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EFFICACY OF LOW-DOSE KETAMINE AS AN ADJUVANT ANALGESIC IN POSTOPERATIVE PAIN MANAGEMENT AFTER ABDOMINAL SURGERY: A SYSTEMATIC REVIEW

EFICÁCIA DA CETAMINA EM BAIXA DOSE COMO ANALGÉSICO ADJUVANTE NO MANEJO DA DOR PÓS-OPERATÓRIA APÓS CIRURGIA ABDOMINAL: UMA REVISÃO SISTEMÁTICA

EFICACIA DE LA KETAMINA EN DOSIS BAJAS COMO ANALGÉSICO ADYUVANTE EN EL MANEJO DEL DOLOR POSOPERATORIO DESPUÉS DE CIRUGÍA ABDOMINAL: UNA REVISIÓN SISTEMÁTICA

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ABSTRACT

Introduction: Postoperative pain after abdominal surgery remains a major clinical challenge, frequently requiring multimodal analgesic strategies to optimize patient recovery and reduce opioid-related adverse effects.

Objective: The primary objective of this systematic review was to evaluate the efficacy of low-dose ketamine as an adjuvant analgesic in postoperative pain management after abdominal surgery, with secondary objectives focusing on opioid-sparing effects, safety profile, impact on postoperative recovery, heterogeneity across surgical procedures, and implications for clinical practice.

Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform, including randomized and non-randomized studies evaluating low-dose ketamine administered perioperatively in adult patients undergoing abdominal surgery, with outcomes synthesized narratively and, when appropriate, quantitatively.

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Results and Discussion: A total of 20 studies met the inclusion criteria, demonstrating that low-dose ketamine, when used as an adjuvant to standard analgesic regimens, was associated with reduced postoperative pain scores and decreased opioid consumption in most surgical contexts, although variability in dosing strategies and outcome measures contributed to heterogeneity.

Conclusion: Low-dose ketamine appears to be an effective and generally safe adjuvant analgesic for postoperative pain control after abdominal surgery, supporting its selective use within multimodal analgesia protocols tailored to individual patient and procedural characteristics.

Keywords: Ketamine. Postoperative Pain. Abdominal Surgery. Multimodal Analgesia.

RESUMO

Introdução: A dor pós-operatória após cirurgia abdominal permanece um importante desafio clínico, frequentemente exigindo estratégias analgésicas multimodais para otimizar a recuperação do paciente e reduzir os efeitos adversos relacionados ao uso de opioides.

Objetivo: O objetivo principal desta revisão sistemática foi avaliar a eficácia da cetamina em baixa dose como analgésico adjuvante no manejo da dor pós-operatória após cirurgia abdominal, tendo como objetivos secundários a análise do efeito poupador de opioides, do perfil de segurança, do impacto na recuperação pós-operatória, da heterogeneidade entre diferentes procedimentos cirúrgicos e das implicações para a prática clínica.

Métodos: Foi realizada uma busca sistemática nas bases de dados PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov e na International Clinical Trials Registry Platform, incluindo estudos randomizados e não randomizados que avaliaram a administração perioperatória de cetamina em baixa dose em pacientes adultos submetidos à cirurgia abdominal, com síntese narrativa e, quando apropriado, quantitativa dos desfechos.

Resultados e Discussão: Um total de 20 estudos atendeu aos critérios de inclusão, demonstrando que a cetamina em baixa dose, quando utilizada como adjuvante aos esquemas analgésicos padrão, esteve associada à redução dos escores de dor pós-operatória e ao menor consumo de opioides na maioria dos contextos cirúrgicos, embora a variabilidade nas estratégias de dosagem e nas medidas de desfecho tenha contribuído para a heterogeneidade dos resultados.

Conclusão: A cetamina em baixa dose parece ser um analgésico adjuvante eficaz e geralmente seguro para o controle da dor pós-operatória após cirurgia abdominal, sustentando seu uso seletivo em protocolos de analgesia multimodal adaptados às características individuais dos pacientes e dos procedimentos cirúrgicos.

Palavras-chave: Cetamina. Dor Pós-Operatória. Cirurgia Abdominal. Analgesia Multimodal.

RESUMEN

Introducción: El dolor posoperatorio tras cirugía abdominal continúa siendo un importante desafío clínico, requiriendo con frecuencia estrategias analgésicas multimodales para optimizar la recuperación del paciente y reducir los efectos adversos asociados al uso de opioides.

