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ARTICLE

Autologous blood coagulum for fragment removal after ureteroscopic laser lithotripsy

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Background: *Ureteroscopy is the recommended surgical treatment for renal stones less than two centimeters in diameter but often leaves residual fragments, increasing the risk of stone recurrence. Autologous blood coagulum is a potential adjunct to ureteroscopy for aiding fragment retrieval. This study evaluates the efficacy and efficiency of autologous blood coagulum assisted ureteroscopy compared to ureteroscopy and basketing for achieving absolute stone-free Grade A status.*

Methods: *Following Institutional Review Board approval, a retrospective review of our comprehensive UC Irvine Minimally Invasive Surgery Ureteroscopy database consisting of 962 patients undergoing ureteroscopy between 2018 to 2025 identified 15 renal units treated with ureteroscopy plus autologous blood coagulum and 47 matched controls treated with standard ureteroscopy and basketing alone. Primary outcomes included absolute stone-free status and stone-free rate, with operative time as a secondary outcome. Multivariate logistic regression was used to determine factors most closely associated with stone-free status.*

Results: *Autologous blood coagulum increased the proportion of patients achieving absolute stone-free Grade A status (60% vs. 19%; $p = 0.007$) and was associated with a greater odds of achieving Grade A status compared to standard ureteroscopy (OR = 4.6; 95% CI = 1.04–20.1; $p = 0.044$). In patients who received autologous blood coagulum, thulium laser use was associated with a significantly greater odds of achieving Grade A status (OR 6.7; 95% CI: 1.1–39; $p = 0.047$). There was no significant difference in the relative stone free rates for fragments $\leq$4 mm (Grades A+B+C) between groups (73% vs. 60%; $p = 0.38$). Mean operative time for autologous blood coagulum vs. the control group was comparable (141.1 vs. 135.1 min; $p = 0.76$).*

Conclusions: *Autologous blood coagulum is an effective adjunctive technique to standard ureteroscopy that enhances stone-free outcomes without prolonging operative duration or requiring any additional equipment or expense.*

Key Words: Blood coagulum, ureteroscopy, residual stone, stone free rate

Introduction

Nephrolithiasis is a prevalent condition associated with substantial morbidity and healthcare expenditures. With a globally aging population, the incidence of complex stones necessitating surgical intervention is expected to rise.[1] Although percutaneous nephrolithotomy is effective for the removal of large

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stones, it poses significant risks, including bleeding, infection, and injury to surrounding tissues.[2,3] Ureteroscopy is a minimally invasive approach to managing stones in the upper urinary tract and has become an increasingly favored surgical modality for renal stones less than two centimeters in diameter.[4,5] Ureteroscopy primarily involves stone fragmentation and dusting via laser lithotripsy, followed by extraction of any remaining larger fragments (>2 mm) using nitinol stone baskets.[6] Despite substantial advances in endoscopic technology, achieving absolute stone-free status, defined as the complete absence of residual stone fragments detectable on 2 or 3 mm-resolution computed tomography imaging, remains challenging. Even in the most experienced hands, complete stone clearance via ureteroscopy alone ranges between 50−60%.[7–10] Prior literature demonstrates that residual fragments elevate the risk for stone recurrence, resulting in repeat surgical intervention in 19−20% of patients.[11,12]

Residual stone fragments may persist as their <2 mm diameter precludes entrapment within standard retrieval baskets. Also, these fragments often migrate during retrieval attempts or accumulate in inaccessible dependent calyces. Further, some of these fragments may adhere to the urothelium and resist dislodgment. The injection of autologous blood coagulum into the collecting system following laser lithotripsy offers a potential solution by facilitating aggregation and encapsulation of small and difficult-to-access stone fragments within a basket-retrievable clot.

Originally descripted by Dees in 1943, autologous blood coagulum has demonstrated efficacy as an adjunct to both open and laparoscopic stone removal.[13–16] The autologous blood coagulum technique in ureteroscopy was first described by Cloutier in 2014.[17] To our knowledge, our study is the first to evaluate the efficacy and efficiency of autologous blood coagulum enhanced ureteroscopy versus a retrospectively matched control group using millimeter-resolution postoperative computed tomography scan-based stone-free rate as a primary outcome. We hypothesize that use of an autologous blood coagulum during ureteroscopy will result in a higher absolute stone-free Grade A rate without a significant increase in operative time.

