermic circulatory arrest, and surgeries that did not involve coronary artery or valve. The patients were divided into two groups: colloid group (n=887) and non-colloid group (n=378) depending on intraoperative HES administration. Our institution's HES specifically include Voluven (6% hydroxyethyl starch 130/0.4) and Hextend (6% hydroxyethyl starch 670/0.75).

### Data Collection

Patient demographics, history, preoperative risk factors, preoperative medications, intraoperative data, baseline and postoperative kidney function, blood administration, bypass and cross-clamp time, all complications, and operative mortality were obtained from the STS Database (Table 1). Patient anesthesia records were reviewed through electronic medical records (EMR) and paper charts for intraoperative HES documentation.

### Primary and secondary outcomes

Postoperative AKI and blood product transfusions were the primary outcomes of this study. Secondary outcomes included postoperative complications and operative mortality. Baseline kidney function was based on preoperative estimated glomerular filtration rate (eGFR mL/min/1.73m$^2$) that was calculated using the Modification of Diet in Renal Disease equation[21]. Patients were divided into 5 stages: Stage 1, normal eGFR (>90); Stage 2, mildly decreased eGFR (60–89); Stage 3, moderately decreased eGFR (30–59); Stage 4, severely decreased eGFR (15–29); Stage 5, kidney failure or dialysis (eGFR <15). STS definition of postoperative renal failure was used to determine postoperative AKI. This definition included the highest Cr level recorded in the post-operative course that is ≥3-fold baseline Cr or Cr ≥4 with an acute increase of ≥0.5mg/dL or new requirement for dialysis.

Blood product transfusion was based on intraoperative and postoperative administration of packed red blood cells (PRBCs), fresh frozen plasma (FFP), cryoprecipitate (cryo) and platelets.

Operative mortality was defined in the STS as death during hospital admission or within 30 days of discharge. All complications is a STS umbrella term which includes any complications that occurred postoperatively such as pulmonary, infectious, renal, cardiac, vascular, or re-operation.

### Statistical Analysis

Continuous variables were reported as mean ± SD or percentages, and compared with the *t* tests or chi-square test (two tailed), respectively. Univariate and multivariate logistic regressions were performed to assess associations of demographic, therapeutic and clinical outcome variables. To mitigate selection bias in HES administration, we computed the propensity score, the conditional probability of each patient receiving HES with a multivariable logistic regression model that includes patient risk factors (Table 1).

To achieve model parsimony and stability, the backward selection procedure was applied with the dropout criterion $P > 0.05$. The candidate risk factors were selected according to clinical plausibility, and variables collected in the database. The candidate independent variables included demographic and clinical risk factors (Table 1). The parsimonious multivariable propensity for HES use included status of procedure, type of surgery, and level of pre-existing chronic kidney disease (CKD) (Figure 1). The risk-adjusted odds ratios (OR) for all outcomes were calculated with use of a stepwise logistic-regression model with patient risk factors as independent control variables and HES use as the independent variable of interest. A propensity-weighted logistic regression model was used for operative mortality in which an inverse (estimated) propensity score as weights for patients given HES and the inverse of 1 minus the propensity score for patients not given HES and added HES as an independent factor to the model. All models fit analysis was evaluated with the Hosmer-Lemeshow goodness-of-fit statistic. The C statistic measures predictive power. Based on the propensity of HES use and general lineadel, we compared propensity weighted and risk adjusted operative mortality between the cohort of HES and no HES. Results are reported as percentages and odds ratios (OR) and with 95% confidence intervals (CI). All reported p values were 2-sided and p values $< 0.05$ were considered statistically significant. Statistical analysis was performed with SAS version 9.3 for Windows (SAS Inc., Cary, NC).

## RESULTS

### Baseline and Intraoperative Parameters

Of the total 1,762 patient records, 1,268 patients met inclusion criteria, and three anesthesia records could not be located which brought final cohort number to 1,265. A total 70% patients received HES and of those, 47% received <1000mL HES while 53% received ≥1000mL HES. We further divided the HES group into Voluven and Hextend subgroups to differentiate outcomes between the two colloids. Demographics and patient characteristics show gender, race, hypercholesterolemia, lipid lowering agents, ejection fraction, intra-aortic

balloon pump (IABP), and bypass time significantly correlating to HES use (Table 1). Also, patients in CKD Stage 3 or higher were less likely to receive HES. Cr was more likely to be lower in the colloid group. Propensity scores for the two groups were used in calculation of adjusted odd ratios when analyzing postoperative outcomes. Zero mL HES use was considered reference point when calculating OR. The parsimonious propensity model for colloids (Figure 1) showed that combined CABG and valve surgeries were less likely associated with HES administration than CABG alone (OR 0.68, P= 0.04). Also, patients with IABP were less likely to be given HES (OR 0.57; P=0.007). Additionally, CKD Stages 3 through 5 were less likely to receive HES with OR 0.56 (P=0.004), OR 0.51 (P= 0.170), and OR 0.23 (P<0.0001) respectively.

### Effects of HES on postoperative AKI

Overall incidence of AKI was less in colloid group with 6.5% vs. 10.3% in non-colloid group (P=0.021) as shown in Table 2. The propensity weighted adjusted OR showed no difference in AKI development between the colloid and non-colloid group (Figure 2). This correlation persisted in the Hextend and Voluven groups as well. We also analyzed the data to determine whether colloids were associated with worsening of pre-existing CKD. Results showed no difference in the development of AKI in various CKD stages (Table 3). The parsimonious model for predicting AKI shows that age, combined CABG and valve surgeries, longer bypass times, urgency, pre-existing CKD, diabetes, history of CVA, history of prior cardiac intervention, and hypercholesterolemia were all associated with AKI. Other surgeries combined with CABG whether valve or unspecified, proved to be the biggest risk factor for predicting AKI.