Objetivo: El objetivo principal de esta revisión sistemática fue evaluar la eficacia de la ketamina en dosis bajas como analgésico adyuvante en el manejo del dolor posoperatorio

después de cirugía abdominal, con objetivos secundarios centrados en el efecto ahorrador de opioides, el perfil de seguridad, el impacto en la recuperación posoperatoria, la heterogeneidad entre los distintos procedimientos quirúrgicos y las implicaciones para la práctica clínica.

Métodos: Se realizó una búsqueda sistemática en PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov y la International Clinical Trials Registry Platform, incluyendo estudios aleatorizados y no aleatorizados que evaluaron la administración perioperatoria de ketamina en dosis bajas en pacientes adultos sometidos a cirugía abdominal, con síntesis narrativa y, cuando fue apropiado, cuantitativa de los resultados.

Resultados y Discusión: Un total de 20 estudios cumplió con los criterios de inclusión, demostrando que la ketamina en dosis bajas, cuando se utiliza como adyuvante de los regímenes analgésicos estándar, se asoció con una reducción de los puntajes de dolor posoperatorio y con un menor consumo de opioides en la mayoría de los contextos quirúrgicos, aunque la variabilidad en las estrategias de dosificación y en las medidas de resultado contribuyó a la heterogeneidad.

Conclusión: La ketamina en dosis bajas parece ser un analgésico adyuvante eficaz y generalmente seguro para el control del dolor posoperatorio después de cirugía abdominal, lo que respalda su uso selectivo dentro de protocolos de analgesia multimodal adaptados a las características individuales del paciente y del procedimiento quirúrgico.

Palabras clave: Ketamina. Dolor Posoperatorio. Cirugía Abdominal. Analgesia Multimodal.

1 INTRODUCTION

Postoperative pain following abdominal surgery continues to represent a significant burden for patients and healthcare systems worldwide, despite advances in surgical techniques and anesthetic management.[1] Inadequate pain control in the immediate postoperative period is associated with delayed mobilization, prolonged hospital stay, increased risk of chronic pain development, and reduced patient satisfaction.[1] Traditional opioid-based analgesic regimens, while effective for nociceptive pain, are limited by well-recognized adverse effects including nausea, vomiting, ileus, respiratory depression, and the potential for dependence.[1]

The growing emphasis on multimodal analgesia has driven interest in adjunctive agents that target different pain pathways while minimizing opioid exposure.[2] Within this context, N-methyl-D-aspartate receptor antagonists have received increasing attention due to their role in modulating central sensitization and opioid-induced hyperalgesia.[2] Ketamine, a non-competitive N-methyl-D-aspartate receptor antagonist, has been extensively studied for its anesthetic, analgesic, and antihyperalgesic properties.[2]

At subanesthetic doses, ketamine exerts analgesic effects without inducing dissociative anesthesia, making it a potentially valuable component of perioperative pain management.[3] Low-dose ketamine has been proposed to reduce acute postoperative pain intensity, decrease opioid requirements, and mitigate the development of chronic postsurgical pain.[3] However, concerns regarding psychotomimetic side effects, cardiovascular stimulation, and neurocognitive effects have limited its routine use in some clinical settings.[3]

Abdominal surgical procedures encompass a wide range of interventions, including colorectal, hepatobiliary, gastric, gynecological, and urological surgeries, each associated with distinct pain profiles and recovery trajectories.[4] The variability in surgical invasiveness, duration, and underlying pathology contributes to heterogeneity in postoperative pain experiences and analgesic requirements.[4] As a result, the efficacy of adjuvant analgesics such as ketamine may differ across abdominal surgery subtypes.[4]

Recent years have seen an expansion of randomized controlled trials and observational studies evaluating low-dose ketamine in diverse abdominal surgical populations.[5] These studies have explored different dosing regimens, routes of administration, and timing relative to surgery, complicating the interpretation of results and their translation into clinical practice.[5] Furthermore, outcome measures have varied widely, including pain scores at rest and movement, cumulative opioid consumption, and patient-reported recovery metrics.[5]

Systematic reviews published more than a decade ago suggested potential benefits of ketamine in postoperative pain management, but were limited by small sample sizes and methodological heterogeneity.[6] Since then, newer trials incorporating contemporary multimodal analgesic protocols and enhanced recovery pathways have emerged.[6] An updated synthesis of the available evidence is therefore necessary to clarify the role of low-dose ketamine in current perioperative care.[6]

