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ARTICLE

Optimizing postoperative pain relief with a novel technique: intraluminal lidocaine administration during retrograde intrarenal surgery

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Objectives: *Retrograde intrarenal surgery (RIRS) has become an increasingly preferred minimally invasive option for the management of kidney stones. However, postoperative pain remains a major clinical concern that may adversely affect patient comfort and recovery. This study aimed to evaluate whether intraluminal administration of lidocaine at the end of RIRS could effectively reduce postoperative pain and analgesic requirements.*
Methods: *A total of 61 patients who underwent RIRS between March and July 2024 were evaluated. Four patients were excluded due to residual stones, and five due to a history of cardiac arrhythmia, leaving 52 patients for analysis. Patients were divided into two groups according to the use of intraluminal lidocaine: Group L (Lidocaine Group, n = 27) received 100 mg of lidocaine prior to DJ stent placement, whereas Group C (Control Group, n = 25) did not. Demographic and stone-related parameters were recorded. Postoperative pain was assessed using the Visual Analog Scale (VAS) at 1, 4, 8, 12, and 24 h, and postoperative analgesic use was documented.*
Results: *No significant differences were observed between the groups regarding demographic characteristics, stone parameters, or preoperative pain scores. However, postoperative VAS scores were significantly lower in Group L at the 8th and 12th hours ($p = 0.041$ and $p = 0.028$, respectively). Moreover, total postoperative analgesic consumption was significantly lower in Group L ($p = 0.027$), supporting the analgesic efficacy of intraluminal lidocaine administration.*
Conclusion: *Intraluminal lidocaine administration at the end of RIRS appears to be a safe, feasible, and effective method for reducing postoperative pain and minimizing analgesic requirements. These findings suggest that the technique may contribute to improved postoperative recovery, although larger multicenter studies are warranted to confirm its clinical value.*

Key Words: Retrograde intrarenal surgery (RIRS), local anesthesia, pain, lidocaine, novel technique

Introduction

The widespread adoption of recent technological advancements has contributed to the growing popularity of retrograde intrarenal surgery (RIRS), a minimally invasive technique for the management of renal calculi.[1] Although RIRS is generally considered a safe and effective procedure, certain complications

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may occasionally arise.[2] Among these, postoperative pain represents one of the most frequent and clinically significant challenges, yet it has been relatively underexplored in the literature.[3]

Several factors have been reported to influence postoperative pain following RIRS, including calyceal rupture, operative duration, stone size, and stone-free status.[4] Additionally, disruption of ureteral blood flow—particularly in cases of mucosal injury or ureteral stenosis—may also contribute to pain. Elevated intrapelvic pressure (IPP) during the procedure has been associated with calyceal rupture, perirenal extravasation, infection, and postoperative discomfort. Therefore, maintaining a low IPP during minimally invasive stone surgery is regarded as a key determinant of favorable outcomes.[5] Intraluminal administration of isoproterenol, a beta-receptor agonist, has been demonstrated to reduce intrarenal pressure during ureteroscopy by promoting relaxation of ureteral smooth muscle.[6]

As an alternative surgical approach, percutaneous nephrolithotomy (PNL) has been extensively investigated with respect to postoperative pain.[7,8] Previous studies have shown that the percutaneous application of local anesthetic agents can effectively reduce postoperative discomfort.[7,8] With the increasing utilization of RIRS, similar strategies for pain management have gained growing attention. Postoperative pain after RIRS may arise from ischemia–reperfusion injury, mucosal trauma during stone fragmentation, or capsular tension secondary to irrigation pressure. One study suggested that administration of a single preoperative dose of corticosteroids may attenuate ischemia–reperfusion injury in the ureter.[9] Based on these pathophysiological mechanisms, intraluminal administration of local anesthetics into the ureteral lumen and collecting system may offer a potential means of reducing postoperative pain. However, to our knowledge, no previous studies have specifically evaluated the efficacy of local anesthetics in minimizing postoperative discomfort following RIRS.