### Effects of HES on blood product transfusion

Overall no significant difference was noted in the use of PRBC between the colloid and non-colloid groups (Figure 2). However, the transfusion of FFP (OR 2.03, P<0.0001), cryo (OR 1.60, P=0.000), and platelets (OR 1.62, P=0.006) were significantly higher in the ≥1000mL colloid group. Colloid group <1000mL did not show this difference.

### Effects of HES on secondary outcomes

No statistical differences exist in the overall incidence of operative death between the 2 groups whether high or low volume (Figure 2). The parsimonious model for predicting operative mortality showed age, female gender, combined CABG and valve surgeries, urgency, diabetes, CKD Stage 5, BMI ≥40, cardiogenic shock, IABP, bypass time, and prior valve surgery to be associated with increased mortality. Combined CKD 5, BMI ≥40, cardiogenic shock, IABP, and previous valve surgery posed to be the highest mortality predictors.

The observed incidence of postoperative complications was 46.6% in colloid vs 45.8% in the non-colloid group (P=0.795) as shown in Table 2. Figure 2 shows that overall postoperative complications were higher with OR of 1.38 in the <1000mL HES group (P=0.004) and 1.46 in the ≥1000mL HES group (P< 0.001). This significantly higher OR also extended to the high volume Voluven (OR 1.33, P= 0.035) as well as high and low volume Hextend groups with OR 1.59 (P=0.002) and 1.63 (P=0.002) respectively. The parsimonious model for

predicting postoperative complications showed that age, combined CABG and valve surgeries, urgency, pre-existing CKD, BMI ≥40, cardiogenic shock, CHF, IABP, both low and high volume HES were all associated with occurrence of postoperative complications. Cardiogenic shock by far was the biggest factor predicting postoperative complications.

Major adverse cardiocerebral events (MACE) often allow studies to target cardiac specific complications. Since no specific definition of MACE exists, we defined MACE as death, myocardial infarction, repeat revascularization, and postoperative stroke. Our results showed significantly increased adjusted OR of 1.36 (P=0.011) in the lower volume colloid group (Figure 2). This result also extended to the lower volume Voluven group with OR of 1.40 (P=0.030). Results were not significant in the Hextend group. Parsimonious model for predicting MACE showed that other than low volume HES, combined CABG + valve cases, urgency, CKD 5, BMI ≥40, and CHF to be positively associated with MACE. Type of case and end stage CKD were the biggest culprits.

## DISCUSSION

This is the largest retrospective study to look at both AKI and intraoperative blood product administration in cardiac surgical patients receiving HES. The principal finding of this study illustrated no difference in AKI in patients who received colloid vs. those who did not. Patients in HES group also did not receive more red blood cell product administration compared to those in non-HES group.

### Acute Kidney Injury after HES Use

AKI is associated with many complications after CPB such as infections, increased mortality, and length of stay[22]. Longer CPB time is also associated with increased risk of AKI[23]; therefore, it is important to avoid factors that may worsen AKI after CPB. Two observational studies showed a dose dependent decrease in glomerular filtration rate (GFR) in patients receiving HES 450/0.7 and increased AKI in patients receiving HES 200/0.5 respectively[24,25]. The former studied a different HES and defined AKI as GFR assessment three to five days postoperatively which differs from the STS criteria we utilized which records peak Cr throughout the postoperative course. The latter study utilized a 10% solution that is now rarely available in the United States and Europe[26] and also used different AKI criteria. Our AKI results were similar to the meta-analysis study assessing smaller randomized controlled trials (10 out of 19 included studies were cardiac surgery) which did not show a difference in AKI in surgical patients who received HES[1]. Our study was unique in that we attempted to determine whether pre-existing kidney disease worsened as a result of colloid administration and found results to not be significantly different between various CKD stages. Our data overall support no correlation between these synthetic colloids and development of AKI in cardiac surgery.

### Blood product administration after HES use

Colloid group patients did not receive more red blood cells intraoperatively or postoperatively when compared to the non-colloid group; instead, they received less PRBC than the non-colloid group. Previous review article containing smaller studies that covered

20 trials totaling 2,151 patients consisting mainly of cardiac, major abdominal, and orthopedic surgeries did not find increased allogenic erythrocyte transfusion in patients who received HES[2]. All included studies involved tetrastarches. Studies in cardiac surgery have shown decreased clot formation rate and strength in patients who received primarily large molecular weight and molar substitution HES, but the same studies did not look at blood product transfusion[27–29]. In studies that looked at blood product administration, results have been conflicting. There have been reports of decreased blood loss and transfusion of PRBC in patients treated with rapidly degradable HES[30,31]. Increased blood loss and transfusions however, have also been reported in studies that used purely higher molecular weight and molar substitution HES[32,33]. When we divided our data between the higher molecular weight Hextend and the lower molecular weight Voluven, increased PRBC transfusion was not demonstrated with either product.

Our study showed increased transfusion of FFP, cryoprecipitate, and platelets particularly in the high volume HES group. Slowly degradable HES solutions with high molar substitution such as Hextend have been known to cause impaired coagulation via decreasing Factor VIII and vWF concentration. These effects have not been shown in the rapidly degradable HES with low molar substitution and molecular weight such as Voluven[26,34,35]. This slowly degradable HES' effect on coagulation could partially contribute to higher blood loss and increased blood product transfusion. While our study did show an overall increase in these blood products in the higher volume HES group, we were unable to show significantly consistent high transfusion rates once we divided the colloid groups between Hextend and Voluven. Overall, using caution with higher HES volumes may seem reasonable in presence of impaired coagulation.

