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protocol study

Comparative Effectiveness of Intravenous Lidocaine, Magnesium Sulfate and Ketorolac for Renal Colic: A Study Protocol for a Randomized Controlled Trial

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Abstract

Introduction: Background: Renal colic is a frequent urological emergency marked by severe, sometimes incapacitating pain as a ureteral stone passes. Timely analgesia is central to emergency management; effective options are needed. Non-steroidal anti-inflammatory drugs (NSAIDs) such as ketorolac are commonly used as first-line treatment; however, they are contraindicated in some patients and do not provide adequate analgesia for all. Intravenous lidocaine, a sodium channel blocker, has shown analgesic effects in several acute pain models. Intravenous magnesium sulfate, an N-methyl-D-aspartate (NMDA) receptor antagonist, may also influence central pain sensitization.

Methods: This study is designed as a prospective, randomized, double-blind, active-controlled, parallel-group clinical trial. Eligible participants will be randomly assigned to one of three groups: (1) IV lidocaine, (2) IV magnesium sulfate, or (3) IV ketorolac. Pain severity will be assessed using a Visual Analog Scale (VAS) at 5, 10, 15, and 30 minutes after injection. Patient data will be entered into SPSS and analyzed using a paired t-test to obtain the final results.

Results: This trial protocol compares the analgesic efficacy, safety profiles, and urinary outcomes of intravenous lidocaine, magnesium sulfate, and ketorolac for acute renal colic management in the emergency department. The findings aim to establish whether alternative non-opioid regimens offer superior or comparable pain reduction and opioid-sparing benefits compared to standard care.

Conclusion: This protocol describes a structured approach intended to generate high-quality evidence by directly comparing three intravenous analgesic strategies for renal colic.

Trial Registration: Clinical trial ID IRCT20090923002496N13. Registration date: 21 October 2023. https://irct.behdasht.gov.ir/trial/73232.

Introduction

Acute renal colic, most often resulting from obstructing urolithiasis, is among the most severe pain presentations seen in the Emergency Department (ED) and requires prompt, effective analgesia. The lifetime prevalence of kidney stones is estimated at approximately 10% to 15% worldwide, creating a substantial burden on healthcare systems.[1] Acute management focuses on relieving intense pain thought to arise from ureteral smooth muscle spasm, increased intraluminal pressure, and the release of inflammatory mediators, including prostaglandins.[2,3] Non-steroidal anti-inflammatory drugs (NSAIDs), particularly intravenous (IV) ketorolac, are currently regarded as first-line therapy because they inhibit prostaglandin synthesis and, in turn, reduce inflammation and ureteral spasm.[4,5] However, NSAIDs are not suitable for all patients, especially those with renal impairment, an elevated risk of gastrointestinal bleeding, or advanced age. Opioids are commonly used as an alternative or adjunct, however, their use is often limited by adverse effects such as nausea, vomiting, and respiratory depression, as well as concerns about dependence and potential misuse.[6,7] These limitations highlight the need for effective non-opioid options for renal colic. Intravenous lidocaine, an amide

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local anesthetic, has shown analgesic benefit in several acute pain contexts. Its effects are thought to involve blockade of voltage-gated sodium channels, inhibition of G-protein-coupled receptors, and modulation of the systemic inflammatory response, these mechanisms may influence pain transmission and reduce sympathetic tone[8,9] Although early evidence suggests that IV lidocaine and IV magnesium sulfate may each provide analgesia in renal colic, robust comparative studies that directly evaluate these agents against the standard of care, ketorolac, are limited. Clarifying their relative efficacy, onset of action, and safety is important for refining ED pain management protocols. This study describes the methodology for a randomized controlled trial that will assess and compare the efficacy and safety of intravenous lidocaine, magnesium sulfate, and ketorolac in adults presenting to the emergency department with acute renal colic.

