Increased risk of acute kidney injury with percutaneous mechanical thrombectomy using AngioJet compared with catheter-directed thrombolysis

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ABSTRACT

Objective: The objective of this study was to investigate the risk of postoperative acute kidney injury (AKI) in patients with acute iliofemoral deep venous thrombosis (IFDVT) who underwent percutaneous pharmacomechanical thrombectomy (PMT) using AngioJet (Boston Scientific, Marlborough, Mass) or catheter-directed thrombolysis.

Methods: Electronic medical records of patients with acute IFDVT from January 2014 to September 2017 were reviewed. Those who received PMT with AngioJet (AJ-PMT group) or catheter-directed thrombolysis (CDT group) were included in this study. Baseline characteristics were recorded and compared. Postoperative serum creatinine concentration was compared with baseline serum creatinine concentration to determine the occurrence of postoperative AKI. Hemolysis was diagnosed on the basis of the decrease of hematocrit (HCT) and the occurrence of hematuria. The incidence of postoperative AKI in the two groups was analyzed. Univariable analysis and logistic regression analysis were used to determine risk factors that contribute to postoperative AKI.

Results: A total 198 patients with acute IFDVT were included (79 in the AJ-PMT group, 119 in the CDT group). Baseline data of the two groups were of no statistical difference. The AJ-PMT group suffered more from acute hemolysis ($P = .018$). Compared with baseline HCT, the absolute HCT reduction of each group was of statistical significance ($P < .01$). The percentage change of absolute HCT of the two groups was of statistical significance ($P < .01$). Univariate analysis and multivariate analysis demonstrated that percutaneous AJ-PMT (odds ratio [OR], 2.82; 95% confidence interval [CI], 1.16-6.82; $P = .02$), history of major surgery within 3 months of endovascular intervention (OR, 8.51; 95% CI, 2.90-24.94; $P < .01$), and HCT drop >14% (OR, 2.73; 95% CI, 1.08-6.87; $P = .03$) are independent risk factors that raise the odds of postoperative AKI.

Conclusions: In patients with acute IFDVT, AJ-PMT will raise the risk of postoperative AKI compared with CDT, especially in patients with a history of major surgery within 3 months of endovascular intervention. AJ-PMT causes more hemolysis and hematuria. An HCT drop >14% may indicate upcoming AKI. (J Vasc Surg: Venous and Lym Dis 2019;7:29-37.)

Keywords: Acute kidney injury; Percutaneous mechanical thrombectomy; AngioJet; Catheter-directed thrombolysis

Post-thrombotic syndrome, the most common and burdensome complication of acute iliofemoral deep venous thrombosis (IFDVT), has been estimated to affect 23% to 60% of patients who have received only conservative therapy.[1] Hence, some clinical guidelines have recommended percutaneous pharmacomechanical thrombectomy (PMT) or catheter-directed thrombolysis (CDT) as first-line therapy to reduce the burden of post-thrombotic syndrome for the advantage in early thrombus removal.[2,3] Compared with CDT, percutaneous PMT using AngioJet (AJ-PMT) is a relatively more efficient choice for early thrombus removal.[4-6]

AngioJet Rheolytic Thrombectomy System (Boston Scientific, Marlborough, Mass) is a PMT device that incorporates mechanical fragmentation, pharmacologic lysis, and rheolytic aspiration of clots.[7] AngioJet will cause not only clot dissipation, with its high-pressure jet spray, but also some destruction of blood cells. As a result, most practitioners regarded hematuria as a corollary and "self-limited" side effect in patients treated with AngioJet.[8] Hence, the large multicenter randomized Acute Venous Thrombosis: Thrombus Removal with Adjunctive Catheter-Directed Thrombolysis (ATTRACT) trial does not seem to include renal function in its data collection.[9] Even the recent Peripheral Use of AngioJet Rheolytic Thrombectomy with a Variety of Catheter Lengths (PEARL) registry gave only a casual glimpse to

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the renal function change after AJ-PMT.[4] Actually, acute hemolysis definitely can cause renal failure in other diseases, such as paroxysmal nocturnal hemoglobinuria and valvular heart diseases.[10,11] With little attention give to the fact that AJ-PMT may increase the odds of postoperative acute kidney injury (AKI), the incidence of postoperative AKI of AJ-PMT may be under-reported. On the other hand, studies have confirmed that postoperative AKI has a strong negative effect on many other diseases.[12-14] These findings imply that AKI after AJ-PMT really counts.

