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PAIN MANAGEMENT IN TRAUMATIC PELVIC FRACTURES: CHALLENGES IN THE UNSTABLE PATIENT

MANEJO DA DOR EM FRATURAS TRAUMÁTICAS DA PELVE: DESAFIOS NO PACIENTE INSTÁVEL

MANEJO DEL DOLOR EN FRACTURAS TRAUMÁTICAS DE PELVIS: DESAFÍOS EN EL PACIENTE INESTABLE

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ABSTRACT

Introduction: Traumatic pelvic fractures in unstable patients represent a high-risk clinical scenario in which severe pain, hemorrhagic shock, mechanical pelvic instability, associated visceral injury, and the need for urgent procedural care frequently coexist. Pain management in this population cannot be treated as an isolated pharmacological problem, because analgesic choices must remain compatible with resuscitation, airway safety, neurologic reassessment, hemorrhage control, and definitive pelvic stabilization.

Objective: The main objective of this systematic review was to evaluate evidence on pain management strategies for adult patients with traumatic pelvic fractures, with emphasis on hemodynamically unstable or physiologically vulnerable patients. Secondary objectives included assessment of systemic analgesia, ketamine-based opioid-sparing strategies, regional anesthesia, stabilization-related analgesia, interaction with hemorrhage-control pathways, and evidence gaps for future research.

Methods: A systematic search was conducted in PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform. Eligible studies included human clinical studies, systematic reviews, trauma guidelines, cohort analyses, and clinically relevant reviews published within the last five years, with expansion to ten years allowed if fewer than ten eligible studies were identified. Study selection, data extraction, risk-of-bias assessment, and certainty-of-evidence evaluation followed PRISMA-based methodology, using RoB 2, ROBINS-I, QUADAS-2 when applicable, and GRADE principles.

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Results and Discussion: Twenty studies were included in the final qualitative synthesis. The available evidence showed that pain control in unstable pelvic trauma is inseparable from early pelvic stabilization, hemorrhage control, blood product resuscitation, and multidisciplinary trauma coordination. Opioids remain useful for rapid titratable analgesia, but opioid-sparing strategies, particularly ketamine-based regimens, may reduce opioid exposure in selected monitored patients. Regional anesthesia may provide meaningful analgesia in trauma care, but its role in unstable pelvic fractures is limited by incomplete anatomical coverage, coagulopathy, neurologic monitoring requirements, positioning constraints, and procedural urgency. The certainty of evidence was moderate for stabilization and hemorrhage-control principles, but low to very low for direct comparisons between analgesic strategies in unstable pelvic fracture patients.

Conclusion: Pain management in unstable traumatic pelvic fractures should be staged, multimodal, physiology-centered, and integrated with damage-control priorities. The most defensible strategy combines early stabilization and hemodynamic resuscitation with titratable systemic analgesia, selective ketamine use, cautious consideration of regional anesthesia, and longitudinal planning for rehabilitation and chronic pain prevention. Future studies should incorporate standardized pain outcomes, opioid consumption, regional anesthesia exposure, respiratory events, delirium, mobilization, and patient-reported recovery into pelvic trauma research.

Keywords: Pelvic Bones. Wounds and Injuries. Pain Management. Hemorrhagic Shock.

RESUMO

Introdução: Fraturas traumáticas da pelve em pacientes instáveis representam um cenário clínico de alto risco, no qual dor intensa, choque hemorrágico, instabilidade mecânica pélvica, lesão visceral associada e necessidade de cuidados procedimentais urgentes frequentemente coexistem. O manejo da dor nessa população não pode ser tratado como um problema farmacológico isolado, pois as escolhas analgésicas devem permanecer compatíveis com ressuscitação, segurança das vias aéreas, reavaliação neurológica, controle da hemorragia e estabilização definitiva da pelve.

Objetivo: O principal objetivo desta revisão sistemática foi avaliar evidências sobre estratégias de manejo da dor em pacientes adultos com fraturas traumáticas da pelve, com ênfase em pacientes hemodinamicamente instáveis ou fisiologicamente vulneráveis. Os objetivos secundários incluíram a avaliação de analgesia sistêmica, estratégias poupadoras de opioides baseadas em cetamina, anestesia regional, analgesia relacionada à estabilização, interação com protocolos de controle hemorrágico e lacunas de evidência para pesquisas futuras.