### Secondary outcomes: mortality, all cause complications, and MACE

There was no difference in the operative mortality in patients who received HES; however, these results are not consistently reproduced in the subgroups of patients divided by Hextend and Voluven. The OR for operative mortality was significantly high in the subgroup of patients who received Hextend <1000mL. The wide confidence interval may be due to outliers.

The increased OR of postoperative complications was significantly higher in both high and low volume colloid groups. Dividing the colloid groups to Voluven and Hextend produced similar significant results. In order to better define complications, MACE was used as a subcategory to enhance relevancy to the cardiac population. Interestingly MACE adjusted OR's were higher in the low volume colloid group and the low volume Voluven group. MACE adjusted OR's were not significantly elevated in the high volume colloid group. A possible explanation for this finding may be that the low volume colloid group received higher amounts of crystalloid administration, which has its own adverse effects such as those related to edema formation[36].

### Limitations

There were several limitations to our study including inability to randomize and blind that naturally co-exist with retrospective studies. This was also a single center study focused on a

very specific patient population in order to lessen the burden of confounding variables that perturb retrospective studies. Although the take home message is that HES is safe, but the clinicians may have selected the patients without CKD when giving HES. However, we have performed propensity weighing to take into consideration variables such as age, gender, race, operation status, surgery type, cross-clamp time, bypass time, CKD stage, presence of other comorbidities, and medications and calculated adjusted ORs. We did not consider baseline anemia which is known risk factor for cardiac surgery-associated AKI[37]. We were also unable to control for the crystalloid and albumin administration. It may be possible that patients receiving lower HES received larger amounts of crystalloids that resulted in different outcomes. In retrospect, it is also important to consider the solution used to deliver the two types of HES that were used in this study. While Hextend is suspended in a balanced salt solution, Voluven is suspended in saline. The difference of chloride in these two products that may have contributed to AKI was not considered. Also other confounding variables may have formed after dividing the patient population by colloid types. For example, Hextend was mainly used from 2007–2009 at our institution, and a transition to Voluven occurred from 2009–2013.

Our AKI criteria also differed from Acute Kidney Injury Network (AKIN) criteria as well as RIFLE (risk, injury, failure, loss of function, ESRD), two popular criteria used to measure AKI[38,39]. STS definition is a more stringent definition adapted and modified from the Failure Stage of the RIFLE criteria. The length of Cr monitoring also differs as AKIN uses a 48-hour window to measure Cr, RIFLE uses a 7-day window[39], while STS criteria utilize the entire postoperative period. Various heterogeneous criteria make it difficult to compare AKI results between studies. We also did not look at long term CKD development or long term mortality.

## CONCLUSIONS

In conclusion, our study found no differences in the development of post-operative AKI as well as administration of PRBC products between the colloid and non-colloid groups. Due to increase in other blood product administration and increase in postoperative complications noted with the colloid group, randomized prospective studies would be need to performed in this population to draw more definite conclusions about HES safety and long term effects.

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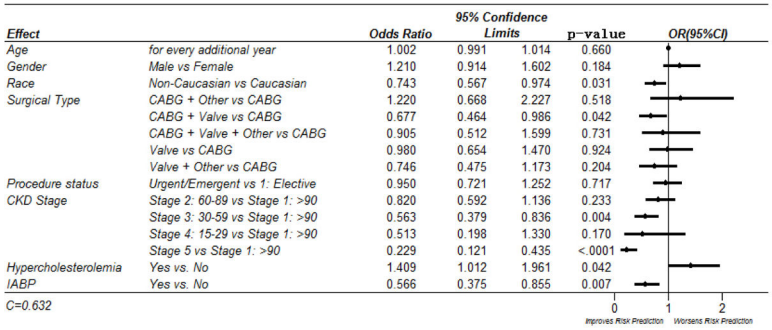


| Effect | | Odds Ratio | 95% Confidence Limits | | p-value | OR(95%CI) |
|---|---|---|---|---|---|---|
| Age | for every additional year | 1.002 | 0.991 | 1.014 | 0.660 | |
| Gender | Male vs Female | 1.210 | 0.914 | 1.602 | 0.184 | |
| Race | Non-Caucasian vs Caucasian | 0.743 | 0.567 | 0.974 | 0.031 | |
| Surgical Type | CABG + Other vs CABG | 1.220 | 0.668 | 2.227 | 0.518 | |
| | CABG + Valve vs CABG | 0.677 | 0.464 | 0.986 | 0.042 | |
| | CABG + Valve + Other vs CABG | 0.905 | 0.512 | 1.599 | 0.731 | |
| | Valve vs CABG | 0.980 | 0.654 | 1.470 | 0.924 | |
| | Valve + Other vs CABG | 0.746 | 0.475 | 1.173 | 0.204 | |
| Procedure status | Urgent/Emergent vs 1: Elective | 0.950 | 0.721 | 1.252 | 0.717 | |
| CKD Stage | Stage 2: 60-89 vs Stage 1: >90 | 0.820 | 0.592 | 1.136 | 0.233 | |
| | Stage 3: 30-59 vs Stage 1: >90 | 0.563 | 0.379 | 0.836 | 0.004 | |
| | Stage 4: 15-29 vs Stage 1: >90 | 0.513 | 0.198 | 1.330 | 0.170 | |
| | Stage 5 vs Stage 1: >90 | 0.229 | 0.121 | 0.435 | <.0001 | |
| Hypercholesterolemia | Yes vs. No | 1.409 | 1.012 | 1.961 | 0.042 | |
| IABP | Yes vs. No | 0.566 | 0.375 | 0.855 | 0.007 | |

