surgeries

MDPI

Article

Comparison of Two Fluid-Management Platforms for Flexible Ureteroscopy in Renal Stone Treatment: Pressure-Feedback Irrigation and Aspiration Versus a Suction Access Sheath Without Pressure Feedback

Petrisor Aurelian Geavlete [1,2], Cristian Mares [1,2,*], Catalin Andrei Bulai [1,2,*], Razvan Dragos Multescu [1,2], Dragos Adrian Georgescu [1,2], Cosmin Victor Ene [1,2] and Bogdan Geavlete [1,2]

[1] Department of Urology, "Saint John" Clinical Emergency Hospital, 042122 Bucharest, Romania; geavlete@gmail.com (P.A.G.); razvan.multescu@umfcd.ro (R.D.M.); dgeorgescu2000@yahoo.com (D.A.G.); cosmin85_ene@yahoo.com (C.V.E.); bogdan_geavlete@yahoo.com (B.G.)
[2] Faculty of Medicine, "Carol Davila" University of Medicine and Pharmacy, 050474 Bucharest, Romania
* Correspondence: dr.marescristian@gmail.com (C.M.); catalinandreib@gmail.com (C.A.B.); Tel.: +40-745-383-552 (C.M.); +40-749-184-205 (C.A.B.)

Abstract

Background/Objectives: In the modern treatment of renal stones, intrarenal pressure management is an important safety factor in flexible ureteroscopy. Modern techniques that include real-time monitoring of intrarenal pressure, continuous irrigation, and controlled aspiration can improve intraoperative visibility while reducing the risk of problems associated with increased pressure. **Methods:** A retrospective comparative observational study was performed on 120 consecutive eligible patients with single pyelocaliceal renal stones and a negative preoperative urine culture. Group 1 included 55 patients treated with the ClearPetra® 10/12 Fr. suction access sheath, without intrarenal pressure monitoring. Group 2 included 65 patients treated with the Elephant IV 10/12 Fr. sheath associated with the Tidor™ device, which allows intrarenal pressure monitoring and automatic control of irrigation and aspiration. In Group 2, the intrarenal pressure limit was set at 30 mmHg. Access sheath insertion was possible in all cases. **Results:** The mean operative time was significantly shorter in Group 2 than in Group 1 (35.9 ± 11.3 versus 53.7 ± 7.7 min, $p < 0.001$). After adjustment for maximum stone diameter, stone density, and stone location, the Elephant IV + Tidor™ platform remained associated with shorter operative time (adjusted mean difference, −17.4 min; 95% CI, −21.8 to −12.9; $p < 0.001$). In Group 2, intrarenal pressure was maintained between 5 and 17 mmHg. At 30 days, the stone-free rate was numerically higher in Group 2 (96.9% versus 90.9%), while mean hospital stay (1.02 versus 1.09 days, $p = 0.077$), postoperative JJ-stent placement (4.6% versus 12.7%), and minor complications (4.6% versus 12.7%) were numerically lower; these differences did not reach statistical significance. **Conclusions:** The Elephant IV + Tidor™ system was feasible and maintained measured intrarenal pressure within a low range during RIRS, while being associated with a significantly shorter operative time. Differences in the other postoperative outcomes should be interpreted as exploratory numerical trends.

Keywords: flexible ureteroscopy; intrarenal pressure; suction ureteral access sheath; renal stones

Check for updates

Academic Editor: Enrico Mario Camporesi

Received: 3 October 2026
Revised: 23 October 2026
Accepted: 28 October 2026
Published: 30 October 2026

Copyright: © 2026 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license.

1. Introduction

Endoscopic treatment of renal lithiasis has evolved significantly in recent decades, with the development of flexible digital ureteroscopes, miniaturization of instrumentation, the emergence of lasers with increased fragmentation efficiency, and the introduction of ureteral access sheaths with additional irrigation and aspiration functions [1]. Currently, flexible ureteroscopy, also known as retrograde intrarenal surgery (RIRS), represents one of the main minimally invasive options for the treatment of kidney stones, especially for small and medium-sized lithiasis located in the pyelocaliceal system. However, the increased efficiency of this procedure must be constantly balanced by the need to maintain a high safety profile, since intraoperative visibility, intrarenal pressure, duration of the intervention and evacuation of lithiasis fragments can directly influence the risk of postoperative complications [2]. One of the essential elements for optimal performance of flexible ureteroscopy is fluid management. Adequate irrigation is indispensable to maintain endoscopic visibility, to distend the pyelocaliceal cavities and to perform laser lithotripsy effectively. However, excessive or uncontrolled irrigation may cause increased intrarenal pressure, with potentially important clinical consequences. Increased intrarenal pressure has been associated with pyelovenous, pyelolymphatic, and pyelotubular reflux, mechanisms that may favor the translocation of bacteria, endotoxins, and detritus into the systemic circulation. These phenomena may contribute to the development of postoperative fever, urinary tract infections, systemic inflammatory response syndrome, and, in severe cases, post-ureteroscopic sepsis [3]. In clinical practice, intrarenal pressure control during RIRS remains a challenge. Traditionally, pressure is indirectly influenced by irrigation flow rate, saline bag height, use of manual or automated pumps, ureteroscope caliber, presence of a ureteral access sheath, and the degree of passive or active drainage of the collecting system. Although the surgeon can manually adjust the irrigation according to visibility and the operative context, this approach does not provide objective real-time information on the actual pressure in the intrarenal cavities. Thus, there may be episodes of transient intrarenal hyperpressure, which are difficult to detect intraoperatively, especially in cases with staghorn stones, prolonged operative time, bleeding, difficult visual field, or insufficient evacuation of fragments [4].

The introduction of ureteral access sheaths was a significant step forward in the development of flexible ureteroscopy. They enable repeated access to the pyelocaliceal system, decrease ureteral damage caused by multiple ureteroscope insertions, enhance irrigation fluid drainage, and may help lower intrarenal pressure by establishing an outflow channel [5]. Aspiration access sheaths were later developed to aid in the evacuation of stone fragments, laser lithotripsy dust or detritus, with the purpose of increasing vision and lowering residual fragment burden. However, many of these systems allow aspiration without providing direct intrarenal pressure monitoring, which limits the operator's ability to objectively adapt irrigation and aspiration to dynamic conditions during the intervention [6].

In this context, modern fluid management systems, which integrate irrigation, aspiration and real-time intrarenal pressure monitoring, represent a promising technological direction in endoscopic surgery of renal lithiasis. The idea behind these devices is to maintain steady intrarenal pressure within safe limits without affecting the visibility or effectiveness of lithotripsy by automatically or semi-automatically regulating the aspiration level and irrigation flow based on continuously measured parameters [7]. These technologies provide the surgeon with accurate control over the intrarenal environment by dynamically adjusting fluid flow through the use of pressure sensors and microprocessors [8]. Potential benefits include early detection of pressure elevations [9], improved visibility through irrigation and aspiration [10], and more effective fragment evacuation [11]. Pressure control may also help reduce infectious complications, particularly in patients with predisposing factors [12].

The present study aims to evaluate the initial experience with the use of an intelligent fluid management system during flexible ureteroscopy for renal stones. The investigated system integrates real-time monitoring of intrarenal pressure, continuous irrigation and suction control through a dedicated access sheath. The main objective is to evaluate the safety and feasibility of this technology, in terms of intrarenal pressure control and intraoperative efficiency. In addition, the results are compared with those obtained by using a standard suction access sheath without monitoring of intrarenal pressure. This comparison aims to highlight the potential benefits of integrating pressure control into fluid management during RIRS. Thus, the study provides preliminary data on the role of real-time intrarenal pressure monitoring and automated fluid management during RIRS.