We therefore aimed to investigate the effectiveness of intraluminal lidocaine administration into the collecting system at the conclusion of RIRS in reducing postoperative pain and the subsequent need for additional analgesics.

Methods

Study design

This retrospective study included 61 patients who underwent RIRS at the Bursa Uludag University Department of Urology between 01 March 2024, and 30 July 2024. All procedures were conducted in accordance with the ethical standards of the Mudanya University Health Sciences Ethics Committee (Reference No.: E-40839601-50.04-64) and with the principles outlined in the Declaration of Helsinki (1975, revised 2008). Written informed consent was obtained from all participants prior to inclusion in the study.

Four patients who did not achieve stone-free status and five patients with a history of cardiac arrhythmia were excluded. After applying the exclusion criteria, a total of 52 patients were included in the final analysis. Among them, 27 patients who received intraluminal lidocaine were classified as the Lidocaine Group (Group L), whereas 25 patients who did not receive the drug were assigned to the Control Group (Group C). VAS scores were recorded prospectively, and all data were analyzed retrospectively.

Demographic and clinical characteristics, including age, sex, body mass index (BMI), stone location, stone size, number of stones, stone-free status, and operation time, were recorded for all patients. Some patients presented with multiple stones in different renal regions; therefore, the total number of stone locations exceeded the total number of participants. Postoperative VAS scores were evaluated at 1, 4, 8, 12, and 24 h after surgery, and the number of postoperative analgesic doses administered within this period was documented.

This study was designed as a single-blind trial. Patients were blinded to the treatment allocation, whereas the operating surgeon was aware of group assignments since the preparation and administration of lidocaine required direct intraoperative handling.

Stone-free status

Routine postoperative ultrasonography was performed at the second postoperative week in accordance with our institutional protocol. In line with previous reports, patients with residual fragments $\leq$3 mm were considered stone-free. This criterion was applied for both inclusion and exclusion. Patients who failed to achieve stone-free status (n = 4) were excluded from the study.

Inclusion and exclusion criteria

Patients aged 18 years or older who underwent RIRS during the specified study period, achieved postoperative stone-free status, and had no cardiac risk were included. Exclusion criteria consisted of the following: Age <18 years; Failure to achieve stone-free status; History of cardiac arrhythmia; Presence

of neurological disorders affecting pain perception (e.g., stroke); Diagnosis of insulin-dependent diabetes mellitus; Pre-stenting (double-J stent placement prior to RIRS), which could influence postoperative pain evaluation.

Anesthesia protocol

All patients underwent general anesthesia. Induction was achieved with intravenous propofol (200 mg/20 mL) and fentanyl (1–2 µg/kg or 100 µg/2 mL), followed by maintenance with sevoflurane. No additional analgesics were administered intraoperatively. At the completion of the procedure, patients in the Lidocaine Group (Group L) received 100 mg of lidocaine intraluminally in accordance with the surgical protocol.

Postoperative pain assessment and analgesic protocol

Postoperative pain intensity was evaluated using the VAS at 1, 4, 8, 12, and 24 h postoperatively. If a patient's VAS score was ≥6 at any time point, intravenous dexketoprofen trometamol (50 mg/2 mL, NSAID) was administered. One hour later, the VAS score was reassessed; if it decreased below 6, no further analgesic was given. In cases where a second analgesic dose was required within 4 h, intravenous paracetamol (10 mg/mL) was used as rescue therapy. Total postoperative analgesic consumption within the first 24 h was documented for each patient.

All patients had sterile preoperative urine cultures. Cardiac risk assessment was performed by a cardiologist using electrocardiography (ECG) findings and medical history. Only patients with no cardiac risk were included. The number, size, and localization of stones were determined using preoperative abdominal computed tomography.

All surgeries were performed by a single experienced surgeon (Hakan Kilicarslan), who has performed RIRS procedures for more than 10 years and has experience of over 700 cases.