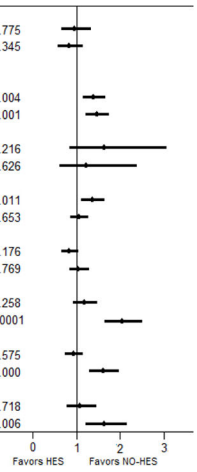
C=0.632



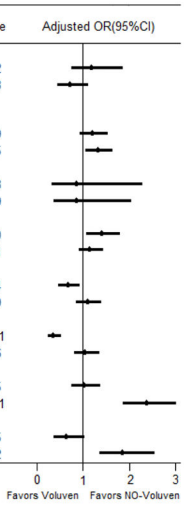
**Figure 1.**

The parsimonious propensity model for colloids. IABP: intra-aortic balloon pump; CKD: chronic kidney disease; CI: confidence interval; OR: odds ratio. The following risk factors were entered in the model development as candidate variables for predicting colloids use: age, gender, race, category of surgeries, emergency status, CKD stages, BMI, hypercholesterolemia, smoking, cerebral vascular accident (CVA), cerebrovascular diseases, cardiogenic shock, circulatory arrest, previous CV interventions, previous CABG, previous valve surgeries, other cardiac interventions, dialysis, last creatinine level, previous myocardial infarction (MI), congestive heart failure (CHF), intra-aortic balloon pump (IABP), ejection fraction (EF), left main coronary artery disease, preoperative lipid lowering medications, cross clamp time and perfusion time. The parsimony was achieved by backward selection at alpha=0.05 except the first 6 variables which were forced into the final parsimonous model.

| | Total HES | Unadjusted Odds Ratio (95% CI) | | | p-value | Adjusted Odds Ratio (95% CI) | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| Popstop AKI | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 0.653 | 0.395 | 1.079 | 0.096 | 0.941 | 0.664 | 1.334 | 0.775 |
| | *2) ≥1000* | 0.569 | 0.345 | 0.939 | 0.027 | 0.816 | 0.574 | 1.162 | 0.345 |
| Postop Overall Complications | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 1.010 | 0.764 | 1.336 | 0.942 | 1.382 | 1.149 | 1.663 | 0.004 |
| | *2) ≥1000* | 1.052 | 0.802 | 1.380 | 0.713 | 1.456 | 1.217 | 1.741 | 0.001 |
| Operative Death | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 1.496 | 0.613 | 3.649 | 0.376 | 1.616 | 0.854 | 3.056 | 0.216 |
| | *2) ≥1000* | 1.206 | 0.488 | 2.982 | 0.685 | 1.219 | 0.625 | 2.377 | 0.626 |
| MACE | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 1.088 | 0.797 | 1.485 | 0.596 | 1.355 | 1.114 | 1.649 | 0.011 |
| | *2) ≥1000* | 0.922 | 0.678 | 1.254 | 0.607 | 1.055 | 0.868 | 1.282 | 0.653 |
| Total RBC ⩾1 | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 0.802 | 0.553 | 1.164 | 0.246 | 0.824 | 0.652 | 1.042 | 0.176 |
| | *2) ≥1000* | 1.094 | 0.776 | 1.544 | 0.608 | 1.039 | 0.838 | 1.289 | 0.769 |
| Total FFP ⩾6 | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 0.792 | 0.572 | 1.096 | 0.160 | 1.172 | 0.931 | 1.475 | 0.258 |
| | *2) ≥1000* | 1.034 | 0.762 | 1.404 | 0.828 | 2.030 | 1.639 | 2.516 | <.0001 |
| Total CRYO ≥2 | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 0.693 | 0.502 | 0.956 | 0.026 | 0.926 | 0.737 | 1.162 | 0.575 |
| | *2) ≥1000* | 1.094 | 0.814 | 1.472 | 0.551 | 1.598 | 1.297 | 1.969 | 0.000 |
| Total Platelets ⩾2 | *0) No HES* | Reference | | | | | | | |
| | *1) <1000* | 0.827 | 0.517 | 1.324 | 0.429 | 1.071 | 0.782 | 1.467 | 0.718 |
| | *2) ≥1000* | 1.115 | 0.724 | 1.716 | 0.623 | 1.615 | 1.213 | 2.149 | 0.006 |




| | Voluven | Unadjusted Odds Ratio (95% CI) | | | p-value | Adjusted Odds Ratio (95% CI) | | | p-value |
|---|---|---|---|---|---|---|---|---|---|
| Popstop AKI | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.724 | 0.394 | 1.331 | 0.299 | 1.181 | 0.746 | 1.872 | 0.552 |
| | *2) ≥1000* | 0.508 | 0.281 | 0.917 | 0.025 | 0.711 | 0.449 | 1.126 | 0.223 |
| Postop Overall Complications | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.803 | 0.570 | 1.131 | 0.209 | 1.198 | 0.936 | 1.535 | 0.229 |
| | *2) ≥1000* | 0.901 | 0.665 | 1.219 | 0.498 | 1.325 | 1.064 | 1.651 | 0.035 |
| Operative Death | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 1.139 | 0.368 | 3.528 | 0.821 | 0.858 | 0.321 | 2.295 | 0.798 |
| | *2) ≥1000* | 1.233 | 0.457 | 3.325 | 0.679 | 0.863 | 0.364 | 2.047 | 0.779 |
| MACE | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 1.033 | 0.733 | 1.456 | 0.853 | 1.401 | 1.085 | 1.810 | 0.030 |
| | *2) ≥1000* | 0.922 | 0.681 | 1.247 | 0.597 | 1.144 | 0.911 | 1.438 | 0.331 |
| Total RBC ⩾1 | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.611 | 0.389 | 0.957 | 0.032 | 0.667 | 0.479 | 0.928 | 0.044 |
| | *2) ≥1000* | 1.034 | 0.739 | 1.447 | 0.845 | 1.096 | 0.852 | 1.411 | 0.549 |
| Total FFP ⩾6 | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.238 | 0.148 | 0.384 | <.0001 | 0.357 | 0.244 | 0.521 | <.0001 |
| | *2) ≥1000* | 0.503 | 0.364 | 0.694 | <.0001 | 1.046 | 0.805 | 1.361 | 0.776 |
| Total CRYO ≥2 | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.773 | 0.534 | 1.120 | 0.174 | 1.025 | 0.756 | 1.389 | 0.895 |
| | *2) ≥1000* | 1.556 | 1.169 | 2.070 | 0.002 | 2.372 | 1.864 | 3.019 | <.0001 |
| Total Platelets ⩾2 | *0) No Voluven* | Reference | | | | | | | |
| | *1) <1000* | 0.448 | 0.234 | 0.857 | 0.015 | 0.622 | 0.374 | 1.035 | 0.125 |
| | *2) ≥1000* | 1.129 | 0.750 | 1.700 | 0.560 | 1.854 | 1.339 | 2.566 | 0.002 |