To our knowledge, there are only a few retrospective studies investigating postoperative AKI in patients who have received PMT.[15,16] Those retrospective studies are heterogeneous, consisting of patients with venous or arterial thrombosis, whereas the patients of our study are much more homogeneous. We sought to determine whether patients with acute IFDVT undergoing AJ-PMT were at increased risk of postoperative AKI compared with CDT and to identify other contributory variables.

ARTICLE HIGHLIGHTS

- **Type of Research:** Single-center retrospective cohort study
- **Take Home Message:** In 198 patients with acute iliofemoral deep venous thrombosis who underwent thrombolytic therapy with AngioJet pharmacomechanical thrombectomy (AJ-PMT) or catheter-directed thrombolysis, the risk factors predicting acute kidney injury included AJ-PMT (odds ratio [OR], 2.82; 95% confidence interval [CI], 1.16-6.82; $P = .02$), history of major surgery within 3 months (OR, 8.51; 95% CI, 2.90-24.94; $P < .01$), and hematocrit drop >14% (OR, 2.73; 95% CI, 1.08-6.87; $P = .03$).
- **Recommendation:** Data suggest that catheter-directed thrombolysis is preferred to AJ-PMT for treatment of acute iliofemoral deep venous thrombosis in patients who are within 3 months of major surgery to lessen the risk of acute kidney injury.

METHODS

Study design and selection of patients. This study is a retrospective study. Study protocol and waiver of informed consent were approved by the Institutional Review Board of our hospital. Medical records of patients with acute IFDVT who had been admitted to our department from January 2014 to September 2017 were reviewed. Those who received CDT or AJ-PMT and had complete baseline data and postoperative surveillance data were included in this study.

Clinical assessments of patients with acute IFDVT. For baseline assessments, patients with acute IFDVT admitted to our ward would usually have workup including routine blood tests, blood biochemistry, blood gas array, blood coagulation indexes, thyroid function, routine urine and stool analysis, tumor biomarkers, electrocardiography, ultrasound examinations for cardiac function and lower limbs, and chest radiography at admission. CDT and AJ-PMT would be recommended as alternatives to patients with no contraindication to CDT and AJ-PMT. The contraindications were as follows: <14 years of age or >90 years of age; pregnancy; contraindication to iodinated contrast media; malignant disease with <1 year of estimated survival; renal dysfunction, defined as serum creatinine (sCr) concentration >84.0 μmol/L (0.95 mg/dL) in women or >104 μmol/L (1.18 mg/dL) in men; hemodynamically unstable; refractory hypertension; allergic to urokinase; bacterial endocarditis; hyperthyroidism; and aneurysm or aortic dissection. For those who have chosen to receive CDT or AJ-PMT therapy, postoperative renal function and routine blood test results were monitored at least once a day for 3 days consecutively for postoperative AKI. A patient's highest value of sCr within 48 hours after intervention was chosen for comparison with the baseline value to determine the occurrence of AKI. Once postoperative AKI occurred, postoperative renal function was monitored until the blood sCr level began to drop.

Renal protective measures and endovascular procedures. For patients who have chosen to receive CDT or AJ-PMT, renal protective measures during the perioperative period were as follows: normal saline was given to every patient intravenously at 1.5 mL/kg/h from 6 hours before the procedure to 24 hours after the procedure; 2.5 mmol/kg sodium bicarbonate was also given to every patient intravenously after the procedure; and hemodialysis was adopted when necessary. Endovascular treatment was mainly according to the surgeon's discretion and not protocol. A maximum 500 mL of suction fluid was used in patients receiving AJ-PMT. Except for contrast medium, we have not added other nephrotoxic drugs during the hospitalization.

Data collection. Clinical data of included patients were reviewed from the hospital's electronic medical record system. Demographic variables and baseline laboratory values included age, sex, hypertension, diabetes mellitus, cardiovascular disease, brain vessel disease, peripheral atherosclerotic disease, psychotropic medication, hormone therapy, history of major surgery within 3 months of endovascular intervention (3M-MS), history of venous thromboembolism, anatomic locations of acute IFDVT (left, right, or both sides), liver function, renal function (represented by sCr concentration), hematocrit (HCT), and chronic obstructive pulmonary disease. Postoperative sCr concentration and HCT of every patient were collected.