Surgical technique

All procedures were performed under general anesthesia with the patient in the lithotomy position. The irrigation fluid height was standardized to 60 cm above the renal level. Two atraumatic soft sensor guidewires (0.035 in × 150 cm, Boston Scientific, MA, USA) were introduced into the renal pelvis under fluoroscopic guidance. Using one of these guidewires, a 7.5F flexible renoscope (Flex X2, Karl Storz SE & Co. KG, Germany) was advanced into the kidney without employing a ureteral access sheath (UAS), and laser lithotripsy was performed with a Holmium:YAG laser system.

During lithotripsy, fragmentation was performed at 1.2 J and 10 Hz, while dusting was conducted at 0.6 J and 20 Hz (Dornier Medilas H Solvo, Dornier MedTech GmbH, Germany). Following completion, contrast medium was administered through the renoscope to ensure the absence of extrarenal leakage. Each calyx was carefully examined to confirm complete stone clearance. Retrograde pyelography was subsequently performed for final confirmation of stone-free status.

For patients in the Lidocaine Group (Group L), 1 mL of 10% lidocaine (100 mg; Aritmal®, Osel, Istanbul, Turkey) was diluted with 9 mL of saline to obtain a total of 10 mL. After discontinuation of irrigation, this solution was instilled into the renal pelvis and ureteral lumen via the 7.5F flexible renoscope (Flex X2, Karl Storz SE & Co. KG, Germany) to ensure adequate mucosal contact. With the renoscope in place, ureteral outflow was temporarily halted, allowing the lidocaine solution to remain in contact with the urothelium for approximately 10 min.

Flow Restriction Technique

Outflow restriction was achieved by maintaining the renoscope within the ureter in a stable position, which mechanically limited passive efflux. Importantly, no ureteral access sheath was used during this step, which further minimized drainage and allowed the instilled solution to remain within the collecting system throughout the dwell period. This maneuver effectively preserved the lidocaine solution in the lumen for approximately 10 min, ensuring consistent exposure of the urothelium.

Subsequently, a 4.7F, 26 cm double-J (DJ) stent was inserted into the renal pelvis. The correct stent length and appropriate coiling of both proximal and distal ends were confirmed fluoroscopically. Since postoperative pain may be related to stent malposition, a urinary tract radiograph was routinely obtained 24 h postoperatively to verify appropriate stent positioning.

Statistical analysis

The normality of continuous variables was assessed using the Shapiro-Wilk test. Continuous data were expressed as mean ± standard deviation or as median (range), according to data distribution, whereas categorical variables were presented as frequencies (n) and percentages (%). Between-group comparisons of continuous variables were performed using the independent samples *t*-test for normally distributed data and the Mann-Whitney *U* test for non-normally

TABLE 1. **Comparison of demographic data between the groups**

Parameter	Group L (n = 27)	Group C (n = 25)	*p*-value
Age (years)	54 (26–71)	51 (24–68)	0.526
BMI (kg/m²)	29.0 (19.1–53.2)	28.1 (18.0–45.2)	0.541
Sex			0.671
-Female	14 (52%)	12 (48%)	
-Male	13 (48%)	13 (52%)	
Operation time (min)	50 (30–75)	47 (28–70)	0.857
Stone size (mm)	21 (9–35)	18 (7–40)	0.271
Stone number	1 (1–3)	1 (1–4)	0.337
Stone location			
-Upper	3 (11%)	2 (8%)	0.235
-Middle	4 (15%)	7 (28%)	0.306
-Lower	9 (33%)	8 (32%)	0.771
-Pelvis	16 (59%)	18 (72%)	0.239

Note. Data are expressed as median (range) or n (%). BMI: Body Mass Index, min: minutes, mm: millimeter.

distributed data. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate.

All statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). A two-tailed p-value of <0.05 was considered to indicate statistical significance.