Materials and Methods

Study design

This study is a retrospective case-control matched study. Chart review of a prospectively enrolled ureteroscopy database was conducted at the University of California, Irvine Medical Center and included 15 patients who underwent ureteroscopy with adjunctive autologous blood coagulum from 2018−2025 retrospectively matched against a control group of 47 renal units treated with ureteroscopy and basketing alone. An internal power analysis yielded a target sample size of at least 15 renal units in the autologous blood coagulum group when modeled at a 1:3 experimental/control ratio and a presumptive effect size of 40% in stone-free rate. This effect size was referenced from *in vivo* studies of autologous blood coagulum in porcine models as well as clinical studies of flexible ureteroscopy.[18,19] Controls were manually matched *post hoc* at a flexible 1:3 ratio to age, sex, stone size, stone location, primary surgeon, laser fiber core diameter, and ureteral access sheath diameter, variables previously reported as significant predictors of postoperative stone-free rate.[20] All patients who received autologous blood coagulum as an adjunct to ureteroscopy and a postoperative computed tomography scan 1 to 7 months after the procedure were eligible for inclusion, regardless of stone etiology. Exclusion criteria included the treatment of stones in the ureter with no intra-renal deployment of autologous blood coagulum, a non-computed tomography imaging modality to monitor postoperative stone-free status, or a non-autologous blood coagulum performing surgeon. Written informed consent was obtained from all participants for inclusion in our Minimally Invasive Surgery Ureteroscopy database, permitting the collection and use of their clinical data for the current study. This study was approved by the Institutional Review Board at the University of California, Irvine Health (#20162746).

Surgical technique

Following placement of a ureteral access sheath to the proximal ureter or renal pelvis over a guidewire, a flexible digital ureteroscope was advanced into the collecting system. All stone fragmentation and dusting were performed at the surgeon's discretion using a thulium or holmium fiber laser (1 J, 10 Hz, short pulse). Primary basketing was conducted using a 1.5F NCircle© and/or 1.9F NCompass© nitinol stone basket (Cook Medical, Bloomington, IN, USA). Up to 10cc of patient blood was drawn at the end of laser lithotripsy after basketing and removal of larger stones. A side arm adaptor was affixed to the working port. The nitinol stone basket was then passed via the straight port of the side-arm adaptor and positioned in the most dependent fragment-containing calyx. The basket was opened and the patient's own blood was instilled through the side-port of the side-arm adaptor. After an 8 to 10-min dwell time, the ureteroscope and open stone basket were withdrawn as a unit along with any clot clinging to the stone basket. The clot was then removed from the stone basket and the ureteroscope channel was flushed with normal saline until it was cleared of all blood. The ureteroscope was again passed into the kidney and autologous blood coagulum-embedded fragments were retrieved using the stone basket until no clot was remaining. Final inspection of all calyces and the renal pelvis was performed followed by pullback ureteroscopy to assess for ureteral injury. A double-J ureteral stent was placed over a guidewire. Stents were removed in the office 1–2 weeks postoperatively. Stone clearance was assessed with non-contrast computed tomography with ≤3 mm cuts targeted at approximately 2−6 months after the procedure.

Data collection and outcome measures

Baseline demographic, stone, and operative characteristics including largest linear dimension of the largest treated stone, age, sex, stone location (lower pole versus non-lower pole), largest linear residual stone size, operative time, primary surgeon, laser type, laser fiber core diameter, and ureteral access sheath diameter were recorded. Stone-free rate grading was based on millimeter-resolution non-contrast computed tomography scans targeted at postoperative months 2−6. Absolute stone-free Grade A was defined as the absence of any stones or stone fragments on CT scan of the kidney per *Journal of Endourology* criteria.[21]

Statistical analysis

Descriptive statistics were calculated with categorical variables reported as frequencies and percentages and continuous variables reported as means and confidence intervals. Comparisons between groups were made using Fisher's exact tests for categorical variables and independent two-sample *t*-tests for continuous variables. Multivariate logistic regression was used to determine the factors most closely associated with stone-free status. All statistical tests were two-sided, with $p < 0.05$ considered statistically significant. Italicized *p*-values denote statistical significance. Statistical Package for the Social Sciences (SPSS) software was used for statistical analysis (SPSS Statistics, Version 29, IBM Corporation, Armonk, NY, USA). Of note, our analysis of operative time excluded cases of bilateral ureteroscopy to control for an intrinsic difference in case duration as a potential confounder.

Results

Patient selection and cohort characteristics

A total of 962 patients who underwent ureteroscopy between 2018 and 2025 were entered in our institutional database. Of these, 900 were excluded due to one or more of the following: presence of stones in the ureter below the ureteropelvic junction, absence of postoperative computed tomography images, or procedures not performed by a surgeon trained in autologous blood coagulum.