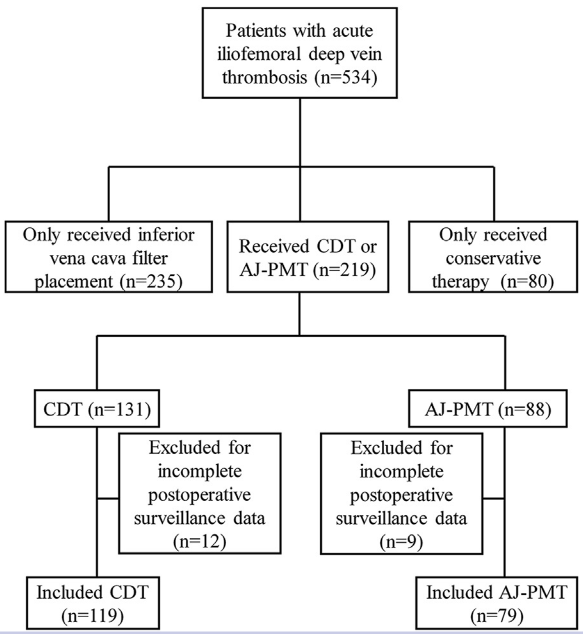


Fig 1. Flow chart of study design. *AJ-PMT,* AngioJet pharmacomechanical thrombectomy; *CDT,* catheter-directed thrombolysis.

The baseline value of each index was defined as the value at admission. The worst laboratory values within 48 hours after intervention were chosen for subsequent analysis (eg, the highest sCr level and lowest HCT). Patients with incomplete preoperative or postoperative laboratory test results were excluded. Total contrast material volume, total urokinase dosage, and total AJ-PMT aspiration volume of every patient were also reviewed.

End point. The end point of this study was postoperative AKI. AKI was determined by assessing changes in sCr concentration. We chose to report a rise in sCr concentration as the indication of AKI, rather than glomerular filtration rate (GFR) reduction, for two reasons: no direct measurement of GFR had been conducted; and in GFR calculation, the only variable that would change within 48 hours would be the sCr concentration. According to the criteria for detecting postoperative AKI, AKI was defined as an absolute increase in sCr concentration of ≥26.4 μmol/L (0.3 mg/dL) or increase ≥50% from baseline within 48 hours after operation.[17-19] Whether AKI occurred within 48 hours or not, another blood test for sCr concentration would be conducted between 48 and 72 hours after operation to confirm our judgment. Hematuria was judged by visual inspection and urine occult blood test result.

Data analysis. Data were compared between CDT and AJ-PMT groups, between AKI and no-AKI groups, and between those who had a history of 3M-MS (3M-MS group) and those who did not (no-3M-MS group). Absolute and percentage change of sCr concentration and HCT of each patient were calculated by comparing the worst laboratory values within 48 hours after the procedure with baseline values that were acquired at admission. Statistical analysis was performed using GraphPad Prism 6 software (GraphPad Software Inc, La Jolla, Calif) and SPSS 20.0 software for Windows (IBM Corp, Armonk, NY). Variables with normal distribution were presented as mean ± standard deviation. Variables with non-normal distribution were presented as median (25%-75%). Fisher exact test or χ^2 test was used for comparing categorical data. Mann-Whitney *U* test and two-tailed *t*-test were used for comparing continuous data. Univariate analysis and logistic regression were used to evaluate the relationship between AJ-PMT and AKI.

Table. Clinic data of the studied population grouped by catheter-directed thrombolysis (*CDT*) and AngioJet pharmacomechanical thrombectomy (*AJ-PMT*)

Variables	CDT (n = 119), No. (%)	AJ-PMT (n = 79), No. (%)	*P* value
Male	57 (47.9)	35 (44.3)	NS
Age, years	64 (55-72)	64 (55-72)	NS
Diabetes mellitus	10 (8.4)	7 (8.9)	NS
Hypertension	34 (28.6)	26 (32.9)	NS
Cardiovascular disease	8 (6.7)	5 (6.3)	NS
Brain vessel disease	6 (5)	5 (6.3)	NS
Peripheral atherosclerotic disease	22 (18.5)	12 (15.2)	NS
Psychotropic medication	2 (1.7)	6 (7.6)	NS
Hormone therapy	5 (4.2)	0 (0)	NS
3M-MS	12 (10.1)	8 (10.1)	NS
History of VTE	11 (9.2)	5 (6.3)	NS
Anatomic location of acute IFDVT			NS
Left	99 (83.2)	64 (81)	
Right	11 (9.2)	13 (16.5)	
Left and right	9 (7.6)	2 (2.5)	
Liver dysfunction			
ALT abnormality	11 (9.2)	3 (3.8)	NS
AST abnormality	5 (4.2)	5 (6.3)	NS
Albumin abnormality	20 (16.8)	10 (12.7)	NS
Total protein abnormality	43 (36.1)	38 (48.1)	NS
COPD	2 (1.7)	1 (1.3)	NS
Baseline HCT	0.376 ± 0.050	0.377 ± 0.046	NS

ALT, Alanine transaminase; *AST,* aspartate transaminase; *COPD,* chronic obstructive pulmonary disease; *HCT,* hematocrit; *IFDVT,* iliofemoral deep venous thrombosis; *3M-MS,* major surgery within 3 months of endovascular intervention; *NS,* not significant; *VTE,* venous thromboembolism.