Results

According to the findings of our study, there were no statistically significant differences between Group L and Group C in terms of demographic parameters, including age ($p = 0.526$), body mass index (BMI; $p = 0.541$), sex distribution ($p = 0.671$), or operation duration ($p = 0.857$). Similarly, stone-related characteristics such as stone size ($p = 0.271$), stone number ($p = 0.337$), and stone location (upper, middle, lower calyces, and renal pelvis; $p = 0.235$, 0.306, 0.771, and 0.239, respectively) did not differ significantly between the groups (Table 1).

No intraoperative complications, including calyceal rupture or extravasation of irrigation fluid, were observed, as confirmed by retrograde pyelography. Postoperatively, none of the patients experienced fever, infection, or complications related to increased intrapelvic pressure. Therefore, classification according to the Clavien–Dindo system was not applicable beyond these findings. All patients included in the study were confirmed to be stone-free, as those with residual fragments had already been excluded from analysis. Consequently, the potential impact of calyceal rupture or urinary tract infection on postoperative pain scores could not be evaluated. No complications associated with DJ stent migration or malposition were encountered. All patients were hospitalized overnight and discharged the following day.

When postoperative pain scores were analyzed, VAS values were comparable between groups at 1 h ($p = 0.130$), 4 h ($p = 0.065$), and 24 h ($p = 0.077$) after surgery. However, statistically significant differences were detected at 8 h ($p = 0.041$) and 12 h ($p = 0.028$), favoring Group L (Table 2).

The proportion of patients requiring postoperative analgesia was consistently lower in Group L compared to Group C: 20% vs. 36% at 1 h, 12% vs. 48% at 4 h, 4% vs. 24% at 8 h, 4% vs. 16% at 12 h, and 0% vs. 8% at 24 h. In line with these findings, median postoperative analgesic consumption was significantly higher in Group C (median: 2, range: 0–4) than in Group L (median: 0, range: 0–2; $p = 0.027$) (Table 3).

Throughout the postoperative period, no patients developed cardiac arrhythmias or allergic reactions associated with the use of lidocaine.

Discussion

Postoperative pain following kidney stone surgery remains a significant clinical concern that can adversely affect patients' quality of life.[10] Therefore, effective management strategies, particularly

TABLE 2. **Visual analogue scores (VAS) of participants according to postoperative hours**

Postoperative hour	Group L (n = 27)	Group C (n = 25)	*p*-value
1 h	0 (0–10)	0 (0–10)	0.130
4 h	0 (0–8)	2 (0–10)	0.065
8 h	0 (0–6)	3 (0–6)	0.041*
12 h	0 (0–2)	4 (0–6)	0.028*
24 h	0 (0–1)	0 (0–3)	0.077

Note. *$p < 0.05$; Data expressed as median (range).

TABLE 3. **Number of painkillers administered at different postoperative time points**

Postoperative hour	Group L (n = 27)	Group C (n = 25)	*p*-value
1 h	5 (19%)	9 (36%)	0.654
4 h	3 (11%)	12 (48%)	0.247
8 h	1 (4%)	6 (24%)	0.189
12 h	1 (4%)	4 (16%)	0.247
24 h	0 (0%)	2 (8%)	0.508
Postoperative medication count	0 (0–2)	2 (0–4)	0.027*

Note. *$p < 0.05$; Data expressed as median (range) or n (%).

those that minimize opioid use, are of great importance. According to the 2018 American Urological Association guidelines, opioids should be administered at the lowest effective dose and for the shortest possible duration.[11] Non-steroidal anti-inflammatory drugs (NSAIDs) provide an important alternative by inhibiting prostaglandin synthesis in ureteral smooth muscle, thereby facilitating pain control in both renal colic and postoperative settings.[12]