Métodos: Foi realizada uma busca sistemática nas bases PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov e International Clinical Trials Registry Platform. Os estudos elegíveis incluíram estudos clínicos em humanos, revisões sistemáticas, diretrizes de trauma, análises de coorte e revisões clinicamente relevantes publicados nos últimos cinco anos, com expansão para dez anos permitida caso menos de dez estudos elegíveis fossem identificados. A seleção dos estudos, extração de dados, avaliação do risco de viés e avaliação da certeza da evidência seguiram metodologia baseada no PRISMA, utilizando RoB 2, ROBINS-I, QUADAS-2 quando aplicável, e princípios do GRADE.

Resultados e Discussão: Vinte estudos foram incluídos na síntese qualitativa final. As evidências disponíveis demonstraram que o controle da dor no trauma pélvico instável é inseparável da estabilização precoce da pelve, do controle hemorrágico, da ressuscitação com hemocomponentes e da coordenação multidisciplinar do trauma. Os opioides

permanecem úteis para analgesia rápida e titulável, mas estratégias poupadoras de opioides, particularmente esquemas baseados em cetamina, podem reduzir a exposição a opioides em pacientes selecionados sob monitorização. A anestesia regional pode fornecer analgesia significativa no cuidado ao trauma, porém seu papel nas fraturas pélvicas instáveis é limitado pela cobertura anatômica incompleta, coagulopatia, necessidade de monitorização neurológica, restrições de posicionamento e urgência procedimental. A certeza da evidência foi moderada para os princípios de estabilização e controle hemorrágico, mas baixa a muito baixa para comparações diretas entre estratégias analgésicas em pacientes com fraturas pélvicas instáveis.

Conclusão: O manejo da dor em fraturas traumáticas instáveis da pelve deve ser escalonado, multimodal, centrado na fisiologia e integrado às prioridades do controle de danos. A estratégia mais defensável combina estabilização precoce e ressuscitação hemodinâmica com analgesia sistêmica titulável, uso seletivo de cetamina, consideração cautelosa da anestesia regional e planejamento longitudinal para reabilitação e prevenção de dor crônica. Estudos futuros devem incorporar desfechos padronizados de dor, consumo de opioides, exposição à anestesia regional, eventos respiratórios, delirium, mobilização e recuperação relatada pelos pacientes nas pesquisas sobre trauma pélvico.

Palavras-chave: Ossos Pélvicos. Ferimentos e Lesões. Manejo da Dor. Choque Hemorrágico.

RESUMEN

Introducción: Las fracturas traumáticas de pelvis en pacientes inestables representan un escenario clínico de alto riesgo, en el cual dolor severo, choque hemorrágico, inestabilidad mecánica pélvica, lesión visceral asociada y necesidad de atención procedimental urgente frecuentemente coexisten. El manejo del dolor en esta población no puede tratarse como un problema farmacológico aislado, ya que las decisiones analgésicas deben mantenerse compatibles con la reanimación, la seguridad de la vía aérea, la reevaluación neurológica, el control de la hemorragia y la estabilización definitiva de la pelvis.

Objetivo: El objetivo principal de esta revisión sistemática fue evaluar la evidencia sobre estrategias de manejo del dolor en pacientes adultos con fracturas traumáticas de pelvis, con énfasis en pacientes hemodinámicamente inestables o fisiológicamente vulnerables. Los objetivos secundarios incluyeron la evaluación de analgesia sistémica, estrategias basadas en ketamina con reducción de opioides, anestesia regional, analgesia relacionada con la estabilización, interacción con protocolos de control hemorrágico y vacíos de evidencia para futuras investigaciones.

Métodos: Se realizó una búsqueda sistemática en PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov y la International Clinical Trials Registry Platform. Los estudios elegibles incluyeron estudios clínicos en humanos, revisiones sistemáticas, guías de trauma, análisis de cohortes y revisiones clínicamente relevantes publicados en los últimos cinco años, permitiéndose la ampliación a diez años si se identificaban menos de diez estudios elegibles. La selección de estudios, extracción de datos, evaluación del riesgo de sesgo y evaluación de la certeza de la evidencia siguieron una metodología basada en PRISMA, utilizando RoB 2, ROBINS-I, QUADAS-2 cuando correspondía, y principios GRADE.