| | Hextend | Unadjusted Odds Ratio (95% CI) | | | p-value | Adjusted Odds Ratio (95% CI) | | | p-value | Adjusted OR(95%CI) |
|---|---|---|---|---|---|---|---|---|---|---|
| Popstop AKI | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 0.582 | 0.303 | 1.118 | 0.104 | 0.741 | 0.459 | 1.196 | 0.303 | |
| | *2) ≥1000* | 0.686 | 0.350 | 1.347 | 0.274 | 1.007 | 0.610 | 1.664 | 0.981 | |
| Postop Overall Complications | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 1.268 | 0.903 | 1.780 | 0.171 | 1.589 | 1.248 | 2.023 | 0.002 | |
| | *2) ≥1000* | 1.406 | 0.973 | 2.031 | 0.069 | 1.630 | 1.255 | 2.117 | 0.002 | |
| Operative Death | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 1.859 | 0.687 | 5.029 | 0.222 | 3.632 | 1.612 | 8.181 | 0.009 | |
| | *2) ≥1000* | 1.156 | 0.343 | 3.895 | 0.815 | 1.611 | 0.641 | 4.051 | 0.395 | |
| MACE | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 1.145 | 0.820 | 1.598 | 0.426 | 1.213 | 0.948 | 1.551 | 0.197 | |
| | *2) ≥1000* | 0.914 | 0.623 | 1.340 | 0.644 | 0.839 | 0.632 | 1.113 | 0.307 | |
| Total RBC ⩾1 | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 1.064 | 0.719 | 1.574 | 0.757 | 1.010 | 0.761 | 1.341 | 0.955 | |
| | *2) ≥1000* | 1.237 | 0.817 | 1.874 | 0.315 | 0.973 | 0.713 | 1.328 | 0.886 | |
| Total FFP ⩾6 | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 2.071 | 1.488 | 2.881 | <.0001 | 1.977 | 1.522 | 2.568 | <.0001 | |
| | *2) ≥1000* | 2.881 | 2.029 | 4.090 | <.0001 | 3.116 | 2.366 | 4.103 | <.0001 | |
| Total CRYO ≥2 | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 0.712 | 0.499 | 1.017 | 0.062 | 0.762 | 0.572 | 1.016 | 0.121 | |
| | *2) ≥1000* | 0.707 | 0.477 | 1.047 | 0.084 | 0.736 | 0.536 | 1.011 | 0.113 | |
| Total Platelets ⩾2 | *0) No Hextend* | Reference | | | | | | | | |
| | *1) <1000* | 1.299 | 0.816 | 2.070 | 0.270 | 1.315 | 0.925 | 1.869 | 0.201 | |
| | *2) ≥1000* | 1.046 | 0.605 | 1.809 | 0.872 | 1.025 | 0.669 | 1.568 | 0.925 | |


**Figure 2.**

**Part A** Unadjusted vs. propensity weighted and risk adjusted odds ratios of total colloids use on postoperative outcomes. **Part B.** Unadjusted vs. propensity weighted and risk adjusted odds ratios of Voluven use on postoperative outcomes. **Part C.** Unadjusted vs. propensity weighted and risk adjusted odds ratios of Hextend Use on postoperative outcomes. The following risk factors were entered in the model development as candidate variables for predicting postop outcomes with inverse propensity weighting of intraoperative colloids use: Total hydroxyethyl starch (HES)/Voluvan/Hextend, age, gender, race, category of surgeries, emergency status, CKD stage, crystalloids, BMI, smoking, CVA, cerebrovascular disease, cardiogenic shock, circulatory arrest, previous CV intervention, previous CABG, previous valve surgeries, other cardiac intervention, dialysis, last creatinine level, previous MI, CHF, IABP, EF, left main coronary artery disease. The parsimony was achieved by a backward selection at alpha=0.05 except first 8 variables which were forced in the final parsimonous model. AKI; acute kidney injury; MACE: major adverse cardio-cerebral events; RBC: red blood cell; FFP: fresh frozen plasma; CRYO: cryoprecipitate.