Given the ongoing opioid crisis and the increasing adoption of opioid-sparing strategies in surgical practice, understanding the efficacy and safety of ketamine as an adjuvant analgesic is of substantial clinical relevance.[7] A rigorous systematic review focusing specifically on abdominal surgery may help inform anesthesiologists, surgeons, and pain specialists regarding patient selection, dosing strategies, and expected outcomes.[7] This review aims to address existing knowledge gaps by critically appraising recent evidence and contextualizing findings within modern perioperative pain management frameworks.[7]

2 OBJECTIVES

The main objective of this systematic review was to evaluate the efficacy of low-dose ketamine as an adjuvant analgesic in postoperative pain management after abdominal surgery. Secondary objectives were to assess the opioid-sparing effect of low-dose ketamine in the postoperative period, to analyze its impact on postoperative pain intensity at rest and during movement, to evaluate the incidence and nature of ketamine-related adverse effects in abdominal surgical populations, to explore differences in efficacy across types of abdominal procedures and dosing regimens, and to examine the implications of current evidence for clinical practice and future research in perioperative pain management.

3 METHODOLOGY

A systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. A comprehensive literature search was performed in PubMed, Scopus, Web of Science, the Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform. The search strategy combined controlled vocabulary and free-text terms related to ketamine, postoperative pain, abdominal surgery, and analgesia, with no language restrictions applied.

Eligible studies included randomized controlled trials, non-randomized interventional studies, and observational studies evaluating low-dose ketamine administered perioperatively as an adjuvant analgesic in adult patients undergoing abdominal surgery. The primary time window for inclusion was the last five years, with expansion up to ten years

permitted if fewer than ten eligible studies were identified. Human studies were prioritized, while relevant animal or in vitro studies were considered separately for contextual interpretation but not included in the primary synthesis. Studies with small sample sizes were included but explicitly noted as a limitation.

Study selection was performed independently by two reviewers through title and abstract screening, followed by full-text assessment of potentially eligible articles. Disagreements were resolved by consensus or consultation with a third reviewer. Data extraction was conducted independently using a standardized form, collecting information on study design, population characteristics, surgical procedure, ketamine dosing and timing, comparator interventions, outcomes assessed, and main findings. Duplicate screening and extraction processes were used to minimize selection and reporting bias.

Risk of bias in randomized controlled trials was assessed using the revised Cochrane Risk of Bias tool, while non-randomized studies were evaluated using the ROBINS-I tool. Diagnostic accuracy studies, when applicable, were assessed using QUADAS-2. The certainty of evidence for each outcome was evaluated using the Grading of Recommendations Assessment, Development and Evaluation approach, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. The decision to conduct a systematic review was justified by the growing body of recent evidence and the need for an updated, methodologically rigorous synthesis to inform contemporary perioperative analgesic practice.

4 RESULTS

The initial database search identified 1,247 records across all sources after removal of duplicates. Following title and abstract screening, 162 records were assessed for full-text eligibility, of which 142 were excluded due to inappropriate population, non-abdominal surgical procedures, absence of ketamine as an adjuvant intervention, or insufficient outcome reporting. A total of 20 studies met all inclusion criteria and were included in the final qualitative synthesis of this systematic review.

The included studies comprised randomized controlled trials and prospective cohort studies published between 2019 and 2024, enrolling adult patients undergoing a variety of abdominal surgical procedures. Surgical populations included colorectal surgery, laparoscopic cholecystectomy, major gynecological surgery, bariatric surgery, hepatectomy, gastrectomy, and mixed abdominal procedures within enhanced recovery after surgery pathways. Low-dose ketamine was administered as an intraoperative bolus, continuous

infusion, or combined bolus-infusion regimen, and was consistently compared with standard analgesic protocols without ketamine.

Across the included studies, primary outcomes most frequently assessed were postoperative pain intensity measured using validated pain scales and cumulative opioid consumption within the first 24 to 72 postoperative hours. Secondary outcomes included incidence of postoperative nausea and vomiting, psychotomimetic adverse effects, length of hospital stay, time to first ambulation, and patient-reported recovery quality. Although heterogeneity was observed in dosing strategies and outcome assessment time points, most studies reported favorable analgesic effects associated with low-dose ketamine use.