Resultados y Discusión: Veinte estudios fueron incluidos en la síntesis cualitativa final. La evidencia disponible mostró que el control del dolor en el trauma pélvico inestable es inseparable de la estabilización temprana de la pelvis, el control de la hemorragia, la reanimación con hemoderivados y la coordinación multidisciplinaria del trauma. Los opioides

siguen siendo útiles para una analgesia rápida y titulable, pero las estrategias ahorradoras de opioides, particularmente los esquemas basados en ketamina, pueden reducir la exposición a opioides en pacientes seleccionados bajo monitorización. La anestesia regional puede proporcionar analgesia significativa en la atención del trauma, pero su papel en las fracturas pélvicas inestables está limitado por la cobertura anatómica incompleta, la coagulopatía, la necesidad de monitorización neurológica, las restricciones de posicionamiento y la urgencia procedimental. La certeza de la evidencia fue moderada para los principios de estabilización y control hemorrágico, pero baja a muy baja para las comparaciones directas entre estrategias analgésicas en pacientes con fracturas pélvicas inestables.

Conclusión: El manejo del dolor en las fracturas traumáticas inestables de pelvis debe ser escalonado, multimodal, centrado en la fisiología e integrado con las prioridades del control de daños. La estrategia más defendible combina estabilización temprana y reanimación hemodinámica con analgesia sistémica titulable, uso selectivo de ketamina, consideración cautelosa de la anestesia regional y planificación longitudinal para la rehabilitación y la prevención del dolor crónico. Los estudios futuros deben incorporar resultados estandarizados de dolor, consumo de opioides, exposición a anestesia regional, eventos respiratorios, delirium, movilización y recuperación reportada por los pacientes en la investigación sobre trauma pélvico.

Palabras clave: Huesos Pélvicos. Heridas y Lesiones. Manejo del Dolor. Choque Hemorrágico.

1 INTRODUCTION

Traumatic pelvic fractures represent one of the most complex injury patterns in acute trauma care because they combine mechanical instability, hemorrhagic risk, visceral injury, neurologic compromise, and severe pain within a single anatomical region.[1] In hemodynamically unstable patients, pain management cannot be separated from resuscitation, because inadequate analgesia may aggravate sympathetic activation, impair ventilatory mechanics, and complicate patient positioning for imaging, pelvic stabilization, or hemorrhage control.[1] Conversely, excessive or poorly selected analgesic strategies may worsen hypotension, obscure evolving neurologic findings, or delay definitive trauma interventions.[1] Therefore, analgesia in unstable pelvic trauma requires a dynamic balance between rapid symptom control, preservation of physiological reserve, and coordination with damage-control priorities.[2]

The pelvis is richly innervated by somatic and autonomic pathways, and fractures involving the pelvic ring, acetabulum, sacrum, sacroiliac complex, or pubic rami may generate intense nociceptive input from bone, periosteum, ligamentous disruption, hematoma expansion, and soft-tissue injury.[2] Pain is often amplified by associated abdominal, genitourinary, perineal, lumbosacral plexus, or lower-limb trauma, making isolated fracture-based analgesic algorithms insufficient for many unstable patients.[2] In this setting, the clinician must distinguish pain arising from mechanical instability from pain caused by vascular, visceral, neurologic, or compartment-related complications.[3] This distinction has practical implications because analgesia alone is inadequate when pain reflects ongoing hemorrhage, progressive pelvic displacement, urethral injury, rectal injury, or evolving neurologic compression.[3]

Hemodynamic instability is the central factor that differentiates pain management in severe pelvic trauma from routine orthopedic analgesia.[3] Patients with major pelvic ring disruption may deteriorate rapidly from venous bleeding, cancellous bone hemorrhage, arterial injury, coagulopathy, hypothermia, acidosis, and associated polytrauma.[4] Analgesic interventions must therefore be compatible with massive transfusion protocols, early pelvic binders, preperitoneal pelvic packing, angioembolization, external fixation, resuscitative endovascular balloon occlusion of the aorta, or emergent laparotomy when indicated.[4] A purely pharmacological approach that ignores mechanical stabilization and hemorrhage control risks treating pain as an isolated symptom rather than as a marker of pelvic instability and systemic injury severity.[4]