2. Materials and Methods

This retrospective comparative observational study analyzed patients treated at the Urology Clinic of "Saint John" Clinical Emergency Hospital, Bucharest, between 1 February and 30 April 2026. The analyzed cohort comprised consecutive eligible patients with single pyelocaliceal renal lithiasis and a negative preoperative urine culture within 7 days before definitive flexible ureteroscopy (retrograde intrarenal surgery—RIRS). The choice of the system used intraoperatively was determined by the availability of instrumentation at the time of the intervention.

A total of 120 patients with a single pyelocaliceal renal stone, with a maximum diameter between 11 and 19 mm and a density between 850 and 1350 HU, were included. Maximum stone diameter was defined as the largest stone dimension measured on multiplanar non-contrast computed tomography images and was used to characterize stone burden. All procedures were performed with the HugeMed 6.3 Fr single-use flexible ureteroscope. Patients were divided into two groups: Group 1 included 55 cases treated with the ClearPetra® (Well Lead Medical Co., Ltd., Guangzhou, China) Flexi Ureteral Access Sheath 10/12 Fr., and Group 2 included 65 cases treated with the Elephant IV 10/12 Fr. sheath associated with the Tidor™ (Yigaomed, Hangzhou, China) intelligent pressure control device. All patients were prestented with a JJ ureteral stent before RIRS, allowing passive ureteral dilatation prior to insertion of the 10/12 Fr ureteral access sheath. The preoperative configuration and intraoperative use of the Elephant IV suction access sheath with the Tidor™ system are illustrated in Figure 1. The ureteroscope and laser lithotripsy setup are illustrated in Figure 2.

Adult patients with single renal lithiasis, located in the pyelocaliceal system, with an indication for endoscopic treatment by RIRS were included. Patients with multiple stones or staghorn calculi, untreated active urinary tract infection, major anatomical abnormalities of the upper urinary tract, uncorrected coagulation disorders, or incomplete perioperative data were excluded. All patients underwent preoperative urinalysis and urine culture within 7 days before the planned RIRS procedure. A urine culture showing bacterial growth >100,000 CFU/mL was considered clinically significant. Only patients with a negative preoperative urine culture proceeded to definitive RIRS and were included in the study. Patients with a positive urine culture received culture-directed antibiotic treatment and did not undergo surgery as scheduled. These patients were not included in the present cohort. Patients initially excluded because of a positive urine culture were not subsequently included in the study, even if a later urine culture became negative. All consecutive patients who met the eligibility criteria during the study period were included, and no eligible patient was excluded. The study was conducted in a high-volume endourology center. Preoperative evaluation included medical history, clinical examination, routine laboratory tests, urinalysis, urine culture, and non-contrast CT. The location of the stone, maximum diameter, and density expressed in Hounsfield units were recorded from the

preoperative non-contrast CT examination. No single primary endpoint was predefined. As this was an exploratory observational study, all recorded demographic, stone-related, intraoperative, and postoperative parameters were analyzed. Operative time, stone-free status, postoperative JJ-stent placement, length of hospitalization, and complications were therefore considered exploratory outcomes. Intrarenal pressure was assessed only in the Elephant IV + Tidor™ group and was considered a technical feasibility parameter rather than a comparative outcome.



Figure 1. Multipanel presentation of the Elephant IV suction ureteral access sheath and the Tidor™ intelligent fluid-management system. Upper panels: Preoperative configuration of the Elephant IV suction access sheath connected to the Tidor™ system, including the interface for real-time intrarenal pressure monitoring and irrigation and suction control. Lower left panel: Detailed view of the ureteral access sheath and its integrated control buttons. Lower right panel: Intraoperative operating parameters displayed on the Tidor™ system interface.

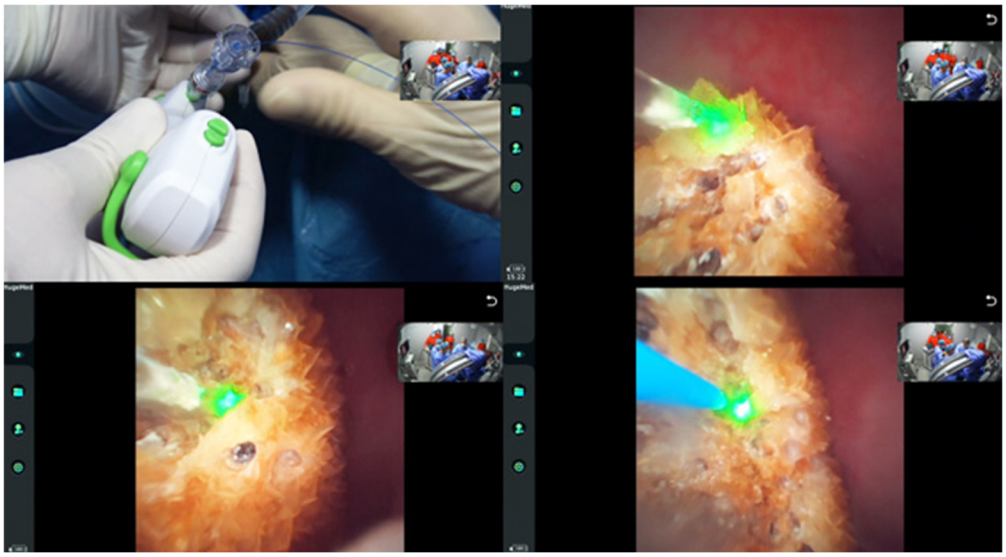


Figure 2. Intraoperative detail of the single-use 6.3 Fr. HugeMed HU30M flexible ureteroscope used with fiber laser for renal stone dusting during RIRS.

All procedures were performed by the same senior urologist with extensive experience in RIRS. The fluid-management platform used during each procedure was determined exclusively by instrument availability at the time of surgery and was not selected according to

patient or stone characteristics or surgeon preference. The procedures were performed under anesthesia (spinal anesthesia or general anesthesia), in the lithotomy position, through a retrograde approach. Both groups received ceftriaxone 2 g once daily, starting one hour before surgery. After inserting a 10/12 Fr. ureteral access sheath, the flexible ureteroscope was advanced to the level of the pyelocaliceal system, and the stone was fragmented with the Thulio Laser System, Pulsed-Tm, (Dornier MedTech Systems GmbH, Germany), 100 W, using a Slim 270 µm, 10× laser fiber. The standard laser parameters were represented by energy 0.3–0.5 J and frequency 20–50 Hz (power < 25 W), adapted intraoperatively according to the characteristics of the stones and visibility.

In Group 1, irrigation was gravity-fed from saline bags, with flow manually adjusted through the ureteroscope. Aspiration through the ClearPetra® sheath was provided by a separate suction unit. Irrigation and aspiration management were adjusted according to visibility and operator judgment, without direct intrarenal pressure monitoring. Irrigation was continuous and suction intermittent; the suction pressure setting was not recorded. In Group 2, after calibration of the Tidor™ system, the operational upper intrarenal pressure limit was set at 30 mmHg, and the configured ranges for automatic adjustment were 10–100 mL/min for irrigation and 10–50 mmHg for suction; these were settings rather than measured intraoperative ranges. The system allowed adjustment of irrigation and aspiration based on the real-time monitored intrarenal pressure. Before each procedure, the Elephant IV + Tidor™ system was calibrated according to the manufacturer's instructions. Intrarenal pressure was measured at the distal tip of the access sheath through a dedicated pressure-monitoring channel and was continuously displayed on the control unit. In automatic mode, the system adjusted irrigation and suction according to the measured intrarenal pressure to avoid exceeding the operator-set upper limit of 30 mmHg. The intrarenal pressure limit was set at 30 mmHg, corresponding to approximately 40.8 cmH_2O. This value was selected because it is generally considered an acceptable pressure level by most experts in the field and is also recommended by the manufacturer for the Tidor™ system. However, as no universally accepted safety threshold has been established, this value should be regarded as an operational limit rather than an absolute biological cutoff.