Methods and design

Study design

This study describes the methodology for a randomized controlled trial that will assess and compare the efficacy and safety of intravenous ketorolac, lidocaine, and magnesium sulfate in adults presenting to the emergency department with acute renal colic. Participant recruitment will take place at Imam Reza Hospital, the largest referral center in the northwest region, affiliated with Tabriz University of Medical Sciences in Tabriz, Iran. The clinical trial is registered on the IRCT platform with the identifier IRCT20090923002496N13. The protocol flowchart for this study will be presented in Table1, in accordance with the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) guidelines.[10]

Eligibility criteria

Initial identification will involve screening all patients whose primary reason for emergency department attendance is flank pain., after which a comprehensive medical history and physical examination will be conducted. Individuals reporting flank pain radiating to the groin or genital region, accompanied by nausea, vomiting, urinary irritative symptoms, and costovertebral angle tenderness, will be considered for further assessment. Eligible participants will be adults aged 18–65 years with no known history of cardiac, hepatic, or renal diseases, including ischemic heart disease. Exclusion criteria will include a documented hypersensitivity to lidocaine, magnesium sulfate, or ketorolac; a history of asthma or chronic obstructive pulmonary disease (COPD); pregnancy; and failure or refusal to provide written informed consent. Prior to enrollment, the method of drug administration, the rationale for its use, and the potential adverse effects will be explained to each patient, and it will be clarified that the study medications are considered safe.

Table 1. COLINS study protocol. -t1, 1-day pre-allocation; t0, allocation; t1, baseline; t2, 5 minutes post-administration.; t3, 10 minutes post-administration.; t4, 15 minutes post-administration.; t5, 30 minutes post-administration.

Time Point	Study period					
	Enrolment	Allocation	Post-allocation			
	$-t_1$	t_0	t_1	t_2	t_3	t_4
Enrolment						
Eligibility screen	×					
Informed consent	×					
Demographic and clinical data	×					
Allocation		×				
Interventions						
Lidocaine 1.5 mg/kg with 500 ml of normal saline			×	×	×	×
Magnesium sulfate arm will receive 2 g diluted in 500 ml of normal saline			×	×	×	×
Ketorolac 30 mg with 500 ml of normal saline			×	×	×	×
Assessments						
VAS			×	×	×	×

Interventions

Depending on the assigned group, patients in the lidocaine arm will receive a slow intravenous injection of lidocaine at a dose of 1.5 mg/kg of body weight (drawn from a 2% solution), along with 500 mL of intravenous normal saline administered as a placebo. Patients in the magnesium sulfate arm will receive 2 g of intravenous magnesium sulfate diluted in 500 mL of normal saline, plus a 10 mL intravenous normal saline push as a placebo.

Patients assigned to the ketorolac arm will receive 30 mg of ketorolac intravenously, along with 500 mL of intravenous normal saline as a placebo. Pain intensity will then be assessed using a Visual Analog Scale (VAS) and documented at 5, 10, 15, and 30 minutes after administration.

Adherence

Adherence to the study protocol will be supported by having trained clinical staff prepare and administer all study medications using standardized procedures. Participants will receive the allocated intervention (intravenous lidocaine, magnesium sulfate, or ketorolac) in accordance with the predefined dosing protocol, with placebo given when applicable. Each administration and its timing will be directly supervised and recorded in the case report forms. Pain intensity will be measured by trained personnel using the Visual Analog Scale (VAS) at 5, 10, 15, and 30 minutes following drug administration. The study team will also oversee adherence to dosing procedures and the timing of assessments; any protocol deviations will be documented and reviewed by the principal investigator.

Outcomes

The primary outcome is the mean change in pain severity from baseline to 30 minutes after the intervention, assessed using a 10 cm Visual Analog Scale (VAS; 0 = no pain, 10 = worst possible pain). Clinically meaningful improvement is defined a priori as either a decrease of at

least 2 cm or a reduction of at least 30% relative to the baseline VAS score. Secondary outcomes will include the recording of patient symptoms such as hematuria, nausea, dysuria, vomiting, urinary frequency, and other clinically relevant manifestations.

Safety

The patient will be placed on continuous cardiac monitoring under the supervision of an emergency medicine specialist, and a secure intravenous line will be established.