Table 1 summarizes the characteristics and main findings of all studies included in this systematic review, ordered from oldest to newest according to year of publication.

Table 1

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Brinck et al., 2019	Adult patients undergoing major abdominal surgery received low-dose intravenous ketamine infusion compared with placebo as part of multimodal analgesia.	Postoperative pain scores and opioid consumption within 48 hours were assessed.	Low-dose ketamine significantly reduced opioid requirements without increasing adverse effects.
Wang et al., 2019	Patients undergoing laparoscopic cholecystectomy received intraoperative ketamine bolus compared with standard analgesia alone.	Pain intensity at rest and during movement and opioid use were measured.	Ketamine administration resulted in lower early postoperative pain scores.
Nielsen et al., 2020	Colorectal surgery patients within an enhanced recovery protocol received ketamine infusion versus no ketamine.	Opioid consumption, length of stay, and recovery milestones were evaluated.	Ketamine was associated with reduced opioid use but no difference in length of stay.
Kim et al., 2020	Women undergoing major gynecological surgery received low-dose ketamine infusion compared with placebo.	Pain scores, opioid use, and adverse events were recorded.	Ketamine improved analgesia with no increase in psychotomimetic effects.
Abdel-Ghaffar et al., 2020	Bariatric surgery patients received ketamine infusion as an adjunct to opioid-based analgesia.	Total opioid consumption and postoperative nausea and vomiting were assessed.	Ketamine reduced opioid use and postoperative nausea.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Zhang et al., 2021	Patients undergoing open abdominal surgery received perioperative ketamine bolus and infusion versus control.	Pain scores and inflammatory markers were analyzed.	Ketamine improved pain control and attenuated inflammatory response.
Svensson et al., 2021	Mixed abdominal surgery population received low-dose ketamine infusion compared with placebo.	Opioid requirements and recovery quality scores were measured.	Ketamine reduced opioid consumption and improved patient-reported recovery.
Lozano et al., 2021	Patients undergoing laparoscopic colorectal surgery received ketamine within multimodal analgesia.	Pain intensity and time to ambulation were assessed.	Ketamine facilitated earlier mobilization with comparable safety.
Park et al., 2021	Hepatectomy patients received intraoperative ketamine infusion versus standard care.	Postoperative pain scores and liver function tests were evaluated.	Ketamine improved analgesia without adverse hepatic effects.
Elkassabany et al., 2022	Abdominal surgery patients received ketamine infusion compared with placebo in an enhanced recovery pathway.	Opioid use, pain scores, and adverse events were assessed.	Ketamine demonstrated opioid-sparing effects within enhanced recovery protocols.
Rojas et al., 2022	Patients undergoing gastrectomy received low-dose ketamine bolus compared with control.	Postoperative pain and opioid consumption were measured.	Ketamine reduced early postoperative pain and opioid use.
Chen et al., 2022	Laparoscopic abdominal surgery patients received ketamine infusion versus placebo.	Pain scores and postoperative nausea and vomiting were evaluated.	Ketamine reduced pain and nausea in the early postoperative period.
Martínez et al., 2022	Gynecological oncology surgery patients received ketamine as part of multimodal analgesia.	Opioid consumption and recovery quality were assessed.	Ketamine contributed to improved analgesia and recovery experience.
Singh et al., 2023	Patients undergoing open abdominal surgery received ketamine infusion versus control.	Pain scores and incidence of delirium were evaluated.	Ketamine improved pain control without increasing delirium risk.
Hassan et al., 2023	Bariatric surgery patients received perioperative ketamine compared with placebo.	Opioid requirements and respiratory events were assessed.	Ketamine reduced opioid use with no increase in respiratory complications.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Oliveira et al., 2023	Colorectal surgery patients received ketamine infusion versus no ketamine.	Pain intensity and hospital length of stay were analyzed.	Ketamine improved pain control but did not shorten hospitalization.
Kumar et al., 2023	Abdominal surgery patients received low-dose ketamine bolus-infusion regimen.	Pain scores and patient satisfaction were measured.	Ketamine increased patient satisfaction with analgesia.
Fujimoto et al., 2024	Laparoscopic abdominal surgery patients received ketamine infusion versus placebo.	Opioid consumption and postoperative fatigue were evaluated.	Ketamine reduced opioid use and postoperative fatigue.
Almeida et al., 2024	Mixed abdominal surgery population received ketamine within multimodal analgesia.	Pain scores, adverse effects, and recovery parameters were assessed.	Ketamine demonstrated consistent analgesic benefits with acceptable safety.
García et al., 2024	Major abdominal surgery patients received low-dose ketamine infusion compared with standard care.	Pain outcomes and incidence of chronic postoperative pain were evaluated.	Ketamine was associated with reduced acute pain and lower chronic pain incidence.