Demographic data, stone characteristics, intraoperative parameters, and postoperative data were collected and analyzed. The monitored parameters included duration of intervention, intraoperative visibility, aspiration efficiency, intra- and postoperative complications, postoperative fever, signs of urinary tract infection, need for additional treatment, length of hospital stay, and stone-free status. Operative time was measured from the insertion of the ureteral access sheath until placement of the Foley catheter. This included postoperative stent placement when required, but excluded preoperative stent removal and device setup/calibration, and therefore did not represent the entire operating-room workflow. Anesthesia induction and recovery time were not included. Postoperative complications were recorded during hospitalization and for 30 days after the procedure and were classified according to the Clavien–Dindo system. Postoperative fever was defined as a body temperature ≥ 38.0 °C. Urinary tract infection was defined as compatible urinary symptoms and/or fever associated with a positive urine culture requiring antimicrobial treatment. Mild postoperative hematuria was defined as macroscopically visible hematuria that resolved with conservative management and did not require transfusion, endoscopic intervention, or prolonged catheterization. Postoperative JJ-stent placement was decided by the operating surgeon according to standard intraoperative findings, including ureteral edema or trauma, difficult access-sheath passage, bleeding, residual fragments, prolonged operative time, and suspected postoperative obstruction. These criteria were not formally predefined in the study protocol. Postoperative stent removal was routinely planned at 7 days. Intraoperative stone clearance was assessed by direct endoscopic inspection of the

pyelocaliceal system combined with fluoroscopy. Visibility and aspiration efficiency were assessed subjectively by the operating surgeon, without a standardized scale. Renal ultrasonography was performed on postoperative day 1, before discharge, and was repeated in all patients at the 30-day follow-up. The reported stone-free endpoint was determined from the 30-day imaging assessment as no detectable residual fragments on ultrasonography and was independently derived from the follow-up imaging data rather than carried forward from the early postoperative evaluation. The imaging assessor was unaware of the platform used. In patients with suspected residual stone on 30-day ultrasonography, non-contrast CT was performed for confirmation, and the final stone-free classification was based on the CT findings. The study workflow is summarized in Figure 3.

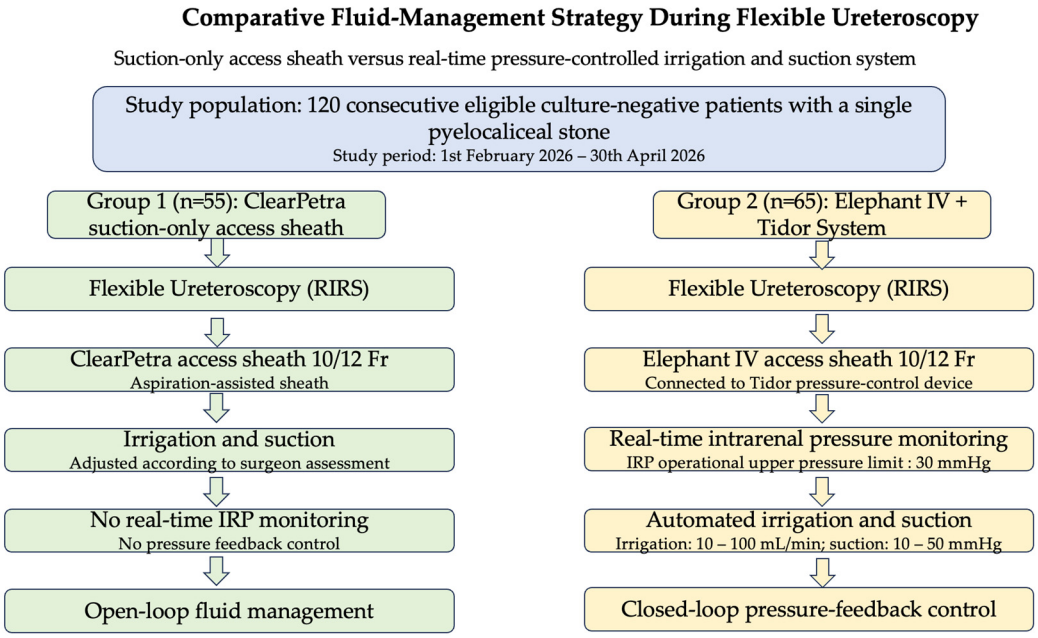


Figure 3. Overview of the two fluid-management platforms and their intraoperative use. This diagram illustrates the treatment configurations rather than patient recruitment.

Data management was performed using Microsoft Excel. Descriptive and univariate statistical analyses were conducted using IBM SPSS Statistics 30, while the multivariable linear regression analysis with heteroscedasticity-robust standard errors was performed using Python with the statsmodels package (version 0.14.6). Continuous variables are presented as mean ± standard deviation (SD), and categorical variables as number and percentage. Normality of continuous variables was assessed using the Shapiro–Wilk test together with visual inspection of Q–Q plots. Homogeneity of variances between groups was evaluated using Levene's test. Although formal normality testing indicated departures from exact normality for some continuous variables, no extreme distributional asymmetry or influential outliers were identified, and both groups included more than 50 patients. Therefore, between-group comparisons of continuous variables were performed using Welch's independent-samples *t*-test, which does not assume equal variances and is robust to moderate departures from normality. Categorical variables were compared using Pearson's chi-square test when expected cell counts were adequate and Fisher's exact test when expected cell counts were <5. No missing data were present for the variables included in the analysis; therefore, no imputation was performed. All statistical tests were two-sided, and a p value < 0.05 was considered statistically significant. Effect estimates are reported with 95% confidence intervals where appropriate. To evaluate whether the observed difference in operative time was independent of baseline stone characteristics, a multivariable linear

regression model was constructed with operative time as the dependent variable. Risk differences for binary outcomes were reported with 95% confidence intervals using the Newcombe–Wilson method. The fluid-management platform (Elephant IV + Tidor™ versus ClearPetra®), maximum stone diameter, stone density, and stone location were entered as independent variables. Maximum stone diameter was used as the measure of stone burden. Stone location was treated as a categorical variable, with renal pelvic location as the reference category. Heteroscedasticity-consistent HC3 robust standard errors were used for coefficient estimation. Multicollinearity was assessed using variance inflation factors (VIF), with no relevant multicollinearity identified (all VIFs < 2). Adjusted regression coefficients are reported with 95% confidence intervals and two-sided p values. Additional model checks included residual normality, the Breusch–Pagan test, Cook's distance, and leave-one-out analyses. A sensitivity analysis repeated the adjusted regression after excluding patients with upper-caliceal stones.

The study was conducted in accordance with the principles of the Declaration of Helsinki and with the institutional regulations regarding medical research and the protection of patient data. The study protocol was approved by the Ethics Committee of the "Saint John" Clinical Emergency Hospital, Bucharest (R614/23.01.2026). Ethical approval covered device use and evaluation in this study and was obtained before the study period. Patients were subsequently identified retrospectively from routine clinical records, and the analysis plan was developed after the procedures had been completed. The study was not prospectively registered.

3. Results

During the analyzed period, 120 consecutive eligible patients with single pyelocaliceal renal stones and a negative preoperative urine culture were included and treated by flexible ureteroscopy. Patients were divided into two groups, depending on the access and fluid management system used intraoperatively. Group 1 included 55 patients treated with the ClearPetra® 10/12 Fr. ureteral access sheath with aspiration, without real-time monitoring of intrarenal pressure. Group 2 included 65 patients treated with the Elephant IV 10/12 Fr. sheath associated with the Tidor™ intelligent pressure control device, which allows for real-time monitoring of intrarenal pressure, irrigation and suction control. The mean age of the patients was comparable between the two groups, with no statistically significant difference. In Group 1, the mean age was 48.7 ± 10.6 years, and in Group 2, 50.0 ± 14.7 years ($p = 0.570$).