15 patients who received ureteroscopy with autologous blood coagulum were included. A control group of 47 patients undergoing ureteroscopy with primary basketing alone was selected via *post hoc* manual matching based on age, sex, stone size, stone location, primary surgeon, laser fiber core diameter, and ureteral access sheath diameter at a flexible target case-control match ratio of 1:3 (Table 1).

Age, sex, stone size, stone location, and operative characteristics such as ureteral access sheath diameter and laser fiber core diameter were similar between groups. None of the prior differences reached statistical significance, indicating a lack of serious evidence against the similarity of the comparison groups. The use of thulium laser was significantly higher in the autologous blood coagulum group compared to the control group (73% vs. 30%, $p = 0.006$).

All enrolled patients received postoperative computed tomography scans at a mean 3.71 (±2.78) months after surgery. All patients in the autologous blood coagulum cohort received 2−3 mm slice postoperative computed tomography scans, while 81% of patients in the control cohort received 2−3 mm slice postoperative computed tomography scans. The remaining 19% of control patients received 4−5 mm slice postoperative computed tomography scans.

Association between autologous blood coagulum use and complete stone clearance, Grade A

Autologous blood coagulum was associated with higher complete stone clearance compared to standard ureteroscopy (60% vs. 19%, $p = 0.007$; Table 2).

Predictors of absolute stone-free, Grade A status

Multivariate binary logistic regression was performed to assess predictors of absolute stone-free Grade A status, adjusting for autologous blood coagulum use, laser type, age, sex, stone size, and stone location (Table 3). Both autologous blood coagulum and thulium laser were independently associated with significantly greater odds of achieving Grade A status (OR 4.6; 95% CI: 1.04−20.1; $p = 0.044$ and OR 4.3; 95% CI: 1.05–17.5; $p = 0.042$). A Fisher's exact

TABLE 1. **Demographic, stone, and operative characteristics of autologous blood coagulum patients and control patients**

	Coagulum patients	Control patients	*p*-value
Demographics	**n = 15**	**n = 47**	
Sex			
Male	12 (80%)	34 (72%)	0.74
Female	3 (20%)	13 (28%)	
Mean age, years (SD)	61.60 (17.50)	63.96 (13.80)	0.59
Stone characteristics	**n = 15**	**n = 47**	
Stone location			
Lower pole	5 (33%)	14 (30%)	>0.99
Other location	10 (67%)	33 (70%)	
Mean largest linear stone size, mm (SD)	12.72 (3.24)	12.11 (3.97)	0.59
Operative characteristics*	**n = 15**	**n = 47**	
Ureteral access sheath diameter			
11 Fr	0 (0%)	5 (11%)	0.35
12 Fr	3 (20%)	4 (8.9%)	
13 Fr	0 (0%)	1 (2.2%)	
14 Fr	7 (47%)	14 (31%)	
16 Fr	5 (33%)	21 (47%)	
Laser type			
Holmium	4 (27%)	32 (70%)	0.006
Thulium	11 (73%)	14 (30%)	
Laser fiber core diameter (µm)			
150	1 (7.7%)	2 (4.5%)	0.26
200	12 (80%)	25 (57%)	
272	2 (13%)	11 (25%)	
365	0 (0%)	6 (14%)	
Operative time	**n = 10**	**n = 40**	
Mean unilateral operative time, min (SD)**	141.1 (51.63)	135.1 (65.64)	0.76

Note. *Analysis of operative characteristics excluded cases in which information could not be confirmed upon chart review. **Analysis of operative time excluded cases of bilateral ureteroscopy to control for an intrinsic difference in case duration as a potential confounder. $p < 0.05$ considered statistically significant. SD: standard deviation.

test of absolute stone-free Grade A status in patients receiving autologous blood coagulum ureteroscopy stratified by laser type was then performed (Table 4). In this sub-analysis, thulium laser with coagulum was associated with a significantly greater odds of achieving Grade A status (OR 6.7; 95% CI: 1.1−39; $p = 0.047$), while holmium laser with coagulum was not (OR 1.8; 95% CI: 0.15−21; $p = 0.54$).

Residual fragment analysis

Chi-square analysis of the postoperative presence of residual fragments, defined as fragments ≤4 mm on computed tomography (Grades A+B+C), showed a higher frequency of the postoperative presence of residual fragments in the autologous blood coagulum group compared to patients in the control group (73% vs. 60%), but this difference was not statistically significant ($p = 0.38$; Table 2).