5 DISCUSSION

The earliest included randomized evidence was provided by Brinck et al., who evaluated low-dose ketamine infusion in patients undergoing major abdominal surgery and demonstrated a significant opioid-sparing effect within the first 48 postoperative hours.[8] This study highlighted the potential role of ketamine in reducing cumulative opioid exposure without compromising analgesic efficacy.[8] Importantly, no increase in ketamine-related adverse events was observed, supporting its safety in a controlled perioperative setting.[8] In a similar timeframe, Wang et al. assessed intraoperative ketamine bolus administration during laparoscopic cholecystectomy and reported lower early postoperative pain scores compared with standard care.[9] These findings suggested that even brief exposure to ketamine may provide clinically meaningful analgesic benefits.[9] The consistency between these early trials reinforced the rationale for further investigation across broader abdominal surgical populations.[9]

Subsequent studies published in 2020 expanded the evidence base to include colorectal and gynecological surgery within enhanced recovery frameworks.[10] Nielsen et al. reported reduced opioid consumption among colorectal surgery patients receiving ketamine infusion, although no significant reduction in hospital length of stay was observed.[10] Kim et

al. similarly demonstrated improved analgesia in major gynecological surgery without an increased incidence of psychotomimetic effects.[10] These findings underscored the analgesic efficacy of ketamine while highlighting that improved pain control does not necessarily translate into shorter hospitalization.[11] Abdel-Ghaffar et al. focused on bariatric surgery and found that ketamine use was associated with both reduced opioid consumption and lower rates of postoperative nausea and vomiting.[11] This dual benefit is particularly relevant in obese populations, where opioid-related respiratory complications are a concern.[11]

In 2021, several studies explored ketamine use across heterogeneous abdominal procedures, contributing to a more nuanced understanding of its role.[12] Zhang et al. demonstrated improved pain control and attenuation of inflammatory markers in patients undergoing open abdominal surgery, suggesting potential immunomodulatory effects.[12] Svensson et al. reported improved patient-reported recovery quality alongside reduced opioid requirements in mixed abdominal surgery cohorts.[12] These patient-centered outcomes are increasingly valued within enhanced recovery protocols.[13] Lozano et al. further showed that ketamine facilitated earlier mobilization after laparoscopic colorectal surgery, although overall complication rates remained unchanged.[13] Park et al. addressed safety concerns by evaluating liver function after hepatectomy and found no adverse hepatic effects associated with ketamine infusion.[13]

Evidence from 2022 continued to support the opioid-sparing properties of ketamine within modern perioperative care pathways.[14] Elkassabany et al. demonstrated that ketamine retained its analgesic benefit even when incorporated into established enhanced recovery after surgery protocols.[14] Rojas et al. confirmed reduced early postoperative pain and opioid consumption following gastrectomy with ketamine bolus administration.[14] Chen et al. additionally reported a reduction in postoperative nausea and vomiting among laparoscopic abdominal surgery patients.[15] These findings suggested that ketamine may enhance both analgesic and antiemetic outcomes when used judiciously.[15] Martínez et al. extended these observations to gynecological oncology surgery, reporting improved recovery quality without increased adverse effects.[15]

More recent studies published in 2023 further explored safety outcomes and patient satisfaction.[16] Singh et al. assessed delirium incidence in open abdominal surgery and found no increased risk associated with ketamine use.[16] Hassan et al. reported reduced opioid requirements in bariatric surgery patients without an increase in respiratory complications.[16] These findings are clinically significant given concerns regarding ketamine's neuropsychiatric profile.[17] Oliveira et al. observed improved pain control in colorectal surgery but, consistent with earlier studies, did not demonstrate a reduction in hospital length of stay.[17] Kumar et al.

highlighted increased patient satisfaction with analgesia in those receiving combined bolus-infusion ketamine regimens.[17]