Stone characteristics were analyzed according to maximum stone diameter, density expressed in Hounsfield units (HU), and pyelocaliceal location. The mean maximum stone diameter was significantly larger in Group 2 compared with Group 1 (16.2 ± 2.1 mm versus 14.2 ± 1.5 mm, $p < 0.001$). Mean stone density was 1016.3 ± 119.8 HU in Group 1 and 1072.0 ± 150.3 HU in Group 2 ($p = 0.026$). The distribution of stone location also differed significantly between the two groups. In Group 1, stones were predominantly distributed in the upper calyx, lower calyx, and renal pelvis, whereas Group 2 included a higher proportion of pelvic and lower-caliceal stones ($p < 0.001$). Group 1 included 29 male patients (52.7%) and 26 female patients (47.3%), while Group 2 included 39 male patients (60.0%) and 26 female patients (40.0%), with no statistically significant difference between groups ($p = 0.423$). All 120 patients included in the analysis had been prestented approximately 14 days before RIRS and had a negative urine culture obtained within 7 days before definitive surgery. Patients with a positive preoperative urine culture were not included in the study cohort. Demographic data and stone characteristics are presented in Table 1, and stone location in Table 2.

Table 1. ClearPetra® and Group 2 Elephant IV + Tidor™. SD = standard deviation; HU = Hounsfield units.

Parameter	Group 1 ClearPetra® n = 55	Group 2 Elephant IV + Tidor™ n = 65	*p*
Male sex	29 (52.7%)	39 (60.0%)	0.423
Female sex	26 (47.3%)	26 (40.0%)	
Age, years, mean ± SD	48.7 ± 10.6	50.0 ± 14.7	0.570
Maximum stone diameter, mm, mean ± SD	14.2 ± 1.5	16.2 ± 2.1	<0.001
Stone density, HU, mean ± SD	1016.3 ± 119.8	1072.0 ± 150.3	0.026
Number of patients	55	65	-

Data are presented as mean ± SD or n (%), as appropriate. Continuous variables were compared using Welch's independent-samples *t*-test, and categorical variables using Pearson's chi-square test or Fisher's exact test, as appropriate. SD = standard deviation; HU = Hounsfield units.

Table 2. Distribution of pyelocaliceal stone location in the two treatment groups.

Stone Location	Group 1 ClearPetra® (n = 55) n/%	Group 2 Elephant IV + Tidor™ (n = 65) n/%
Pelvic	16/55, 29.1%	32/65, 49.2%
Lower calyx	17/55, 30.9%	24/65, 36.9%
Middle calyx	3/55, 5.5%	8/65, 12.3%
Upper calyx	19/55, 34.5%	1/65, 1.5%

$p < 0.001$, The distribution of stone location between groups was compared using Pearson's chi-square test.

Ureteral access sheath insertion was possible in all cases included in the study. The success rate of access sheath insertion confirmed the feasibility of using both systems under conditions of appropriate patient selection and a prestented ureter. There were no reported cases of impossibility of access sheath placement, conversion to another surgical technique, or interruption of the procedure due to impossibility of retrograde approach. In Group 1, the ClearPetra® sheath allowed aspiration of irrigation fluid, stone fragments, and lithotripsy debris. However, this system did not provide direct information on intrarenal pressure, irrigation and aspiration management being dependent on operator judgment and intraoperative visibility. In Group 2, the use of the Elephant IV and Tidor™ system allowed the integration of real-time monitoring of intrarenal pressure with continuous irrigation and controlled suction. After calibration, the intrarenal pressure limit was set at 30 mmHg, the irrigation flow rate was between 10 and 100 mL/min, and the automatic suction was between 10 and 50 mmHg. During the procedures in Group 2, the intrarenal pressure was maintained within a narrow range, between 5 and 17 mmHg, below the pre-established operational upper pressure limit. This suggests that the pressure control system allowed for dynamic stabilization of intrarenal pressure without compromising endoscopic visibility.

The mean operative time was 53.7 ± 7.7 min in Group 1 and 35.9 ± 11.3 min in Group 2. In the unadjusted analysis, operative time was significantly shorter in Group 2, with a mean between-group difference of −17.8 min when expressed as Group 2 minus Group 1 (95% CI, −21.3 to −14.3; $p < 0.001$).

A multivariable linear regression analysis was subsequently performed to account for differences in baseline stone characteristics. After adjustment for maximum stone diameter, stone density, and stone location, treatment with the Elephant IV + Tidor™ platform remained independently associated with shorter operative time (adjusted mean

difference, −17.4 min; 95% CI, −21.8 to −12.9; $p < 0.001$). The adjusted estimate was similar in magnitude to the unadjusted between-group difference. The multivariable model explained 52.9% of the variability in operative time ($R^2 = 0.529$; adjusted $R^2 = 0.504$). VIFs ranged from 1.13 to 1.63. Residuals departed from normality (Shapiro–Wilk $p < 0.001$) and showed heteroscedasticity (Breusch–Pagan $p = 0.042$); inference used HC3 robust standard errors. Maximum Cook's distance was 0.061, and leave-one-out analyses retained the direction of the diameter and platform associations. After excluding the 20 patients with upper-caliceal stones, the remaining 100 patients (36 ClearPetra and 64 Tidor) showed a similar adjusted difference in operative time: −18.35 min (95% CI −23.31 to −13.38; $p < 0.001$). The complete multivariable model is presented in Table 3.

Table 3. Multivariable linear regression analysis of factors associated with operative time.

Predictor	Adjusted β, min	95% CI	*p* Value
Elephant IV + Tidor™ vs. ClearPetra®	−17.37	−21.82 to −12.92	<0.001
Maximum stone diameter, per 1 mm	−1.18	−2.26 to −0.10	0.033
Stone density, per 1 HU	0.006	−0.006 to 0.018	0.307
Lower calyx vs. renal pelvis	1.59	−2.67 to 5.86	0.460
Middle calyx vs. renal pelvis	−4.27	−10.18 to 1.64	0.155
Upper calyx vs. renal pelvis	−5.41	−9.74 to −1.08	0.015

β = multivariable linear regression coefficient; CI = confidence interval; HU = Hounsfield units. Negative β values indicate shorter operative time. ClearPetra® was the reference fluid-management platform, and renal pelvic location was the reference stone location. HC3 heteroscedasticity-robust standard errors were used. Model $R^2 = 0.529$; adjusted $R^2 = 0.504$.

In Group 1, irrigation and suction were manually adjusted according to intraoperative needs. Although aspiration through the ClearPetra® sheath allowed the evacuation of fragments and maintained adequate visibility, the absence of intrarenal pressure monitoring was an important methodological limitation. In this group, the surgeon did not have objective feedback on intrarenal pressure variations, which may make it difficult to identify transient episodes of intrarenal hyperpressure. In Group 2, the Tidor™ system allowed continuous control of intrarenal pressure, with automatic adjustment of irrigation and suction. Intraoperative visibility was described as very good, with irrigation contributing to cleaning the surgical field by removing blood, stone fragments and detritus. At the same time, automatic suction allowed the evacuation of fluid and fragments without exceeding the set pressure limit. The main intraoperative parameters monitored in the present study are presented in Table 4. Representative intraoperative images of laser lithotripsy with controlled aspiration are shown in Figure 4.