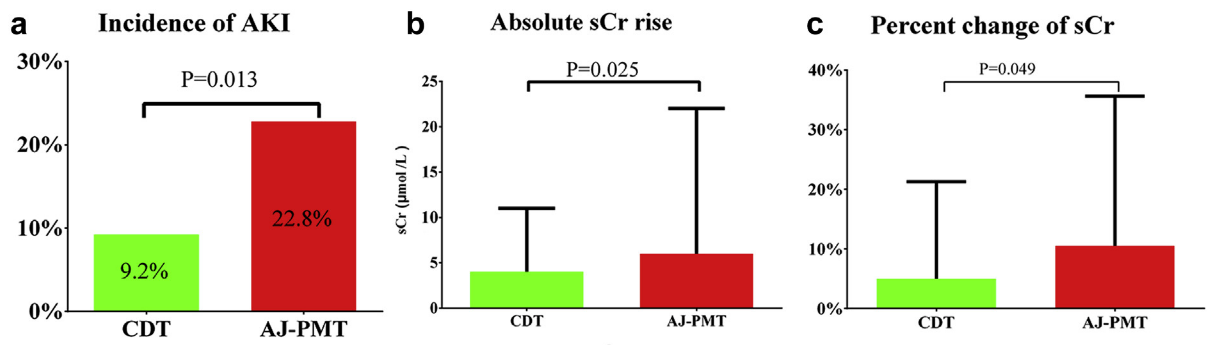


Fig 2. Acute kidney injury (*AKI*) incidence and change of serum creatinine (*sCr*) concentration in catheter-directed thrombolysis (*CDT*) and AngioJet pharmacomechanical thrombectomy (*AJ-PMT*) groups. **a,** Incidence of AKI in CDT and AJ-PMT groups compared by Fisher exact test. **b,** Absolute rise in sCr concentration in CDT and AJ-PMT groups compared by Mann-Whitney test: 4 μmol/L (−6 to 11 μmol/L) vs 6 μmol/L (−3 to 22 μmol/L). **c,** Percentage change of sCr concentration in CDT and AJ-PMT groups compared by Mann-Whitney test: 4.97% (−9.72% to 21.28%) vs 10.53% (−4.65% to 35.62%). The *colored columns* represent the median; *error bar* represents 75th percentile.

$P < .05$ was considered significant. Confidence intervals (CIs) were considered at 95%. A Bonferroni correction was calculated for every variable that was assessed.

RESULTS

There were 534 patients with acute IFDVT who were treated consecutively in our department from January 2014 to September 2017. Only 198 patients were finally included in this study (119 received CDT, 79 received AJ-PMT; Fig 1). Total contrast material volume, total urokinase dosage, and total AJ-PMT aspiration volume were not available in the majority of medical records. Demographic and baseline data are shown in the Table. There is no statistically significant difference of the baseline data between the AJ-PMT group and the CDT group, such as age, sex, and HCT. Postoperative gross hematuria occurred in all patients of the PMT group. No patient in the CDT group presented with postoperative gross hematuria.

AJ-PMT raises incidence of postoperative AKI. AKI developed in 18 of 79 patients in the AJ-PMT group and in 11 of 119 patients in the CDT group. The incidence of AKI in the AJ-PMT group was higher than that in the CDT group (22.8% vs 9.2%; $P = .013$; Fig 2, *a*). The postoperative sCr and baseline sCr concentrations in non-AKI patients were of no statistical difference. The median of absolute change of sCr concentration in the AJ-PMT group was higher than that in the CDT group (6 μmol/L vs 4 μmol/L [0.069 mg/dL vs 0.045 mg/dL]; $P = .025$; Fig 2, *b*), as was the median of percentage change of sCr concentration (10.53% vs 4.97%; $P = .049$; Fig 2, *c*). Two patients with AKI from the AJ-PMT group required short-term dialysis before discharge.