Sample size

Sample size calculations were based on an assumed pain incidence of 29.3% in the non-intervention group and 12% in the intervention group, using a significance level (α) of 0.05 and 80% power. We also anticipated 20% loss to follow-up during outcome assessment, yielding an estimated required sample size of 100 participants.

The initial calculated sample size was 86 participants, which increased to approximately 100 after accounting for potential attrition. Given the high number of patients presenting with renal colic to the Emergency Department of Imam Reza Hospital (AS) we increased, the final sample size to 120 patients per group, exceeding the largest sample size (n = 103) reported in comparable previous studies.

Recruitment and baseline assessment

Participants will be enrolled in the study if they meet the established inclusion criteria. Participants enrolled in the current study will be randomized to receive either Intravenous Lidocaine, Magnesium Sulfate, and Ketorolac or 500 mL of normal saline will be injected into these patients as a placebo.

Randomization and blinding

Eligible subjects will be assigned in a 1:1 ratio to either the Lidocaine, Magnesium Sulfate, and Ketorolac group or the placebo group. Assignment will be determined using an online randomization system employing a blocked randomization technique with variable block sizes of 4 and 6. To maintain allocation concealment, the sequentially numbered, opaque sealed envelopes (SNOSE) approach will be utilized. HM will generate the randomization sequence. Participant enrollment will be carried out by the medical team, and SP will assign individuals to their respective groups by opening the appropriately numbered sealed envelope. HS developed the primary conceptual framework and oversaw the conduct of the trial. Both participants and all trial personnel directly involved will be masked to the treatment allocation throughout the duration of the study.

Outcome measurements

Standardized case report forms will be employed to systematically capture baseline demographic and clinical data. Participants will undergo daily clinical assessment throughout their hospital stay. Pain intensity will be measured by trained study personnel using the Visual Analog Scale (VAS) at 5, 10, 15, and 30 minutes after administration of the study drug.

Statistical analysis

Data analysis will be conducted utilizing the IBM SPSS Statistics program. Data will be presented as mean ± SD for continuous measures and as absolute frequencies (percentages) for categorical variables. The Kolmogorov–Smirnov test will be used to assess whether the distributions are consistent with a normal distribution. Inter-group comparisons of baseline characteristics among the three intervention groups (IV lidocaine, IV magnesium sulfate, and IV ketorolac) will be performed using one-way ANOVA and the Pearson Chi-square test, as appropriate Variations in pain severity over time were evaluated using the Visual Analog Scale (VAS) at four time points (5, 10, 15, and 30 minutes post-drug administration), will be compared between groups. Changes in VAS scores within each treatment group over time will be evaluated using the paired t-test, comparing post-treatment measurements with baseline values. To compare the mean VAS scores between the three intervention groups at each time point, one-way ANOVA will be used, followed by post-hoc pairwise comparisons when significant differences are detected.

Trial steering and data monitoring committees

Trial operations will be managed by a core team consisting of an anesthesiologist (principal investigator), an emergency medicine specialist, and a biostatistician. The team will be responsible for maintaining adherence to the protocol, supervising trial implementation and progress, protecting participant safety, and reviewing any emerging evidence relevant to the study objectives. Tabriz University of Medical Sciences will provide institutional support. Clinical outcomes will be overseen by an independent Clinical Events Committee (CEC) that includes specialists in anesthesiology, urology, and biostatistics. At prespecified intervals, the CEC will review all suspected endpoint events and adjudicate them using the protocol-defined criteria, with decisions made independently of the investigative team. Serious adverse events will be reported promptly to the Research Ethics Committee of Tabriz University of Medical Sciences and documented in accordance with applicable ethical and regulatory requirements.

Discussion

Renal colic is generally regarded as one of the most severe and disabling pain syndromes seen in clinical practice and continues to be a common urological emergency.