The literature contains limited data regarding the degree and management of postoperative pain following RIRS.[13] To the best of our knowledge, this is the first study to evaluate the effects of intraluminal local anesthetic administration on postoperative pain after RIRS. In a previous PNL study involving 135 patients, local anesthetic agents were administered peritubally during the procedure, and while postoperative VAS scores were lower at 8, 12, and 24 h in the treated group, no significant differences were observed at 1 and 4 h.[8] Consistent with these findings, our study demonstrated significantly lower VAS scores in Group L at the 8th and 12th postoperative hours, while scores at earlier and later time points were comparable between the two groups. Furthermore, postoperative analgesic requirements were significantly reduced in Group L compared to Group C, similar to the results reported in earlier studies.[8,14]

The absence of significant differences in early postoperative VAS scores (1–4 h) may be attributed to the residual effects of perioperative anesthesia, including fentanyl and propofol administration, as well as the transient cooling and mechanical effects of continuous irrigation during RIRS. The consistently low median VAS scores observed in the lidocaine group (median: 0 at all time points) reflect the effectiveness of the local anesthetic action of intraluminal lidocaine. Although the median value was zero, the range indicates that mild pain was still reported in some patients, highlighting interindividual variability in pain perception. The significant differences at the 8th and 12th hours likely reflect the delayed yet sustained analgesic influence of lidocaine as perioperative anesthetic effects diminished.

Lidocaine, an amide-type local anesthetic, exerts its analgesic, anti-inflammatory, and anti-hyperalgesic effects primarily by blocking fast voltage-gated sodium channels, thereby modulating smooth muscle tone and interrupting pain transmission.[15] Its efficacy, which is comparable to that of NSAIDs, also contributes to the reduction of

ureteral spasm.[16] Previous studies have demonstrated that intravenous lidocaine (1.5 mg/kg) provides superior analgesia to morphine in renal colic patients within the first hour.[17] In the present study, intraluminal administration of lidocaine into the renal collecting system and ureter was intended to suppress smooth muscle spasm and interrupt nociceptive signaling. The lower analgesic requirement in the lidocaine group supports the effectiveness of this approach. Experimental studies have also shown that drugs administered intraluminally can be absorbed into ureteral tissue, influencing ureteral peristalsis and intraluminal pressure.[18,19] Although pharmacokinetic data specific to intraluminal ureteral administration are limited, previous experimental models indicate that urothelial permeability allows measurable transmucosal absorption of local anesthetics, with peak tissue penetration occurring within minutes. This supports the feasibility of achieving a localized neuromodulatory effect even without systemic elevation of lidocaine levels. In our study, mucosal injury caused by stone manipulation may have facilitated lidocaine absorption, further enhancing its local effect.

Neuronal hypersensitivity and nociception during endoscopic surgery are primarily maintained by sensitized nociceptors. Therefore, the duration and timing of analgesic interventions play a critical role in managing postoperative hyperalgesia.[20] One study comparing spinal-epidural anesthesia with general anesthesia in PNL have demonstrated significantly lower postoperative pain scores and analgesic requirements in the spinal-epidural group.[21] Although the pharmacologic effect of lidocaine lasts approximately two hours, its administration in RIRS may have contributed to reduced pain perception at later time points by modulating perioperative neuronal sensitization. The lack of difference in pain levels after 24 h likely reflects the minimally invasive nature of RIRS compared to PNL.

Pain following RIRS may result from various mechanisms, including renal capsule stretching, fluid extravasation, ureteral ischemia, obstruction by clots or fragments, or residual stone.[22,23] Previous reports indicate a strong association between residual fragments and pain intensity.[4,23] In our study, both groups were comparable in stone characteristics, and patients with residual stones >3 mm were excluded, thus minimizing confounding influences. Additionally, no perirenal extravasation was observed in any patient, likely due to careful control of irrigation fluid pressure and continuous drainage during the procedure. Maintaining bladder drainage throughout surgery may have contributed to reduced intrarenal pressure and the absence of calyceal rupture.[24]

Mechanical stress on the ureter during RIRS may cause transient ischemia-reperfusion injury and contribute to postoperative discomfort. While some studies reported higher pain levels in patients without ureteral access sheaths (UAS), others found that prolonged UAS use increased postoperative pain.[23,25] Since no patient in our cohort underwent UAS placement, we could not evaluate its potential effect on postoperative pain. Similarly, although DJ stent placement may occasionally cause irritative symptoms, it may also help prevent postoperative ureteral obstruction.[26] Because all patients in our study received a DJ stent, its independent impact on postoperative pain could not be assessed.