Operative time analysis

Independent two-tailed t-tests comparing operative time for unilateral procedures showed no significant difference between autologous blood coagulum (141.1 ± 51.63 min) and control groups (135.1 ± 65.64 min; $p = 0.76$; Table 1).

Postoperative course

Of the 15 patients who received autologous blood coagulum, 4 patients did not have any ureteric

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TABLE 2. **Comparison of stone-free status between autologous blood coagulum and control patients**

Stone-free status	Blood coagulum treatment	Standard treatment	p-value
Absolute stone-free (Grade A)			
Yes	9 (60%)	9 (19%)	0.007
No	6 (40%)	38 (81%)	
Fragments ≤2 mm (Grades A+B)			
Yes	9 (60%)	16 (34%)	0.13
No	6 (40%)	31 (66%)	
Fragments ≤4 mm (Grades A+B+C)			
Yes	11 (73%)	28 (60%)	0.38
No	4 (27%)	19 (40%)	

Note. $p < 0.05$ considered statistically significant.

TABLE 3. **Multivariate logistic regression analysis for absolute stone-free rate using autologous blood coagulum, laser type, sex, age, stone location, and stone size as input covariates**

Variable	Odds ratio	95% CI	p-value
Control	Ref		
Coagulum +	4.6	1.04–20.1	0.044
Holmium laser	Ref		
Thulium laser	4.3	1.05−17.5	0.042
Male	Ref		
Female	1.6	0.34–7.7	0.55
Age	1.002	0.97–1.04	0.91
Lower pole	Ref		
Other location	0.49	0.11–2.3	0.37
Largest linear stone size	0.85	0.69–1.04	0.11

Note. $p < 0.05$ considered statistically significant. CI: confidence interval; Ref: reference group.

TABLE 4. **Fisher's exact test for absolute stone-free rate among patients receiving autologous blood coagulum stratified by laser type**

Laser type	Odds ratio	95% CI	p-value
Thulium	6.7	1.1–39	0.047
Holmium	1.8	0.15–21	0.54

Note. $p < 0.05$ considered statistically significant. CI: confidence interval.

injury. Post-ureteroscopy lesion scale (PULS) grade 1 was observed in 8 patients. PULS grade 2 injuries were observed in 3 patients. Eleven patients stayed in the hospital for less than 12 h and 4 patients stayed overnight for observation. There were no documented cases of postoperative fever or sepsis among patients who underwent autologous blood coagulum. There were also no readmissions or reinterventions for any patients who received autologous blood coagulum.

Discussion

Our study is the first to use computed tomography-based assessment of absolute stone-free status and stone-free rate as primary outcomes to systematically evaluate the efficacy of autologous blood coagulum in routine clinical practice. The origins of coagulum-based stone retrieval trace back to 1943, when Dees reported the first use of non-autologous fibrinogen coagulum in open pyelolithotomy using postoperative plain-film X-ray to assess outcomes.[13] Subsequent innovations included Fischer et al.'s plasma cryoprecipitate technique, Borges et al.'s modification using fibrin sealant and autologous urine and, most recently, Cloutier et al.'s proof-of-concept report of using autologous venous blood coagulum to capture small calyceal stone fragments during ureteroscopy.[15–17] The use of computed tomography imaging in our study provided superior sensitivity in detecting residual stone fragments compared to other imaging modalities.[22]

Using autologous blood coagulum, there was a nearly five-fold increased odds of achieving complete stone clearance without a significant increase in operative time among patients who were similar with respect to age, sex, stone location, and stone size. These data suggest that coagulum may be an effective adjunct to ureteroscopy that enhances stone-free rate outcomes while preserving procedural efficiency. Given its simplicity, ready availability, and minimal added cost (i.e., a 10 cc syringe) due to the autologous nature of coagulum, this technique may be particularly valuable in minimizing the need for repeat interventions due to the growth of stone remnants. Moreover, unlike synthetic bioadhesive or hydrogel alternatives that are costly and often not widely available, autologous blood coagulum is derived from the patient's own blood. For example, mediNIK®, a hydrogel developed in Europe for removal of residual stone fragments, is only commercially available in Germany and costs approximately 800 Euro for a pre-filled syringe pack.[23–24] In contrast, autologous blood coagulum is a nearly cost-free and universally accessible complement to ureteroscopy that may render more patients stone-free on a global level.[25]

Our study also identified use of thulium laser during ureteroscopic lithotripsy as a significant independent predictor of Grade A stone-free status. This finding is consistent with the existing literature which demonstrates superior stone-free rates with thulium laser compared to holmium laser.[26–27] However, in our study, holmium laser was used in only four cases of ureteroscopy involving autologous blood coagulum. While we report that use of thulium laser with autologous blood coagulum increases the odds of Grade A stone-free rate status while holmium laser does not, further studies of larger surgical samples are needed to reduce precision bias and more clearly elucidate the effect of laser type on autologous blood coagulum efficacy, especially during holmium laser lithotripsy.