History of 3M-MS increases odds of postoperative AKI. In total, 20 patients had a history of 3M-MS. The median time from major surgery to treatment for IFDVT was 1.25 months. Compared with the no-3M-MS group,

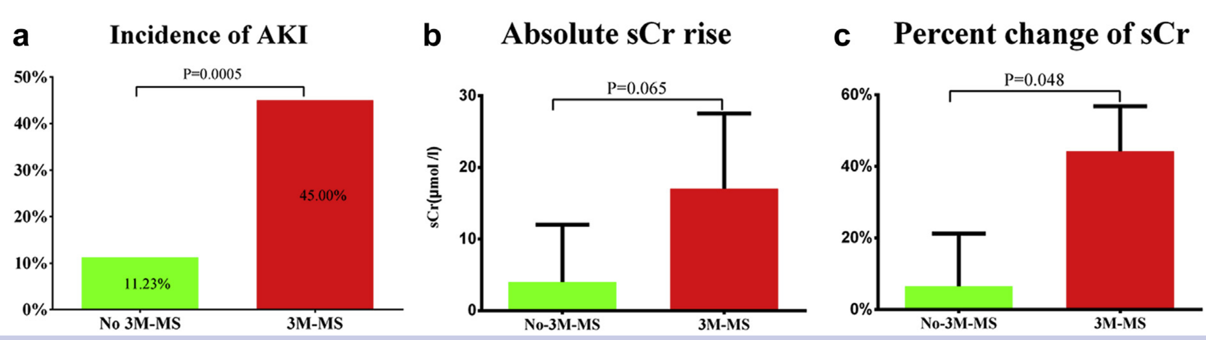


Fig 3. Acute kidney injury (*AKI*) incidence and change of serum creatinine (*sCr*) concentration in patients who had major surgery within 3 months before endovascular intervention (*3M-MS*) and those who did not (*no-3M-MS*). **a,** Incidence of AKI in no-3M-MS and 3M-MS groups compared by Fisher exact test. **b,** Absolute rise in sCr concentration in no-3M-MS and 3M-MS groups compared by Mann-Whitney test: 4 μmol/L (−4.25 to 12.05 μmol/L) vs 17.03 μmol/L (−4.71 to 21.5 μmol/L). **c,** Percentage change of sCr concentration in no-3M-MS and 3M-MS groups compared by Mann-Whitney test: 6.51% (−6.21% to 21.23%) vs 44.23% (−7.21% to 56.77%). The *colored columns* represent the median; *error bar* represents 75th percentile.

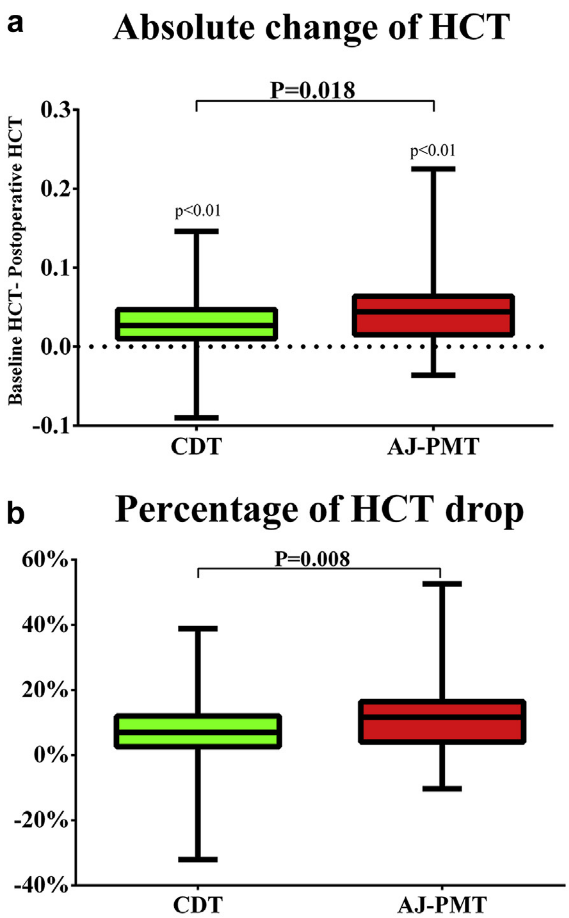


Fig 4. Change of hematocrit (*HCT*) in catheter-directed thrombolysis (*CDT*) and AngioJet pharmacomechanical thrombectomy (*AJ-PMT*) groups. **a,** Absolute HCT reduction in CDT and AJ-PMT groups. **b,** Percentage of HCT drop in CDT and AJ-PMT group. Wilcoxon test was used to compare preoperative HCT with postoperative HCT within each group. Mann-Whitney test was used to compare the absolute or percentage change of HCT between CDT and AJ-PMT groups. The *error bar* represents minimum or maximum.