The reduced analgesic requirement in Group L supports the clinical benefit of intraluminal lidocaine administration. Previous research has demonstrated that local anesthetic infiltration, whether peritubular or intraluminal, effectively reduces postoperative discomfort after urologic endoscopic procedures.[27,28] Notably, preoperative administration of steroids has also been shown to significantly reduce analgesic needs due to their anti-inflammatory effects.[9] In our study, a total of 100 mg of lidocaine was used, which remains within the safe systemic absorption range even if fully absorbed. No cardiac complications were observed perioperatively or postoperatively, consistent with previous literature.[29,30]

Limitations

This study has several limitations that should be acknowledged. The relatively small sample size may limit the generalizability of the findings. Intra-renal pressure was not directly measured, and the extent of lidocaine absorption through the urothelium remains unknown, which may have influenced the interpretation of its local and systemic effects. No accessory sheath was used in any patient during the procedure; a DJ stent was placed in all patients, and those with residual stones were excluded from the analysis. Notably, none of the patients experienced calyceal rupture or urinary extravasation; therefore, the potential impact of these factors on postoperative pain could not be evaluated. Other limitations include the possible confounding effects of the anesthetic regimen—particularly the perioperative administration of propofol and fentanyl—on early postoperative analgesia and VAS outcomes. Furthermore, comorbidities that can influence pain perception, such as diabetes mellitus, were not analyzed separately. The single-blind design, in which the operating surgeon was aware of group allocation, may also have introduced observer bias. In addition, the absence of

randomization may have introduced selection bias, as patient allocation could have been influenced by clinical or procedural factors. Combined with the single-blind design, these limitations may have affected the interpretation of postoperative pain outcomes and analgesic requirements. Nevertheless, as, to the best of our knowledge, one of the first studies to evaluate intraluminal lidocaine administration during RIRS, it provides valuable preliminary evidence and highlights the need for larger, multicenter prospective trials to validate these findings.

Conclusions

Our findings provide new insight into the safety and feasibility of a novel technique involving the administration of a single dose of lidocaine into the collecting system and ureteral lumen prior to stent placement at the end of RIRS. This approach appears to significantly reduce postoperative pain and decrease the need for analgesic medication in patients undergoing RIRS. To the best of our knowledge, this is one of the first studies to evaluate the intraluminal use of a local anesthetic for postoperative pain management in RIRS. These results highlight the potential clinical benefit of this method, but further large-scale, randomized, multicenter studies are needed to confirm its effectiveness and to establish it as a standard strategy for postoperative pain control.

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None.

Author Contributions

Sezgin Yeni: Conceptualization, methodology, writing—review and editing; Hakan Kilicarslan: Conceptualization, writing—review and editing; Bertan Tanribuyurdu: Software and methodology; Levent Turan: Conceptualization and methodology; Hatice Ortac: Formal analysis; Onur Kaygisiz: Conceptualization, methodology, formal analysis, writing—review and editing. All authors reviewed and approved the final version of the manuscript.

Availability of Data and Materials

The datasets generated or analyzed during the current study are not publicly available due to patient confidentiality but are available from the corresponding author upon reasonable request.

Ethics Approval

All procedures were conducted in accordance with the ethical standards of the Mudanya University Health Sciences Ethics Committee (Reference No.: E-40839601-50.04-64).

Informed Consent

Written informed consent was obtained from all participants included in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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