**Table 1**

Baseline Patient Characteristics

| Variables | | Total, N (%) | No Colloids Use | Colloids Used, N (%) | P value |
|---|---|---|---|---|---|
| | | N=1,265 (100.0%) | N=378 (29.9%) | N=887 (70.1%) | |
| Age, years. Mean (SD) | | | 61.7 (13.4)* | 62.3 (12.3)* | 0.404 |
| Gender | Female | 376 (29.7) | 127 (33.6) | 249 (28.1) | 0.049 |
| | Male | 889 (70.3) | 251 (66.4) | 638 (71.9) | |
| Race | White | 830 (65.6) | 223 (59) | 607 (68.4) | 0.001 |
| | Other | 435 (34.4) | 155 (41) | 280 (31.6) | |
| Operation status | Elective | 587 (46.4) | 168 (44.4) | 419 (47.2) | 0.571 |
| | Urgent | 678 (53.6) | 210 (55.6) | 468 (52.8) | |
| Surgery type | CABG only | 591 (46.7) | 161 (42.6) | 430 (48.5) | 0.138 |
| | CABG + Other | 68 (5.4) | 17 (4.5) | 51 (5.7) | |
| | CABG + Valve | 175 (13.8) | 63 (16.7) | 112 (12.6) | |
| | CABG + Valve + Other | 69 (5.5) | 21 (5.6) | 48 (5.4) | |
| | Valve | 220 (17.4) | 65 (17.2) | 155 (17.5) | |
| | Valve + Other | 142 (11.2) | 51 (13.5) | 91 (10.3) | |
| CKD stage | 1: <90 | 315 (24.9) | 80 (21.2) | 235 (26.5) | <.0001 |
| | 2: 60–89 | 642 (50.8) | 176 (46.6) | 466 (52.5) | |
| | 3: 30–59 | 236 (18.7) | 83 (22) | 153 (17.2) | |
| | 4: 15–29 | 20 (1.6) | 8 (2.1) | 12 (1.4) | |
| | 5: < 15 or Dialysis | 52 (4.1) | 31 (8.2) | 21 (2.4) | |
| BMI | <18.5 | 11 (0.9) | 7 (1.9) | 4 (0.5) | 0.048 |
| | 18.5–39.9 | 1165 (92.1) | 344 (91) | 821 (92.6) | |
| | >=40 | 89 (7) | 27 (7.1) | 62 (7.0) | |
| Diabetes | No | 797 (63) | 241 (63.8) | 556 (62.7) | 0.717 |
| | Yes | 468 (37) | 137 (36.2) | 331 (37.3) | |

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| Variables | | Total, N (%) | No Colloids Use | Colloids Used, N (%) | P value |
|---|---|---|---|---|---|
| | | N=1,265 (100.0%) | N=378 (29.9%) | N=887 (70.1%) | |
| Hypertension | No | 318 (25.1) | 101 (26.7) | 217 (24.5) | 0.397 |
| | Yes | 947 (74.9) | 277 (73.3) | 670 (75.5) | |
| Hypercholesteroemia | No | 310 (24.5) | 109 (28.8) | 201 (22.7) | 0.019 |
| | Yes | 955 (75.5) | 269 (71.2) | 686 (77.3) | |
| Smoking | No | 687 (54.3) | 195 (51.6) | 492 (55.5) | 0.205 |
| | Yes | 578 (45.7) | 183 (48.4) | 395 (44.5) | |
| CVA | No | 1154 (91.2) | 345 (91.3) | 809 (91.2) | 0.971 |
| | Yes | 111 (8.8) | 33 (8.7) | 78 (8.8) | |
| Cardiogenic shock | No | 1253 (99.1) | 375 (99.2) | 878 (99) | 0.711 |
| | Yes | 12 (0.9) | 3 (0.8) | 9 (1.0) | |
| Previous MI | No | 818 (64.7) | 246 (65.1) | 572 (64.5) | 0.840 |
| | Yes | 447 (35.3) | 132 (34.9) | 315 (35.5) | |
| CHF | No | 755 (59.7) | 201 (53.2) | 554 (62.5) | 0.002 |
| | Yes | 510 (40.3) | 177 (46.8) | 333 (37.5) | |
| IABP | No | 1146 (90.6) | 330 (87.3) | 816 (92.0) | 0.009 |
| | Yes | 119 (9.4) | 48 (12.7) | 71 (8.0) | |
| Cerebrovascular disease | No | 1047 (82.8) | 311 (82.3) | 736 (83.0) | 0.762 |
| | Yes | 218 (17.2) | 67 (17.7) | 151 (17.0) | |
| Previous CV intervention | No | 971 (76.8) | 282 (74.6) | 689 (77.7) | 0.236 |
| | Yes | 294 (23.2) | 96 (25.4) | 198 (22.3) | |
| Previous CABG | No | 1217 (96.2) | 362 (95.8) | 855 (96.4) | 0.594 |
| | Yes | 48 (3.8) | 16 (4.2) | 32 (3.6) | |
| Previous Valve Surgery | No | 1209 (95.6) | 358 (94.7) | 851 (95.9) | 0.329 |
| | Yes | 56 (4.4) | 20 (5.3) | 36 (4.1) | |

| Variables | | Total, N (%) | No Colloids Use | Colloids Used, N (%) | P value |
|---|---|---|---|---|---|
| | | N=1,265 (100.0%) | N=378 (29.9%) | N=887 (70.1%) | |
| Other Cardiac Intervention | No | 1234 (97.5) | 366 (96.8) | 868 (97.9) | 0.277 |
| | Yes | 31 (2.5) | 12 (3.2) | 19 (2.1) | |
| Dialysis | No | 1218 (96.3) | 349 (92.3) | 869 (98) | <.0001 |
| | Yes | 47 (3.7) | 29 (7.7) | 18 (2) | |
| Left Main Coronary Artery Disease | No | 990 (78.3) | 302 (79.9) | 688 (77.6) | 0.358 |
| | Yes | 275 (21.7) | 76 (20.1) | 199 (22.4) | |
| Preoperative β Blocker | No | 432 (34.2) | 118 (31.2) | 314 (35.4) | 0.151 |
| | Yes | 833 (65.8) | 260 (68.8) | 573 (64.6) | |
| Preoperative ACEi/ARBi | No | 668 (52.8) | 187 (49.5) | 481 (54.2) | 0.121 |
| | Yes | 597 (47.2) | 191 (50.5) | 406 (45.8) | |
| Preoperative Nitrates | No | 1218 (96.3) | 363 (96) | 855 (96.4) | 0.756 |
| | Yes | 47 (3.7) | 15 (4) | 32 (3.6) | |
| Preoperative Anticoagulants | No | 1000 (79.1) | 301 (79.6) | 699 (78.8) | 0.742 |
| | Yes | 265 (20.9) | 77 (20.4) | 188 (21.2) | |
| Preoperative Coumadin Use | No | 1165 (92.1) | 343 (90.7) | 822 (92.7) | 0.244 |
| | Yes | 100 (7.9) | 35 (9.3) | 65 (7.3) | |
| Preoperative Steroids | No | 1226 (96.9) | 364 (96.3) | 862 (97.2) | 0.404 |
| | Yes | 39 (3.1) | 14 (3.7) | 25 (2.8) | |
| Preoperative Aspirin | No | 350 (27.7) | 111 (29.4) | 239 (26.9) | 0.378 |
| | Yes | 915 (72.3) | 267 (70.6) | 648 (73.1) | |
| Preoperative lipid lowering Medications | No | 321 (25.4) | 111 (29.4) | 210 (23.7) | 0.033 |
| | Yes | 944 (74.6) | 267 (70.6) | 677 (76.3) | |
| Preoperative GPIIbIIIa Inhibitor | No | 1221 (96.5) | 368 (97.4) | 853 (96.2) | 0.291 |
| | Yes | 44 (3.5) | 10 (2.6) | 34 (3.8) | |