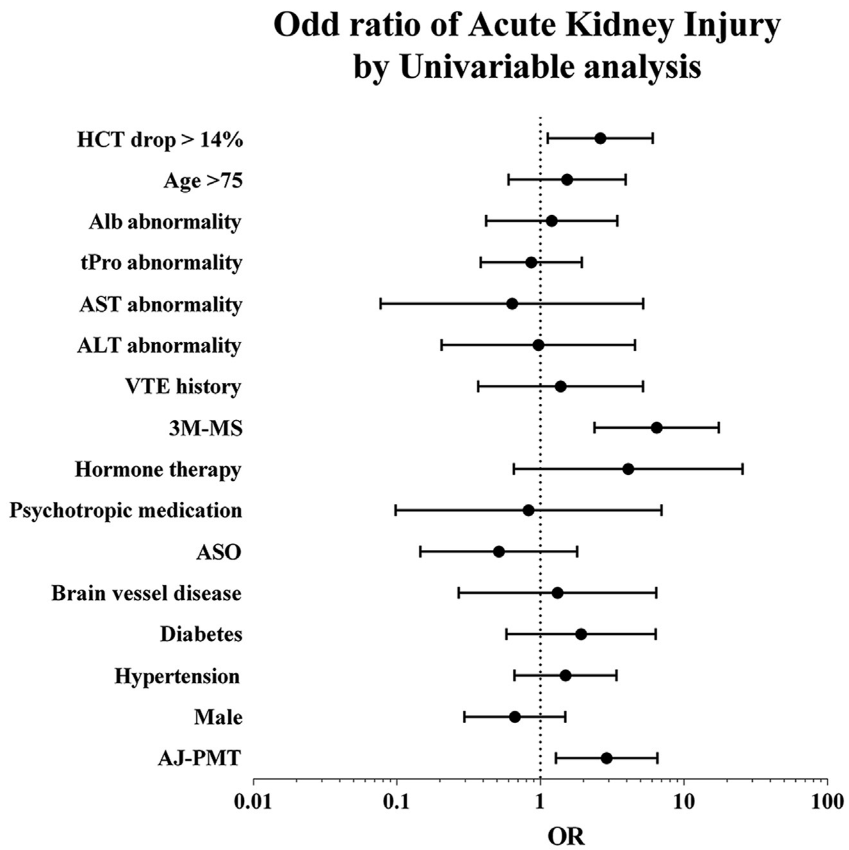
patients in the 3M-MS group were more likely to develop AKI (9/20 in the 3M-MS group vs 20/178 in the no-3M-MS group [45.0% vs 11.23%]; $P = .0005$, Fig 3, *a*). The number of patients who received AJ-PMT between the 3M-MS group and the no-3M-MS group was of no statistically significant difference (8/20 in 3M-MS group vs 71/178 in no-3M-MS group [40.0% vs 39.9%]; $P = .586$). Demographic and baseline data analysis showed no statistically significant difference between the no-3M-MS group and the 3M-MS group, except for sex ($P = .003$) and baseline HCT ($P = .003$). The baseline HCT of the 3M-MS group was lower than the HCT of the no-3M-MS group (3M-MS, 0.350 [0.331-0.377]; no-3M-MS, 0.377 [0.350-0.408]; $P = .003$) by Mann-Whitney test. No patient in the 3M-MS group had received blood transfusion. Although the absolute changes of sCr concentration of the no-3M-MS group and the 3M-MS group were of no statistically significant difference (Fig 3, *b*), the percentage change of sCr concentration of the 3M-MS group was higher than that of the no-3M-MS group ($P = .048$; Fig 3, *c*).

Drop in HCT >14% increases hazards of postoperative AKI. Both AJ-PMT and CDT led to absolute HCT reduction (median of AJ-PMT group: baseline 37.0% vs postoperative 33.4% [$P < .01$]; median of CDT group: baseline 37.7% vs postoperative 35.0% [$P < .01$]). The AJ-PMT group suffered more from acute hemolysis ($P = .018$; Fig 4, *a*). The baseline HCT (0.376 ± 0.050 for the CDT group vs 0.377 ± 0.046 for AJ-PMT group; $P = .84$) and postoperative HCT (CDT group, 0.348 ± 0.046; AJ-PMT group, 0.337 ± 0.053; $P = .15$) between the AJ-PMT group and the CDT group were of no statistical difference by *t*-test. However, the percentage change of postoperative HCT from baseline between these two groups was of statistically significant difference by Mann-Whitney test (CDT group, 7.0% [2.6%-12.0%]; AJ-PMT group, 11.6% [4.0%-16.4%]; $P = .008$; Fig 4, *b*).

Based on these findings, we analyzed the odds ratio (OR) of AKI after HCT drop >14% in our univariable analysis and multivariable modeling. Univariable analysis showed that AJ-PMT, 3M-MS, and HCT drop of at least 14% increased the OR of AKI (Fig 5). Multivariable logistic regression analysis corroborated that AJ-PMT, 3M-MS, and HCT drop >14% are independent risk factors that raise the odds of postoperative AKI (OR, 2.82 [95% CI, 1.16-6.82; $P = .02$] for AJ-PMT; OR, 8.51 [95% CI, 2.90-24.94; $P < .01$] for 3M-MS; OR, 2.73 [95% CI, 1.08-6.87; $P = .03$] for HCT drop >14%; Fig 6).