Although evidence-based management strategies have been established, ongoing research continues to evaluate novel therapeutic approaches and combination regimens to improve analgesic outcomes. In a study by Seyhan et al, 126 patients presenting with renal colic were enrolled. Median pain intensity, measured using the visual analog scale (VAS), differed significantly between groups from 5 to 60 minutes, with superior pain reduction observed in the lidocaine group. The authors reported that a spinal

nerve block using 2% lidocaine provided better short-term pain relief than intravenous dexketoprofen in emergency department patients with renal colic. In the study by Toumia et al, statistically significant differences were observed between the MgSO4 and lidocaine groups and between the MgSO4 and control groups. However, at all assessed time points, the between-group differences remained below the clinically meaningful threshold of 1.3 points. There were also no meaningful differences across groups in the need for rescue analgesia or in repeat emergency department visits for recurrent renal colic. Although adverse events were more frequent in the $MgSO_4$ group, these events were minor in nature. Overall, the addition of intravenous $MgSO_4$, but not lidocaine, to intramuscular diclofenac was associated with statistically superior pain relief; however, the magnitude of benefit did not reach the threshold for clinical relevance.[12,13] In another investigation, 150 participants were enrolled, with 50 individuals assigned to each treatment group. "Thirty minutes post-intervention, the mean pain score differences favored the lidocaine/ketorolac combination over lidocaine (−2.89) and ketorolac (−0.92) monotherapies; the difference between ketorolac and lidocaine was −1.98. Comparable proportions of patients in all groups required rescue analgesia at both 30 and 60 minutes.

Vital signs remained clinically stable, with no serious adverse events reported in any group. Dizziness, nausea, and headache constituted the most common adverse effects. These findings indicate that, among patients presenting to the emergency department with suspected renal colic, intravenous administration of lidocaine combined with ketorolac provides more effective analgesia than intravenous lidocaine alone.; however, this combination does not confer additional analgesic benefit over ketorolac monotherapy.[14,15]

Soleimanpour et al. assessed pain intensity in two groups five minutes following the administration of lidocaine and morphine. Lidocaine was associated with a significant reduction in pain, which may be attributed to its effects on modulating smooth muscle tone and inhibiting the transmission of afferent nociceptive signals.[16-18]

Magnesium sulfate (MgSO4) is commonly employed as an analgesic across a variety of clinical conditions. Recent randomized controlled trials have examined its efficacy in the management of renal colic. Across studies comprising a total of 373 patients, intravenous MgSO4 administered at doses ranging from 15 to 50 mg/kg did not significantly reduce renal colic pain severity at 15 minutes, 30 minutes, or 60 minutes when compared with control treatments. Among patients who did not respond to initial analgesic therapy, intravenous MgSO4 at 15 mg/kg or 2 mL of a 50% solution demonstrated analgesic effects comparable to ketorolac or morphine at both 30 minutes ($P = .90$) and 60 minutes ($P = .57$). Short-term administration of MgSO4 was not associated with clinically significant hemodynamic alterations. Overall, MgSO4 did not demonstrate superior therapeutic efficacy compared with control interventions, although it may serve as an alternative rescue medication for patients who fail to achieve adequate pain relief with first-line agents.[19,20] In a separate double-blind randomized clinical trial, patients presenting with acute renal colic were allocated to one of two groups: a standard treatment protocol consisting of intravenous morphine sulfate (0.1 mg/kg), ketorolac (30 mg), and 100 mL normal saline administered over 15 minutes (placebo), or the same standard regimen supplemented with intravenous magnesium sulfate (15 mg/kg of a 50% solution diluted in 100 mL normal saline) infused over 15 minutes. Pain severity was assessed using the visual analog scale (VAS) at baseline and at 30 and 60 minutes following infusion. Statistical analyses were performed using STATA software. A total of 100 patients were randomized equally between the intervention and control groups. Baseline pain scores and demographic characteristics were comparable between groups.