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| Variables | Total, N (%) | No Colloids Use | Colloids Used, N (%) | P value |
|---|---|---|---|---|
| | N=1,265 (100.0%) | N=378 (29.9%) | N=887 (70.1%) | |
| Last creatinine level(mg/dl) | | 1.53 (1.66) * | 1.14 (0.80) * | <0.0001 |
| EF (%) | | 50.8 (13.8) * | 52.6 (13.1) * | 0.029 |
| Cross Clamp Time | | 133.2 (57.2) | 126.7 (55.7) | 0.059 |
| Perfusion Time | | 189.5 (76.9) | 178.7 (69.3) | 0.019 |
| Propensity Score | | 0.666 (0.117) * | 0.714 (0.091) * | <0.0001 |

Note: CKD: chronic kidney diseases; BMI: body mass index; CVA: cerebral vascular accident; MI: myocardial infarction; CHF: congestive heart failure; IABP: intra-aortic balloon pump; CV: cardiovascular; CABG: coronary artery bypass graft; EF: ejection fraction.

* statistical significant. SD: standard deviation.

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**Table 2**

omes of Colloids vs. No Colloids

| | N (%) | AKI | | Complications Any | | Operative Death | | MACE | | Total RBC ≥1 | | Total FFP ≥6 | | Total CRYO ≥2 | | Total Platelets ≥2 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N (%) | p-value | N (%) | p-value | N (%) | p-value | N (%) | p-value | N (%) | p-value | N (%) | p-value | N (%) | p-value | N (%) | p-value |
| No | 378 (29.9) | 39 (10.3) | 0.021 * | 173 (45.8) | 0.795 | 8 (2.1) | 0.473 | 102 (26.98) | 0.989 | 70 (18.52) | 0.765 | 100 (26.46) | 0.536 | 109 (28.84) | 0.415 | 40 (10.58) | 0.911 |
| Yes | 887 (70.1) | 58 (6.5) | | 413 (46.6) | | 25 (2.8) | | 239 (26.94) | | 158 (17.81) | | 220 (24.80) | | 236 (26.61) | | 92 (10.37) | |
| 0) No HES | 378 (29.9) | 39 (10.3) | 0.062 | 173 (45.8) | 0.924 | 8 (2.1) | 0.665 | 102 (26.98) | 0.553 | 70 (18.52) | 0.212 | 100 (26.46) | 0.197 | 109 (28.84) | 0.010 * | 40 (10.58) | 0.410 |
| 1) < 1000 | 417 (32.8) | 29 (6.99) | | 191 (46.02) | | 13 (3.13) | | 119 (28.67) | | 64 (15.42) | | 92 (22.17) | | 91 (21.93) | | 37 (8.92) | |
| 2) ≥1000 | 472 (37.3) | 29 (6.14) | | 222 (47.03) | | 12 (2.54) | | 120 (25.42) | | 94 (19.92) | | 128 (27.12) | | 145 (30.72) | | 55 (11.65) | |
| 0) No Voluven | 378 (42.3) | 39 (10.3) | 0.070 | 173 (45.8) | 0.445 | 8 (2.1) | 0.916 | 102 (26.98) | 0.845 | 70 (18.52) | 0.095 | 100 (26.46) | <.0001 * | 109 (28.84) | 0.003 * | 40 (10.58) | 0.028 * |
| 1) < 1000 | 208 (23.3) | 16 (7.69) | | 84 (40.38) | | 5 (2.40) | | 58 (27.88) | | 26 (12.50) | | 21 (10.10) | | 44 (21.15) | | 11 (5.29) | |
| 2) ≥1000 | 308 (34.5) | 17 (5.52) | | 133 (43.18) | | 8 (2.60) | | 79 (25.65) | | 60 (19.48) | | 59 (19.16) | | 108 (35.06) | | 38 (12.34) | |
| 0) No Hextend | 378 (50.47) | 39 (10.32) | 0.202 | 173 (45.8) | 0.137 | 8 (2.1) | 0.446 | 102 (26.98) | 0.623 | 70 (18.52) | 0.806 | 100 (26.46) | 0.001 * | 109 (28.84) | 0.153 | 40 (10.58) | 0.726 |
| 1) < 1000 | 207 (27.64) | 13 (6.28) | | 107 (51.69) | | 8 (3.86) | | 61 (29.47) | | 38 (18.36) | | 71 (34.30) | | 47 (22.71) | | 26 (12.56) | |
| 2) ≥1000 | 164 (21.90) | 12 (7.32) | | 89 (54.27) | | 4 (2.44) | | 41 (25.00) | | 34 (20.73) | | 69 (42.07) | | 37 (22.56) | | 17 (10.37) | |

dney injury; MACE: major adverse cardiocerebral events; RBC: red blood cell; FFP: fresh frozen plasma; CRYO: cryoprecipitate; HES: hydroxyethyl starches;

sidered statistical significant.