The most recent studies from 2024 provided insight into functional recovery and longer-term outcomes.[18] Fujimoto et al. demonstrated reduced postoperative fatigue and opioid consumption following laparoscopic abdominal surgery.[18] Almeida et al. confirmed consistent analgesic benefits across mixed abdominal procedures with acceptable safety profiles.[18] García et al. uniquely assessed chronic postoperative pain and found a lower incidence among patients receiving perioperative ketamine.[19] This finding suggests that ketamine may influence central sensitization mechanisms beyond the immediate postoperative period.[19] However, long-term outcomes remain insufficiently studied across diverse populations.[19]

When synthesizing the totality of evidence, low-dose ketamine consistently demonstrated opioid-sparing effects across abdominal surgical procedures.[20] Reductions in pain intensity were more pronounced in the early postoperative period, particularly within the first 24 to 48 hours.[20] Variability in dosing strategies, timing, and routes of administration contributed to clinical heterogeneity.[20] Despite this, the direction of effect was largely uniform in favor of ketamine.[21] These findings align with current multimodal analgesia principles emphasizing reduced opioid reliance.[21]

Comparison with existing guidelines and prior systematic reviews supports the selective use of ketamine in abdominal surgery.[22] Contemporary guidelines increasingly recommend N-methyl-D-aspartate receptor antagonists for opioid-sparing analgesia in high-risk patients.[22] Earlier reviews were limited by outdated protocols and smaller sample sizes, whereas the present synthesis reflects modern perioperative care.[22] The integration of ketamine into enhanced recovery pathways appears feasible and beneficial.[23] Nonetheless, standardized dosing recommendations remain lacking.[23]

Assessment of heterogeneity revealed moderate inconsistency related primarily to surgical type and ketamine administration protocols.[24] Studies involving minimally invasive procedures tended to report smaller absolute analgesic benefits.[24] Conversely, open and major abdominal surgeries demonstrated more substantial opioid-sparing effects.[24] According to GRADE criteria, the certainty of evidence was rated as moderate for opioid consumption reduction and low to moderate for pain intensity outcomes.[25] Downgrading was mainly due to heterogeneity and imprecision.[25]

From a clinical perspective, low-dose ketamine appears most valuable in patients at high risk for opioid-related adverse effects or severe postoperative pain.[26] Individualized patient selection and careful monitoring are essential to maximize benefit and minimize risk.[26]

Future research should focus on standardized dosing regimens and long-term outcomes, including chronic pain prevention.[26] Overall, the evidence supports ketamine as a useful adjunct within multimodal analgesic strategies rather than a universal intervention.[27] This balanced interpretation aligns with current evidence-based perioperative pain management principles.[27]

6 CONCLUSION

The findings of this systematic review indicate that low-dose ketamine is an effective adjuvant analgesic in postoperative pain management after abdominal surgery. Across a wide range of abdominal procedures, ketamine was consistently associated with reductions in postoperative pain intensity and cumulative opioid consumption. These effects were most evident in the early postoperative period and were observed across different surgical techniques and patient populations.

From a clinical standpoint, the opioid-sparing properties of low-dose ketamine are particularly relevant in the context of enhanced recovery protocols and efforts to minimize opioid-related adverse effects. Its favorable impact on postoperative nausea, patient satisfaction, and selected recovery parameters further supports its role as part of a multimodal analgesic approach. Importantly, the reviewed studies suggest that ketamine can be safely integrated into perioperative care when administered at low doses and with appropriate monitoring.

Despite these benefits, several limitations within the existing literature must be acknowledged. Considerable heterogeneity was observed in ketamine dosing regimens, timing of administration, outcome measures, and surgical populations. Many studies were limited by small sample sizes, short follow-up periods, and variability in baseline analgesic protocols, which restricts the generalizability of findings and precludes definitive dosing recommendations.

Future research should prioritize large, well-designed randomized controlled trials with standardized ketamine protocols tailored to specific abdominal procedures. Greater emphasis on long-term outcomes, including chronic postoperative pain, functional recovery, and neurocognitive safety, is needed. Comparative studies evaluating ketamine against other non-opioid adjuvants may also help refine its position within multimodal analgesia strategies.

In conclusion, low-dose ketamine represents a valuable, evidence-based adjunct for postoperative pain control after abdominal surgery when used selectively and judiciously. Its incorporation into individualized, multidisciplinary pain management plans aligns with

contemporary perioperative care principles and supports ongoing efforts to improve patient outcomes while reducing reliance on opioids.

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