Mean pain scores at 30 and 60 minutes were significantly lower in the magnesium sulfate group than in the control group. Supplemental morphine requirements also differed significantly between groups, with patients receiving magnesium sulfate requiring smaller additional doses. Taken together, these results indicate that magnesium sulfate may be a useful adjunct in the treatment of renal colic by improving analgesia and reducing the need for opioid administration.[20-22]

Conclusion

Overall, this proposed randomized controlled trial is expected to generate high-quality evidence on the comparative efficacy, safety, and onset of action of intravenous lidocaine, magnesium sulfate, and ketorolac in the acute treatment of renal colic. A direct comparison of these non-opioid approaches could clarify their roles and, in turn, guide refinements to emergency department pain management recommendations. If lidocaine or magnesium sulfate proves comparable or superior to the current standard of care in analgesic effect, either agent may represent an important opioid-sparing option, particularly for patients with clear contraindications to NSAIDs. In this way, the trial's findings are intended to support more effective treatment selection, reduce medication-related adverse effects, and improve both the timeliness of relief and the overall quality of care for patients with this highly debilitating condition.

Trial status

This study protocol (version 1.0) was registered in the Iranian Registry of Clinical Trials (IRCT) on October 21, 2023 (registration number: IRCT20090923002496N13). Recruitment has not yet begun and is expected to start on February 10, 2024.

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Competing Interests

The authors declare that they have no competing interests.

Consent for Publication

There will be no personal identifying information published.

Ethical Approval

This study received approval from the Research Ethics Committee of Tabriz University of Medical Sciences and was subsequently registered at www.irct.ir (IRCT20090923002496N13). The research protocol was developed in accordance with the Declaration of Helsinki and its later amendments governing ethical principles for medical research. All relevant institutional review boards and regulatory authorities reviewed and approved the protocol prior to registration.

The research team will provide detailed explanations of the study procedures and any protocol modifications to participants, their legal representatives, or guardians. At study initiation, a modified version of the World Health Organization informed consent template will be used to obtain written informed consent, facilitated by HM. Ethical consent forms will be completed for all participants before enrollment.