All 120 patients completed the 30-day imaging follow-up, and no patient was lost to follow-up. Renal ultrasonography was performed in all 55 patients in Group 1 and all 65 patients in Group 2. At the 30-day ultrasonographic assessment, residual stone was suspected in five patients in Group 1 and two patients in Group 2. All seven patients underwent confirmatory non-contrast CT, which confirmed residual lithiasis in each case. Accordingly, 50 of 55 patients (90.9%) in Group 1 and 63 of 65 patients (96.9%) in Group 2 were classified as stone-free at 30 days. These classifications were independently derived from the 30-day follow-up imaging and were not carried forward from the early postoperative assessment. All confirmed residual fragments were located in the lower calyx. The identical stone-free counts at the two assessment time points reflect the absence of a change

in stone-free status during follow-up. The between-group difference did not reach statistical significance (Fisher's exact test, $p = 0.245$). The 30-day stone-free results are presented in Table 5. Risk differences are expressed as Group 2 minus Group 1 in percentage points, with 95% confidence intervals calculated using the Newcombe–Wilson method.

Table 4. Main intraoperative parameters and characteristics of fluid management in the two groups.

Parameter	Group 1 ClearPetra®	Group 2 Elephant IV + Tidor™	Between-Group Effect (95% CI)	*p* Value
Successful insertion of the access sheath	55/55, 100%	65/65, 100%	-	-
Operative time, min, mean ± SD	53.7 ± 7.7 min	35.9 ± 11.3 min	−17.8 min (95% CI −21.3 to −14.3)	<0.001
Real-time IRP monitoring	No	Yes	-	-
Operational upper IRP limit	NA	30 mmHg	-	-
IRP interval observed intraoperatively	NA	5–17 mmHg	-	-
Automatically controlled irrigation	No	Yes, 10–100 mL/min	-	-
Automatic suction	No	Yes, 10–50 mmHg	-	-

SD = standard deviation; CI = confidence interval; IRP = intrarenal pressure; NA = not applicable. Mean difference in operative time was calculated as Group 2 minus Group 1 using Welch's independent-samples *t*-test.

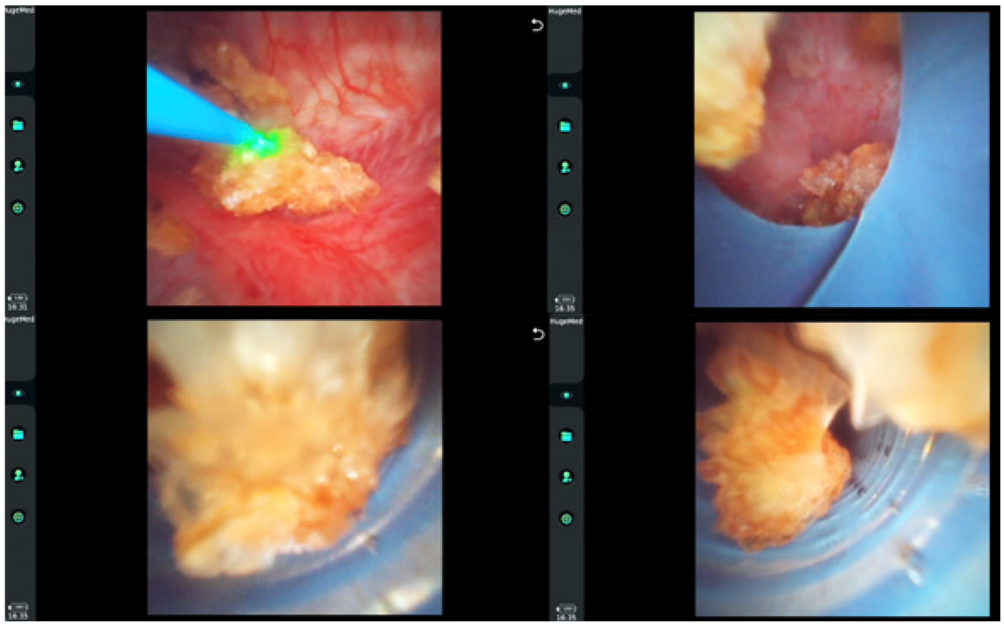


Figure 4. Intraoperative images during laser lithotripsy with controlled aspiration. The use of the Elephant IV ureteral sheath together with the laser fiber is shown, with fragmentation of the stone and simultaneous aspiration of the fragments using the Tidor™ system, to maintain visibility and effectively evacuate the lithiasis detritus.

Table 5. Stone-free status at the 30-day postoperative follow-up in the two treatment groups.

Parameter	Group 1 ClearPetra®	Group 2 Elephant IV + Tidor™	Risk Difference, Percentage Points (95% CI)	*p*
Stone-free, n (%)	50/55 (90.9%)	63/65 (96.9%)	6.0 (−3.1 to 16.7)	0.245
Residual stone detected, n (%)	5/55 (9.1%)	2/65 (3.1%)	−6.0 (−16.7 to 3.1)	0.245

Stone-free status was assessed at 30 days using renal ultrasonography as routine follow-up imaging, with non-contrast CT performed when residual stone was suspected. Between-group comparisons were performed using Fisher's exact test.

Postoperative JJ-stent placement was required in 7 patients (12.7%) in Group 1 and 3 patients (4.6%) in Group 2. Although numerically lower in Group 2, this difference did not reach statistical significance ($p = 0.183$). Mean hospital stay was 1.09 ± 0.29 days in Group 1 and 1.02 ± 0.12 days in Group 2 (Welch's *t*-test, $p = 0.077$). A 2-day hospital stay was required in 5/55 patients (9.1%) in Group 1 and 1/65 patients (1.5%) in Group 2 (Fisher's exact test, $p = 0.092$).

Postoperative complications were minor and classified as Clavien–Dindo grades I–II, without the need for additional interventions. In Group 1 ClearPetra®, 7 complications were recorded out of 55 cases (12.7%). A total of 4 cases of mild postoperative hematuria and 3 cases of transient fever were present. In Group 2 Elephant IV + Tidor™, 3 complications were observed out of 65 cases (4.6%), all of which were mild hematuria. The overall complication rate was numerically lower in Group 2, but the difference did not reach statistical significance ($p = 0.183$). No cases of postoperative fever, fluid extravasation, fornix rupture, sepsis, or major complications were reported in Group 2. Mild hematuria was classified as Clavien–Dindo grade I. The three febrile episodes were classified as grade II because ceftriaxone was continued for one additional day. Blood cultures were negative in all three cases, and discharge was delayed by one day. Although the complication rate was numerically lower in Group 2, the difference was not statistically significant ($p = 0.183$). No major complications were observed in either group. Therefore, the observed difference in minor complications should be considered exploratory and cannot establish a comparative safety advantage. Complication data in the two groups are presented in Table 6. Risk differences are expressed as Group 2 minus Group 1 in percentage points, with 95% confidence intervals calculated using the Newcombe–Wilson method.

Table 6. Minor postoperative complications and adverse events in the two treatment groups.

Parameter	Group 1 ClearPetra®	Group 2 Elephant IV + Tidor™	Risk Difference, Percentage Points (95% CI)	*p*
Overall complications	7/55, 12.7%	3/65, 4.6%	−8.1 (−19.8 to 2.2)	0.183
Mild postoperative hematuria	4/55, 7.3%	3/65, 4.6%	−2.7 (−13.1 to 6.6)	0.701
Transient postoperative fever	3/55, 5.5%	0/65, 0.0%	−5.5 (−14.9 to 1.2)	0.093
Major complications, Fornix rupture/extravasation/sepsis	0/55, 0.0%	0/65, 0.0%	0.0 (−6.5 to 5.6)	-

Between-group comparisons were performed using Fisher's exact test.

The comparative analysis showed a significantly shorter mean operative time in Group 2. Mean hospital stay, stone-free rate, postoperative complication rate, and postoperative JJ-stent placement also differed numerically between groups; however, these differences did

not reach statistical significance and should therefore be interpreted as exploratory findings rather than comparative advantages of the Elephant IV + Tidor™ platform.