DISCUSSION

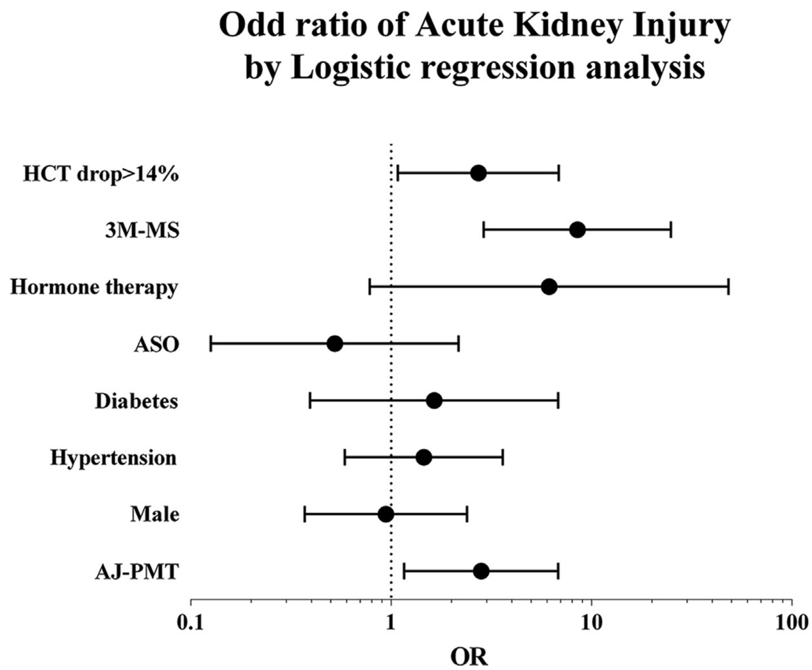
In our institution, we found that AJ-PMT increased the odds for development of AKI (OR, 2.8; $P = .022$) in comparison with CDT. AJ-PMT is more likely than CDT to cause acute hemolysis. Univariable analysis and logistic regression analysis showed that HCT drop >14% is an independent risk factor of AKI (OR, 2.7; $P = .033$). Of note, anemia is a well-documented risk factor for AKI in many other scenarios.[20-22] However, anemia does not explain the AJ-PMT group's increased risk of postoperative AKI compared with the CDT group in our study because the acute blood loss did not lead to statistically different postoperative HCT levels of the two groups. However, both acute overwhelming intravascular hemolysis and chronic low-degree hemolysis have been proved to cause tubular necrosis resulting from heme proteins and hemosiderin deposition.[23-25] Given the inevitable gross hematuria in patients treated with AJ-PMT, we postulated that acute hemolysis caused by AJ-PMT might be the underlying reason for increased postoperative AKI risk of the AJ-PMT group. Even if the sCr concentration does not rise immediately after the procedure, the detrimental effect could be cumulative.



	OR	SE	P	95%CI	
HCT drop>14%	2.616	0.430	0.025	1.126	6.079
Age>75	1.536	0.480	0.371	0.600	3.932
Alb abnormality	1.200	0.537	0.734	0.419	3.439
tPro abnormality	0.864	0.413	0.724	0.384	1.943
AST abnormality	0.635	1.074	0.672	0.077	5.209
ALT abnormality	0.969	0.792	0.968	0.205	4.574
VTE-history	1.385	0.675	0.630	0.369	5.195
3M-MS	6.464	0.508	0.000	2.387	17.504
Hormone therapy	4.099	0.936	0.132	0.654	25.675
Psychotropic medication	0.827	1.088	0.861	0.098	6.978
ASO	0.514	0.641	0.299	0.146	1.805
Brain vessel Disease	1.317	0.809	0.734	0.270	6.429
Diabetes	1.920	0.611	0.286	0.580	6.359
Hypertension	1.497	0.419	0.335	0.659	3.399
Male	0.664	0.413	0.321	0.296	1.490
AJ-PMT	2.897	0.415	0.010	1.285	6.533

Fig 5. Odds ratio (*OR*) of acute kidney injury (AKI) by univariable analysis. Univariable analysis showed that AngioJet pharmacomechanical thrombectomy (*AJ-PMT*), major surgery within 3 months before endovascular intervention (*3M-MS*), and hematocrit (*HCT*) drop of at least 14% increased the OR of AKI. *Alb,* Albumin; *ALT,* alanine transaminase; *ASO,* atherosclerosis obliterans; *AST,* aspartate transaminase; *CI,* confidence interval; *SE,* standard error; *tPro,* total protein; *VTE,* venous thromboembolism.