**Table 3**

Colloids Effects on AKI for CKD Stage 1–4

| | | N (%) | Observed AKI | |
|---|---|---|---|---|
| **CKD Stage 1–4 Combined:** | | | **N (%)** | **p-value** |
| Intraoperative Colloids | No | 346 (28.6) | 25 (7.5) | 0.481 |
| | Yes | 865 (71.4) | 53 (6.1) | |
| Intraoperative Colloids | 0) No HES | 346 (28.6) | 26 (7.5) | 0.656 |
| | 1) <1000 | 406 (33.5) | 27 (7.0) | |
| | 2) ≥1000 | 459 (37.5) | 26 (6.7) | |
| Voluven | No Voluven | 346 (40.7) | 25 (7.2) | 0.477 |
| | 1) <1000 | 204 (24.0) | 14 (6.9) | |
| | 2) ≥1000 | 301 (35.4) | 15 (5.0) | |
| Hextend | No Hextend | 346 (49.0) | 25 (7.2) | 0.940 |
| | 1) <1000 | 202 (28.6) | 13 (6.4) | |
| | 2) ≥1000 | 158 (22.4) | 11 (7.0)) | |
| CKD Stage 1: >90 | | | | |
| Intraoperative Colloids | No | 62 (25.2) | 2 (3.3) | 0.642 |
| | Yes | 184 (74.8) | 4 (2.2) | |
| Intraoperative Colloids | 0) No HES | 62 (25.2) | 2 (3.3) | 0.716 |
| | 1) <1000 | 78 (31.7) | 1 (1.3) | |
| | 2) ≥1000 | 106 (43.1) | 3 (2.8) | |
| Voluven | No Voluven | 62 (34.6) | 2 (3.2) | 0.922 |
| | 1) <1000 | 40 (22.4) | 1 (2.5) | |
| | 2) ≥1000 | 77 (43.0) | 3 (3.9) | |
| Hextend | No Hextend | 62 (48.1) | 2 (3.2) | 0.334 |
| | 1) <1000 | 38 (29.5) | 0 | |
| | 2) ≥1000 | 29 (22.5) | 0 | |
| CKD Stage 2: 60–89 | | | | |
| Intraoperative Colloids | No | 165 (26.2) | 9 (5.5) | 0.197 |
| | Yes | 466 (73.8) | 15 (3.2) | |
| Intraoperative Colloids | 0) No HES | 165 (26.2) | 9 (5.5) | 0.269 |
| | 1) <1000 | 218 (34.6) | 5 (2.3) | |
| | 2) ≥1000 | 248 (39.3) | 10 (4.0) | |
| Voluven | No Voluven | 165 (37.8) | 9 (5.5) | 0.186 |
| | 1) <1000 | 111 (25.4) | 2 (1.8) | |
| | 2) ≥1000 | 161 (36.8) | 4 (2.5) | |
| Hextend | No Hextend | 165 (45.9) | 9 (5.5) | 0.404 |
| | 1) <1000 | 107 (29.8) | 3 (2.8) | |
| | 2) ≥1000 | 87 (24.2) | 6 (6.9) | |
| CKD Stage 3: 30–59 | | | | |

| | | N (%) | Observed AKI | |
|---|---|---|---|---|
| **CKD Stage 1–4 Combined:** | | | **N (%)** | **p-value** |
| Intraoperative Colloids | No | 106 (34.7) | 11 (10.4) | 0.209 |
| | Yes | 199 (65.3) | 31 (15.6) | |
| Intraoperative Colloids | 0) No HES | 106 (34.7) | 11 (10.4) | 0.259 |
| | 1) <1000 | 99 (32.5) | 18 (18.2) | |
| | 2) ≥1000 | 100 (32.8) | 13 (13.0) | |
| Voluven | No Voluven | 106 (50.0) | 11 (10.4) | 0.485 |
| | 1) <1000 | 46 (21.7) | 8 (17.4) | |
| | 2) ≥1000 | 60 (28.3) | 8 (13.3) | |
| Hextend | No Hextend | 106 (53.3) | 11 (10.4) | 0.324 |
| | 1) <1000 | 53 (26.6) | 10 (18.9) | |
| | 2) ≥1000 | 40 (20.1) | 5 (12.5) | |
| CKD Stage 4: 15–29 | | | | |
| Intraoperative Colloids | No | 13 (44.8) | 3 (23.1) | 0.775 |
| | Yes | 16 (55.2) | 3 (18.7) | |
| Intraoperative Colloids | 0) No HES | 13 (44.8) | 3 (23.1) | 0.440 |
| | 1) <1000 | 11 (37.9) | 3 (27.3) | |
| | 2) ≥1000 | 5 (17.2) | 0 | |
| Voluven | No Voluven | 13 (56.5) | 3 (23.1) | 0.343 |
| | 1) <1000 | 7 (30.4) | 3 (42.9) | |
| | 2) ≥1000 | 3 (13.0) | 0 | |
| Hextend | No Hextend | 13 (68.4) | 3 (23.1) | 0.44 |
| | 1) <1000 | 4 (21.1) | 0 | |
| | 2) ≥1000 | 2 (10.5) | 0 | |

Note: CKD: chronic kidney diseases; HES: hydroxyethyl starches; p value: <0.05 considered statistically significant. Total patients in this table do not add up to the total of 1265 included in the study due to CKD 5 patients being omitted.