4. Discussion

4.1. Intrarenal Pressure and Fluid Management in RIRS

Endoscopic treatment of renal lithiasis by flexible ureteroscopy has undergone significant development in recent years, with the miniaturization of ureteroscopes, the increase in the performance of laser systems and the emergence of access sheaths with additional functions of aspiration and flow control. Currently, the goals of treatment are no longer limited to obtaining a stone-free rate as high as possible, but include reducing infectious complications, decreasing operative time, reducing postoperative morbidity and maintaining a good safety profile. In this context, fluid management and intrarenal pressure control are central elements of safety in retrograde intrarenal surgery (RIRS). Importantly, the present study compared two complete fluid-management platforms rather than isolating the effect of intrarenal pressure monitoring. In addition to pressure feedback, the platforms differed in access sheath design, irrigation delivery, suction regulation, and device operation. Consequently, the observed differences should be interpreted as reflecting the combined performance of the two systems and should not be attributed exclusively to pressure monitoring or automated pressure control.

The present study identified a statistically significant difference in operative time between the two fluid-management platforms, with shorter procedures observed in the Elephant IV + Tidor™ group. Stone-free rate, length of hospital stay, postoperative complication rate, and postoperative JJ-stent placement showed numerical differences favoring Group 2, but none of these comparisons reached statistical significance. Accordingly, these findings should be regarded as exploratory trends and should not be interpreted as evidence of superiority of the Elephant IV + Tidor™ platform for these outcomes.

An important feature of the study is that, in Group 2, intrarenal pressure was maintained intraoperatively between 5 and 17 mmHg, below the pre-established limit of 30 mmHg. This is relevant because recent literature increasingly emphasizes the role of increased intrarenal pressure in the occurrence of pyelovenous, pyelolymphatic, and pyelotubular reflux, mechanisms implicated in postoperative fever, urinary tract infections, urosepsis, and fluid extravasation [3]. In routine practice, the surgeon adjusts irrigation according to visibility, but this approach does not provide objective information about the actual pressure in the pyelocaliceal system. Therefore, transient episodes of intrarenal hypertension may go unnoticed, especially in cases with longer operative time, bleeding, difficult visual field, or insufficient evacuation of fragments.

Sierra et al. demonstrated the feasibility of real-time monitoring of intrapelvic pressure during flexible ureteroscopy using a vascular PressureWire. In their pilot study, pressures varied significantly with operative time and the use of forced irrigation, with significant pressure peaks during lithotripsy and manual irrigation. The authors showed that continuous monitoring allows for the identification and avoidance of potentially dangerous pressure increases [13]. Our results are consistent with this concept, but add an additional element, namely not only monitoring pressure, but also integrating it into a system capable of adjusting irrigation and suction in real time.

In a recently published European Delphi consensus, Somani et al. emphasized that elevated intrarenal pressure is a real concern for patient safety during ureteroscopy. Although no universally accepted threshold for "high pressure" has been established, most experts considered that values above 61–80 cmH_2O may raise safety concerns. The consensus also highlighted that any pressure above the physiological level should be viewed with caution and that further clinical data are needed to define relevant thresholds and patient risk

categories [14]. In this context, the maintenance of low intrarenal pressure in Group 2 of our study represents an important argument in favor of pressure control systems.

Recent experimental data support the same direction. Bai et al. evaluated intrarenal pressure monitoring using optical sensors in a porcine model and demonstrated that pressure is influenced by the type of access sheath, infusion rate, surgical position, and location of the measurement point. In this study, pressure increased with irrigation rate, and a larger access sheath was associated with lower intrarenal pressure values [15]. These observations support the idea that intrarenal pressure is a dynamic parameter, influenced by multiple factors, and that it cannot be accurately assessed based on endoscopic visibility alone.

In the same vein, Yuen et al. evaluated noninvasive intrarenal pressure monitoring devices during flexible ureteroscopy in an in vitro experimental model, reporting a good correlation between the measured values and the actual intrarenal pressure [16]. This type of research supports the current interest in developing more accurate, reproducible, and easily integrated pressure monitoring methods in endourological practice. In comparison, the system used in our study has the advantage of integrating pressure monitoring with automatic irrigation and suction control, which can transform pressure measurement from a simple observed parameter into an active intraoperative safety mechanism.

4.2. The Role of Active Aspiration and Comparison with Modern Ureteral Access Technologies

The role of ureteral access sheaths in reducing intrarenal pressure and improving drainage has been known for some time. Wright et al. showed, in a porcine model, that the size of the access sheath significantly influences both irrigation flow and intrarenal pressure. A 12/14 Fr. sheath allowed better flow and lower pressures compared to a 10/12 Fr. sheath, and the use of hand pumps caused marked increases in pressure, especially in the smaller caliber sheaths [17]. These data are important for the interpretation of our results, because both groups used 10/12 Fr. sheaths, but only Group 2 benefited from pressure feedback and automatic adjustment of suction and irrigation. Thus, the differences observed between groups appear to be related to the type of fluid management rather than the simple presence of an access sheath.

In the randomized trial by Eldib et al., the use of a flexible, navigable sheath with suction was associated with a higher stone-free rate, shorter operative time, and lower infection rate compared with a traditional sheath [18]. These results are similar to the direction observed in our study, in which Group 2 had a mean operative time of 35.9 min compared with 53.7 min in Group 1, a numerically higher stone-free rate, and a numerically lower complication rate.

Recent meta-analyses on the use of suction in ureteroscopy also confirm a potential benefit on stone-free rate, infectious complications, and length of hospital stay. Tzelves et al. reported that the use of suction through access sheaths, catheters, or ureteroscopes can improve stone-free rate and reduce overall and infectious complications, although the authors emphasize the need for further randomized trials to standardize indications and protocols [19]. Similarly, meta-analyses dedicated to FANS-UAS have suggested advantages over standard sheaths in terms of fragment clearance and safety, but have highlighted heterogeneity of studies and lack of uniform protocols [20,21]. Our study follows this direction, but differs by comparing a suction sheath without pressure monitoring with a sheath associated with an intelligent intrarenal pressure control system.

4.3. Clinical Impact, Study Limitations and Future Perspectives

A relevant finding of the present study was the significantly shorter operative time observed in the Elephant IV + Tidor™ group. Because the two groups differed significantly in baseline stone characteristics, an adjusted analysis was performed to account for potential

confounding. In the multivariable linear regression model, the association between the Elephant IV + Tidor™ platform and shorter operative time persisted after adjustment for maximum stone diameter, stone density, and stone location. The adjusted mean difference was −17.4 min (95% CI, −21.8 to −12.9; $p < 0.001$), closely resembling the unadjusted difference of −17.8 min. This consistency suggests that the observed association with operative time was not explained by the measured differences in these stone characteristics. Nevertheless, given the observational and non-randomized design of the study, residual confounding from unmeasured factors cannot be excluded and the finding should not be interpreted as demonstrating causality. The inverse association between stone diameter and operative time was unexpected and was also present within each group. Its explanation remains uncertain and may involve unmeasured factors; it should not be interpreted as a causal effect of stone size.

The 30-day stone-free rate was 96.9% in Group 2 and 90.9% in Group 1. Although numerically higher in Group 2, this difference did not reach statistical significance ($p = 0.245$) and should therefore be interpreted as an exploratory numerical difference rather than evidence of improved stone clearance with the Elephant IV + Tidor™ platform. Although evaluated in a PCNL cohort, Kingma et al. demonstrated that even small residual fragments (≤4 mm) were associated with higher rates of stone-related events and reinterventions compared with a completely stone-free status, emphasizing the clinical relevance of complete stone clearance [22].

Postoperative complications were minor in both groups and occurred numerically less frequently in Group 2 (4.6% versus 12.7%); however, this difference was not statistically significant ($p = 0.183$). No postoperative fever was observed in Group 2 compared with three cases in Group 1, but the low number of events precludes conclusions regarding a potential effect of the fluid-management platform on infectious morbidity.