Major surgery has been reported to cause postoperative AKI.[13,14] However, there is no study available investigating how long previous major surgery may have negative effects on renal function. Clinically, it may take 3 to 12 months for a patient to recover from AKI. Referring to the guidelines of the American College of Cardiology/American Heart Association,[26] we postulated that 3 months may be a relatively rational threshold to eliminate the impact of previous major surgery on renal function. In our study, the baseline HCT values were lower in the 3M-MS group than in the no-3M-MS group ($P = .003$). However, the baseline HCT value and the absolute and percentage change of HCT values between the AKI group and the no-AKI group were of no statistical



	OR	SE	P	95%CI	
HCT drop>14%	2.727	0.472	0.033	1.082	6.872
3M-MS	8.508	0.549	0.000	2.902	24.944
Hormone therapy	6.148	1.052	0.084	0.782	48.322
ASO	0.524	0.726	0.372	0.126	2.170
Diabetes	1.640	0.727	0.496	0.394	6.825
Hypertension	1.456	0.463	0.418	0.587	3.608
Male	0.942	0.475	0.900	0.371	2.392
AJ-PMT	2.816	0.451	0.022	1.162	6.823

Fig 6. Odds ratio (*OR*) of acute kidney injury (AKI) by multivariable analysis. Multivariable logistic regression analysis showed that AngioJet pharmacomechanical thrombectomy (*AJ-PMT*), major surgery within 3 months before endovascular intervention (*3M-MS*), and hematocrit (*HCT*) drop of at least 14% were independent risk factors for postoperative AKI. *ASO,* Atherosclerosis obliterans; *CI,* confidence interval; *SE,* standard error.

significance. Meanwhile, in our study, renal function of all patients at baseline was normal. Although the mechanism of AKI after major surgery is still unknown, our study suggested that a history of 3M-MS before receiving endovascular intervention (CDT or AJ-PMT) is an independent risk factor for postoperative AKI in patients with acute IFDVT (OR, 8.5; $P < .001$). It means that 3M-MS before CDT or AJ-PMT may lead to acute blood loss as well as other undefined risk factors that may increase the hazard of postoperative AKI to some extent. That kind of negative impact may subsequently increase the risk for development of AKI after endovascular intervention.

We noticed some limitations in our study. Regardless of the CDT group's lower incidence of postoperative AKI, we acknowledge that 9.2% of patients in the CDT group suffered from postoperative AKI as well. These patients with postoperative AKI in the CDT group did not have acute hemolysis or hematuria. In our institution, we use only hypo-osmolar nonionic contrast medium (370 mgI/L iodixanol). Surgeons usually dilute the contrast agent according to their discretion before injection. That makes the volume of contrast agent we used in every patient difficult to estimate. Hence, we were not sure whether the main reason for postoperative AKI in the CDT group could be attributed to the contrast agent-induced kidney injury that has been widely reported in other research.[27,28] Besides, the iodixanol, which was excreted primarily unchanged in urine, may have a synergistic effect with heme proteins and hemosiderin deposition in causing tubular necrosis. Under these circumstances, we cannot determine to what extent contrast agent-induced kidney injury has contributed to postoperative AKI in either the AJ-PMT or CDT group. In addition, the data of AJ-PMT aspiration volume and time were not complete. Furthermore, this study is a single-center retrospective observational analysis with a limited sample size and lacking long-term follow-up results. The interventions were not randomized and are subject to systematic bias. Future research should be designed to determine safe aspiration volumes, aspiration time, and contrast material volumes for patients undergoing AJ-PMT.

CONCLUSIONS

In patients with acute IFDVT, AJ-PMT will raise the risk of postoperative AKI compared with CDT, especially in patients with history of 3M-MS. An HCT drop >14% after AJ-PMT may indicate upcoming AKI. Every surgeon should keep renal protective measures in mind, including hydration, use of sodium bicarbonate, limitation of aspiration volumes and time, and postoperative vigilance.

AUTHOR CONTRIBUTIONS

Conception and design: YS, WZ
Analysis and interpretation: YS, SJ
Data collection: YS, XW, SJ, RZ, GC
Writing the article: YS, SJ
Critical revision of the article: YS, XW, RZ, WZ, GC
Final approval of the article: YS, XW, SJ, RZ, WZ, GC
Statistical analysis: YS, XW, WZ
Obtained funding: YS, RZ, WZ
Overall responsibility: WZ

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