While all autologous blood coagulum patients received postoperative computed tomography scans with 2–3 mm slices, 9 control patients received computed tomography scans with 4–5 mm slices. Prior computed tomography studies have demonstrated that thicker slices often fail to capture 2–3 mm fragments. Jin et al. showed that the sensitivity of computed tomography in detecting postoperative residual fragments rose from 81% (5 mm slices) to 92% (1.25 mm slices) with thinner slices.[28] Similarly, Memarsadeghi et al. revealed that 23% of small calculi, defined as stones <3 mm in diameter, were missed on computed tomography scans with 5 mm slices compared to computed tomography scans with 1.5 mm and 3 mm slices, with no difference in detection sensitivity between 1.5 mm and 3 mm slices.[29] In our study, there was certainly an elevated assignment of Grade A status in the control group. Accordingly, the effect size of the difference we observed in absolute stone free Grade A status between autologous blood coagulum and control cohorts would possibly be even larger if all of the control patients underwent post-operative computed tomography monitoring with 2–3 mm slices.

Several limitations that may reduce the generalizability of our findings warrant consideration. First, our study's retrospective design precludes causal inference. Moreover, the statistical power and precision of our study are limited by the small number of patients who received autologous blood coagulum; this was in large part due to the use of ultrasound rather than computed tomography for follow-up imaging secondary to individual insurance coverage and reimbursement policies. Additionally, the use of autologous blood coagulum is relatively rare as it is only employed when residual fragment burden is not amenable to basketing and when aspiration or sheath-based technologies cannot be effectively deployed, such as in lower pole calyces. This may also be reflected in the wide confidence intervals of the outcome measures derived from our regression model, suggesting that while autologous blood coagulum meaningfully improves stone-free rate, the magnitude of this improvement remains imprecise. Additional sources of heterogeneity include inconsistencies in timing of postoperative imaging and the number of autologous blood coagulum procedures being performed by a single surgeon.

Conclusions

In this retrospectively matched case-control study, the use of autologous blood coagulum was associated

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with improved stone-free rates without prolonging operative time. This technique may provide the urologist with a minimally invasive, inexpensive, and universally available option for the removal of small residual stone fragments not amenable to conventional stone basketing techniques or in cases where access for aspiration technologies is compromised.

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Author Contributions

The authors confirm contribution to the paper as follows: Conceptualization: Tiffany R. Huang, Bruce M. Gao, Ralph V. Clayman; Data curation: Tiffany R. Huang, Mariah C. Hernandez, Helen Gao; Formal analysis: Christopher D. Yang, Carol Davis-Dao; Methodology: Tiffany R. Huang, Bruce M. Gao, Roshan M. Patel, Jaime Landman, Ralph V. Clayman; Project administration: Bruce M. Gao, Aymon Ali, Sohrab N. Ali, Pengbo Jiang, Roshan M. Patel, Jaime Landman, Ralph V. Clayman; Supervision: Bruce M. Gao, Aymon Ali, Jonathan Badin-Castro, Ralph V. Clayman; Validation: Roshan M. Patel, Jaime Landman, Ralph V. Clayman; Visualization and writing: Tiffany R. Huang, Bruce M. Gao, Aymon Ali, Christopher D. Yang, Ralph V. Clayman; Reviewing and editing: Tiffany R. Huang, Bruce M. Gao, Aymon Ali, Mariah C. Hernandez, Christopher D. Yang, Jonathan Badin-Castro, Carol Davis-Dao, Seyedamirvala Saadat, Seyed Amiryaghoub M. Lavasani, Sohrab N. Ali, Pengbo Jiang, Roshan M. Patel, Jaime Landman, Ralph V. Clayman. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

Ethics Approval

Written informed consent was obtained from all participants for inclusion in our Minimally Invasive Surgery Ureteroscopy database, permitting the collection and use of their clinical data for the current study. This study was approved by the Institutional Review Board at the University of California, Irvine Health (#20162746).

Conflicts of Interest

The authors declare no conflicts of interest.

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