Intrarenal reflux may occur at relatively low pressures, depending on papillary morphology and renal compliance, supporting caution when defining a universal safety threshold [23]. Good visibility was subjectively reported with the Elephant IV + Tidor™ system, but no comparative improvement was established. In RIRS, visibility is essential for stone identification, laser guidance and avoidance of mucosal damage. However, increasing irrigation to improve visibility may result in pressure increases. Pressure feedback systems can partially resolve this conflict by allowing for an adequate field of view by simultaneously adjusting irrigation and suction. Thus, the surgeon is no longer solely dependent on subjective assessment of visibility, but benefits from an objective safety parameter.

Another relevant aspect is the association between miniaturization of ureteroscopes and aspiration efficiency. In our study, all procedures were performed with the HugeMed 6.3 Fr. disposable ureteroscope, which offers a favorable ratio between the diameter of the ureteroscope and the lumen of the access sheath. Recent experiments with FANS sheaths have shown that a thinner ureteroscope allows a larger drainage surface around the instrument and may increase the efficiency of fragment aspiration. Menzies-Wilson and colleagues observed, in an experimental model, that FANS associated with a 6.3 Fr. ureteroscope allowed for superior particle clearance compared with larger ureteroscopes [24]. However, the same 6.3 Fr ureteroscope was used in both groups, so its caliber cannot explain the observed between-group difference in operative time.

The results of this study should be interpreted in light of several limitations. First, this was a single-center, retrospective, non-randomized observational study, and allocation to the two treatment groups depended on device availability. The groups differed significantly in maximum stone diameter, stone density, and pyelocaliceal location, which may have influenced the results. The imbalance in upper-caliceal stones (19 versus 1) further limits comparability; however, a sensitivity analysis excluding these patients yielded a

similar adjusted difference in operative time. For operative time, a multivariable analysis adjusted for these variables was performed and the association with the Elephant IV + Tidor™ platform remained statistically significant. However, residual confounding cannot be excluded. Binary outcomes such as stone-free status, postoperative stenting, and complications were not adjusted because of the low number of events and should therefore be considered exploratory. Although the operative-time analysis accounted for measured stone characteristics, residual confounding from unmeasured patient-related factors remains possible, particularly for postoperative complications. In addition, only patients with a negative urine culture within 7 days before surgery were included. However, data on previous urinary tract infections and diabetes mellitus were not available for analysis. Patients with positive cultures were treated and were not included in the analyzed cohort. Because the retrospective dataset included only the final eligible culture-negative cohort, the total number of RIRS candidates initially screened, including those excluded because of a positive urine culture, could not be reconstructed. Consequently, the overall preoperative screening denominator and the number of patients excluded on the basis of urine-culture status cannot be reported.

Second, intrarenal pressure was measured only in the Elephant IV + Tidor™ group, so a direct comparison of intrarenal pressure between the two groups was not possible. The two systems also differed in several technical aspects, including sheath design, irrigation, suction, and pressure monitoring; therefore, the observed differences cannot be attributed to a single component of the system. All procedures were performed by the same experienced surgeon, which reduced operator variability but may limit the generalizability of the results. In addition, intraoperative visibility and the decision to place a postoperative JJ-stent were based on the surgeon's clinical judgment and were not independently assessed.

Other limitations include the absence of a predefined primary endpoint, the lack of prospective study registration, and the low number of complications. Stone burden in the present study was assessed using maximum stone diameter, which was documented during the preoperative CT evaluation and served as the imaging parameter for patient eligibility. Accordingly, all analyses involving stone burden in the revised manuscript are based on maximum stone diameter. Finally, stone-free status at 30 days was routinely assessed by ultrasonography, while non-contrast CT was performed only when residual stone was suspected. Because CT was not systematically performed in all patients, small residual fragments may have been missed and the stone-free rate may have been overestimated. Larger prospective, randomized studies with standardized postoperative imaging are needed to confirm these findings. This study provides preliminary comparative data on suction-based fluid management with and without pressure feedback, while acknowledging that the contribution of individual system components cannot be separated.

5. Conclusions

In this non-randomized comparative study, the Elephant IV + Tidor™ platform was associated with a shorter operative time after adjustment for maximum stone diameter, stone density, and stone location. The adjusted mean difference was −17.4 min (95% CI, −21.8 to −12.9). Intrarenal pressure remained within a low range during procedures performed with the Elephant IV + Tidor™ system. The 30-day stone-free rate, postoperative JJ-stent placement, complications, and hospital stay showed numerical differences between groups, but these were not statistically significant. Further prospective randomized studies are needed to confirm these findings.

Author Contributions: Conceptualization, P.A.G., C.M. and B.G.; methodology, P.A.G., C.M., C.A.B. and B.G.; software, C.A.B., D.A.G. and C.V.E.; validation, P.A.G., C.A.B. and D.A.G.; formal analysis,

C.A.B., C.V.E. and B.G.; investigation, C.M., R.D.M. and C.V.E.; resources, C.A.B., R.D.M., D.A.G. and C.V.E.; data curation, C.M., C.A.B., R.D.M., D.A.G., C.V.E. and B.G.; writing—original draft preparation, C.M., C.A.B., R.D.M., D.A.G. and C.V.E.; writing—review and editing, P.A.G. and B.G.; visualization, C.M., R.D.M., C.V.E. and B.G.; supervision, P.A.G. and B.G.; project administration, P.A.G. and B.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of "Saint John" Clinical Emergency Hospital, no. R614/23.01.2026 (approval date 23 January 2026).

Informed Consent Statement: Written informed consent was obtained from all patients prior to admission and surgery, including agreement for the endoscopic procedure and for the use of anonymized clinical and perioperative data for scientific and research purposes. The manuscript does not include any information that would allow identification of patients.

Data Availability Statement: The data presented in this study are available on request from the corresponding author due to patient confidentiality restrictions and ethical considerations.