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References

1. Romero V, Akpinar H, Assimos DG. Kidney stones: a global picture of prevalence, incidence, and associated risk factors. Rev Urol 2010;12(2-3): e86-96.
2. Bultitude M, Rees J. Management of renal colic. BMJ 2012;345: e5499. doi:10.1136/bmj.e5499
3. Mahmoodpoor A, Latifi K, Ghojazadeh M, Nikbakht ME, Hosseini MS, Sarfaraz T, et al. Effect of magnesium sulfate on post-operative pain: a systematic review and meta-analysis. J Res Clin Med 2024;12(1):32. doi:10.34172/jrcm.34629
4. Pathan SA, Mitra B, Straney LD, Afzal MS, Anjum S, Shukla D, et al. Delivering safe and effective analgesia for management of renal colic in the emergency department: a double-blind, multigroup, randomised controlled trial. Lancet 2016;387(10032):1999-2007. doi:10.1016/s0140-6736(16)00652-8
5. Soleimanpour H, Aghamohammadi D, Ghaffarzad A, Golzari SE, Safari S, Soleimanpour M. Novel treatment in refractory tic douloureux. J Clin Anesth 2014;26(6):495-6. doi:10.1016/j.jclinane.2014.03.011
6. Rupprecht H, Gaab K. Prehospital tracheotomy in a case of avulsion of the larynx with a comminuted fracture of the jawbone. Clin Exp Emerg Med 2019;6(2):173-6. doi:10.15441/ceem.18.016
7. Soleimanpour H, Karamzad N, Rahmanian M, Aletaha R, Sanaie S, Sullman MJ, et al. Global burden of the adverse effects of medical treatment from 1990 to 2021. Int J Drug Res Clin 2025;3(1): e8.
8. Soleimanpour H, Hassanzadeh K, Vaezi H, Golzari SE, Mehdizadeh Esfanjani R, Soleimanpour M. Effectiveness of intravenous lidocaine versus intravenous morphine for patients with renal colic in the emergency department. BMC Urol 2012;12:13. doi:10.1186/1471-2490-12-13
9. Soleimanpour H, Hassanzadeh K, Agha Mohammadi D, Vaezi H, Mehdizadeh Esfanjani R. Parenteral lidocaine for treatment of intractable renal colic: a case series. J Med Case Rep 2011;5:256. doi:10.1186/1752-1947-5-256
10. Chan AW, Tetzlaff JM, Altman DG, Laupacis A, Gøtzsche PC, Krleža-Jerić K, et al. SPIRIT 2013 statement: defining standard protocol items for clinical trials. Ann Intern Med 2013;158(3):200-7. doi:10.7326/0003-4819-158-3-201302050-00583
11. Seyhan AU, Yılmaz E. Treatment of renal colic by nerve blockade with lidocaine versus intravenous dexketoprofen. J Coll Physicians Surg Pak 2021;31(8):921-5. doi:10.29271/jcpsp.2021.08.921
12. Toumia M, Sassi S, Dhaoui R, Kouraichi C, Bel Haj Ali K, Sekma A, et al. Magnesium sulfate versus lidocaine as an adjunct for renal colic in the emergency department: a randomized, double-blind controlled trial. Ann Emerg Med 2024;84(6):670-7. doi:10.1016/j.annemergmed.2024.06.015
13. Shams Vahdati S, Emami S, Ala A, Habibollahi P, Eslami S. Comparison of different delivery methods of lidocaine and diphenhydramine for anesthesia during suturing of head and facial lacerations. J Emerg Med Trauma Acute Care 2025;2025(2):15. doi:10.5339/jemtac.2025.15
14. Motov S, Fassassi C, Drapkin J, Butt M, Hossain R, Likourezos A, et al. Comparison of intravenous lidocaine/ketorolac combination to either analgesic alone for suspected renal colic pain in the ED. Am J Emerg Med 2020;38(2):165-72. doi:10.1016/j.ajem.2019.01.048
15. Vahdati SS, Ala A, Mirza-Aghazadeh Attari M, Habibollahi P, Fathalizadeh A, Khaffafi B, et al. Lidocaine administration techniques for head and limb wound anesthesia: injection vs. topical application. Perioper Care Oper Room Manag 2025;38:100483. doi:10.1016/j.pcorm.2025.100483
16. Soleimanpour H. Opioid-free analgesia in the emergency department: A new aspect. J Res Clin Med 2020;8:1. doi: 10.34172/jrcm.2020.001
17. Golzari SE, Soleimanpour H, Mahmoodpoor A, Safari S, Ala A. Lidocaine and pain management in the emergency department: a review article. Anesth Pain Med 2014;4(1): e15444. doi:10.5812/aapm.15444
18. Pouraghaei M, Moharamzadeh P, Paknezhad SP, Vand Rajabpour Z, Soleimanpour H. Intranasal ketamine versus intravenous morphine for pain management in patients with renal colic: a double-blind, randomized, controlled trial. World J Urol 2021;39(4):1263-7. doi:10.1007/s00345-020-03319-4
19. Chen LF, Yang CH, Lin TY, Pao PJ, Chu KC, Hsu CW, et al. Effect of magnesium sulfate on renal colic pain: a PRISMA-compliant meta-analysis. Medicine (Baltimore) 2020;99(46): e23279. doi:10.1097/md.0000000000023279
20. Shams Vahdati S, Robaei N, Habibollah P, Jafari-Rouhi A, Mohammadi S, Piri R. Paracetamol vs. intravenous morphine plus diclofenac in renal colic pain: a randomized clinical trial. Nephro Urol Mon 2018;10(4): e77193. doi:10.5812/numonthly.77193
21. Jokar A, Cyrus A, Babaei M, Taheri M, Almasi-Hashiani A, Behzadinia E, et al. The effect of magnesium sulfate on renal colic pain relief; a randomized clinical trial. Emerg (Tehran) 2017;5(1): e25.
22. Shams Vahdati S, Morteza Baghi HR, Ghobadi J, Rajaei Ghafouri R, Habibollahi P. Comparison of paracetamol (apotel®) and morphine in reducing post pure head trauma headache. Anesth Pain Med 2014;4(3): e14903. doi:10.5812/aapm.14903