Acknowledgments: The authors used ChatGPT (OpenAI, GPT 5.6) exclusively for the final drafting and linguistic finishing of the manuscript. All AI-assisted content was reviewed and edited by the authors, who take full responsibility for the final content. The Tidor™ system and Elephant IV sheaths were supplied free of charge for trial use, subject to availability. The manufacturer provided technical support. ClearPetra® sheaths were available through routine hospital supplies. No financial support was received.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Talyshinskii, A.; Hameed, B.M.Z.; Naik, N.; Guliev, B.; Zhanbyrbekuly, U.; Khairley, G.; Juliebø-Jones, P.; Somani, B.K. Miniaturization of flexible ureteroscopes: A comparative trend analysis of 59 flexible ureteroscopes. *Urolithiasis* **2023**, *52*, 16. [CrossRef] [PubMed]
2. Mitroi, G.F.; Drăgoescu, P.O.; Mitroi, M.R.; Mitroi, G.G.; Dudan, I.B.; Popescu, T.C.T.; Nedelcuță, C.M.; Drocaș, A.I. Clinical Outcomes and Safety Assessment of Flexible Ureteroscopy as an Outpatient Procedure: A Retrospective Single-Center Study. *Life* **2024**, *14*, 1131. [CrossRef] [PubMed]
3. Punga, A.M.; Ene, C.; Bulai, C.A.; Georgescu, D.A.; Multescu, R.; Georgescu, D.E.; Geavlete, B.; Geavlete, P. Complications of Single-Use Flexible Ureteroscopy vs. Reusable Flexible Ureteroscopy: A Narrative Review. *Cureus* **2024**, *16*, e76256. [CrossRef] [PubMed]
4. Hong, A.; Browne, C.; Jack, G.; Bolton, D. Intrarenal pressures during flexible ureteroscopy: An insight into safer endourology. *BJU Int*. **2024**, *133*, 18–24. [CrossRef] [PubMed]
5. Huang, Y.; Liu, S.; Yuen, S.K.K.; Gauhar, V.; Pang, X.; Zhang, G.; Liu, W.; Zhou, J.; Huang, Q.; Zeng, G.; et al. Effect of Conventional Versus Flexible and Navigable Suction Ureteral Access Sheaths on Ureteral Temperature Modulation During High-power Ho:YAG Laser Lithotripsy: An In Vitro Evaluation. *Eur. Urol. Open Sci.* **2026**, *84*, 62–69. [CrossRef] [PubMed]
6. Tsaturyan, A.; Peteinaris, A.; Ventimiglia, E.; Sargsyan, H.; Muradyan, A.; Sener, T.E.; Keller, E.X.; De Coninck, V.; Esperto, F.; Mykoniatis, G.; et al. Aspiration properties of flexible and navigable suction ureteral access sheath (FANS) and flexible ureteroscope with direct-in-scope suction (DISS): An in-vitro experimental study by EAU young academic urologists (YAU) urolithiasis and endourology working group. *Int. Urol. Nephrol.* **2025**, *57*, 2371–2377. [CrossRef] [PubMed]
7. Fulla, J.; Larenas, F.; Saldivia, D.; Ibañez, H.; Elorrieta, V.; Sanchez, C.; Salvadó, J.A. Automated intrarenal pressure control in flexible ureteroscopy using an integrated ureteroscope pressure measurement and fluid management system: First-in-human use. *World J. Urol.* **2025**, *44*, 45. [CrossRef] [PubMed]
8. Deng, X.; Chen, Y.; Zhai, Q.; Song, L.; Du, C.; Tan, W. Fluid absorption during flexible ureteroscopy with intelligent control of renal pelvic pressure: A randomized controlled trial. *World J. Urol.* **2024**, *42*, 331. [CrossRef] [PubMed]
9. Chen, K.W.; Koo, K.C.; Zhong, T.; Ren, R.; Wong, V.K.; Almousa, S.; Levitt, M.; Guennoun, A.; Chew, B.H.; Bhojani, N. Real time monitoring of intrarenal pressures while using the flexible and navigable suction ureteral access sheath. *World J. Urol.* **2025**, *43*, 76. [CrossRef] [PubMed]
10. Duan, H.; Xu, B.; Xie, T. Flexible negative pressure suction ureteral access sheath combined with ureteroscopy in the treatment of upper urinary tract calculi: A meta-analysis. *Medicine* **2025**, *104*, e45933. [CrossRef] [PubMed]

11. Yaşar, H.; Aşik, A.; Erdoğan, E.; Sarica, G.; Aydin, A.; Yildirim, S.; Sarica, K. Prediction of Residual Fragments After Flexible Ureteroscopic Stone Management: A Critical Evaluation Based on Patient- and Stone-Related Parameters. *J. Clin. Med.* **2025**, *14*, 4739. [CrossRef] [PubMed]
12. Yuen, S.K.K.; Zhong, W.; Chan, Y.S.; Castellani, D.; Bhojani, N.; Agarwal, M.S.; Tokas, T.; Croghan, S.; Jung, H.; Herrmann, T.; et al. Global Research on Intra-renal Pressure Collaborative Group. Current utility, instruments, and future directions for intra-renal pressure management during ureteroscopy: Scoping review by global research in intra-renal pressure collaborative group initiative. *Ther. Adv. Urol.* **2025**, *17*, 17562872251314809. [CrossRef] [PubMed]
13. Sierra, A.; Corrales, M.; Kolvatzis, M.; Doizi, S.; Traxer, O. Real Time Intrarenal Pressure Control during Flexible Ureterorrenscopy Using a Vascular PressureWire: Pilot Study. *J. Clin. Med.* **2022**, *12*, 147. [CrossRef] [PubMed]
14. Somani, B.; Davis, N.; Emiliani, E.; Göcke, M.I.; Jung, H.; Keller, E.X.; Miernik, A.; Proietti, S.; Turney, B.; Wiseman, O.; et al. Intrarenal Pressure Monitoring During Ureteroscopy: A Delphi Panel Consensus. *Eur. Urol. Open Sci.* **2025**, *73*, 43–50. [CrossRef] [PubMed]
15. Bai, J.; Chi, Y.; Shangguan, T.; Lin, J.; Ye, Y.; Liu, R.; Chen, R.; Huang, J.; Wen, Y.; Cai, W.; et al. Intrarenal pressure detection during flexible ureteroscopy with fiber optic pressure sensor system in porcine model. *Sci. Rep.* **2024**, *14*, 9446. [CrossRef] [PubMed]
16. Yuen, S.K.K.; Chen, Z.; Yuen, S.; Liu, A.Q.; Leung, C.H.; Ko, I.C.H.; Chan, C.K.; Somani, B.; Herrmann, T.; Jung, H.; et al. Novel non-invasive intrarenal pressure monitoring devices in flexible ureteroscopy: An in-vitro comparative study. *World J. Urol.* **2025**, *43*, 402. [CrossRef] [PubMed]
17. Wright, A.; Williams, K.; Somani, B.; Rukin, N. Intrarenal pressure and irrigation flow with commonly used ureteric access sheaths and instruments. *Cent. Eur. J. Urol.* **2015**, *68*, 434–438. [CrossRef] [PubMed]
18. Eldib, H.; Abdelrahman, M.; Nouh, I.; Mobarak, M.; Farag, M. Efficacy and safety of bilateral same session flexible ureteroscopy using flexible and navigable suction ureteral access sheath (FANS) versus conventional access sheath: A prospective randomized comparative study. *World J. Urol.* **2025**, *44*, 66. [CrossRef] [PubMed]
19. Tzelves, L.; Geraghty, R.; Juliebø-Jones, P.; Yuan, Y.; Kapriniotis, K.; Castellani, D.; Gauhar, V.; Skolarikos, A.; Somani, B. Suction use in ureterorenoscopy: A systematic review and meta-analysis of comparative studies. *BJUI Compass* **2024**, *5*, 1009–1026. Erratum in *BJUI Compass* **2024**, *5*, 1324–1329. https://doi.org/10.1002/bco2.482. [CrossRef] [PubMed]
20. Liu, Q.; Zeng, T.; Zhu, S. Flexible and navigable suction ureteral access sheath versus traditional ureteral access sheath for flexible ureteroscopy in renal and proximal ureteral stones: A meta-analysis of efficacy and safety. *BMC Urol.* **2025**, *25*, 127. [CrossRef] [PubMed]
21. Alnadhari, I.; Abdeljaleel, O.; Ali, O.; Shamsodini, A.; Al-Ansari, A.; Salah, M. Comparison between flexible and navigable suction ureteral access sheath and standard ureteral access sheath during flexible ureteroscopy for the management of kidney stone: Systematic review and meta-analysis. *BMC Urol.* **2025**, *25*, 115. [CrossRef] [PubMed]
22. Kingma, R.A.; Doppen, C.; Bus, M.T.J.; Altobelli, E.; de Jong, I.J.; Roemeling, S. The significance of clinically insignificant residual fragments after percutaneous nephrolithotomy: An analysis into the relevance of complete stone clearance. *World J. Urol.* **2024**, *42*, 78. [CrossRef] [PubMed]
23. Lykkegaard, E.G.; Jung, H. Intrarenal Pressure During Ureteroscopy. *Eur. Urol. Focus* **2025**, *11*, 709–711. [CrossRef] [PubMed]
24. Menzies-Wilson, R.; Williams, J.; Ayyappan, K.; Ruiken, T.; Rhodes, C.; Turney, B. Flexible and navigable suction access sheaths: What size stone particles can be cleared? *BJU Int.* **2026**, *137*, S71–S77. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.