Opioids remain frequently used in the acute phase because of their rapid titratability, familiarity, and effectiveness for severe traumatic pain.[5] However, opioid-centered analgesia

is problematic in unstable pelvic trauma because respiratory depression, sedation, ileus, delirium, nausea, hypotension, and impaired clinical reassessment may be particularly harmful in polytraumatized patients.[5] These risks are magnified in patients with traumatic brain injury, chest trauma, shock, renal dysfunction, older age, alcohol exposure, or need for repeated procedural sedation.[5] For these reasons, contemporary trauma analgesia increasingly emphasizes multimodal regimens that reduce opioid burden while preserving hemodynamic safety and procedural flexibility.[6]

Multimodal analgesia may include acetaminophen, cautious use of nonsteroidal anti-inflammatory drugs, low-dose ketamine, regional anesthesia, local infiltration, neuropathic pain agents in selected phases, and nonpharmacological strategies such as early stabilization and careful positioning.[6] The unstable pelvic fracture patient, however, is not an idealized postoperative orthopedic patient, and each component of multimodal therapy must be filtered through bleeding risk, renal perfusion, coagulation status, mental status, airway safety, and need for urgent procedures.[6] Ketamine is attractive in selected unstable trauma patients because it can provide analgesia with relative preservation of airway reflexes and sympathetic tone, but it requires careful dosing, monitoring, and consideration of psychiatric, cardiovascular, and intracranial factors.[7] Regional anesthesia may reduce systemic opioid exposure, but its use in pelvic trauma is constrained by anatomical complexity, anticoagulation, evolving neurologic assessment, limited positioning tolerance, and the urgency of hemorrhage-control interventions.[7]

Regional and fascial plane blocks have transformed analgesia for hip fracture and selected lower-limb trauma, yet their role in unstable pelvic fractures remains less clearly defined.[7] Fascia iliaca compartment block, femoral nerve block, lumbar plexus block, sacral plexus techniques, erector spinae plane block, and other ultrasound-guided approaches may cover some components of pelvic and proximal lower-extremity pain, but no single block reliably addresses the full nociceptive burden of complex pelvic ring disruption.[8] In addition, unstable patients may have pelvic hematomas, altered tissue planes, coagulopathy, hypotension, or inability to tolerate the position required for safe needle placement.[8] As a result, regional analgesia should be considered an adjunct to structured trauma care rather than a substitute for systemic analgesia, stabilization, and hemorrhage control.[8]

Mechanical stabilization itself is an analgesic intervention because pelvic binders, external fixation, C-clamps, and definitive fixation reduce pathologic motion, limit soft-tissue strain, and may decrease ongoing bleeding.[9] Pain relief after stabilization can also facilitate ventilation, nursing care, imaging, transport, and rehabilitation planning.[9] In unstable patients, the sequence of stabilization, analgesia, airway management, blood product resuscitation,

and operative or endovascular intervention must be individualized rather than rigidly protocolized.[9] This sequencing is particularly important when the patient is combative, intubated, obtunded, anticoagulated, hypothermic, or undergoing simultaneous evaluation for abdominal, thoracic, cranial, or spinal injury.[10]

Evidence synthesis in this field is difficult because studies often focus on mortality, transfusion requirement, hemorrhage control, fixation strategy, or functional recovery rather than pain as a primary endpoint.[10] Analgesic outcomes are inconsistently reported, and pain intensity may be confounded by sedation, intubation, neurologic injury, delirium, operative timing, and differences in fracture classification.[10] Moreover, studies of regional anesthesia in trauma frequently include heterogeneous fracture populations, with hip fractures and femoral fractures overrepresented compared with unstable pelvic ring injuries.[11] This creates an important knowledge gap: clinicians must manage pain daily in unstable pelvic fracture patients despite limited direct comparative evidence for the optimal analgesic strategy.[11]

A systematic review is therefore justified because the topic lies at the intersection of trauma surgery, orthopedic surgery, anesthesiology, emergency medicine, interventional radiology, and critical care.[11] The available literature must be interpreted not only for analgesic efficacy but also for hemodynamic safety, compatibility with damage-control principles, feasibility in the emergency setting, and implications for definitive fracture management.[12] A structured synthesis may help clarify which interventions have direct evidence in traumatic pelvic fractures, which are extrapolated from adjacent trauma populations, and which remain investigational or inadequately evaluated.[12] This review consequently examines pain management in traumatic pelvic fractures with particular emphasis on the unstable patient, integrating evidence on systemic analgesia, regional techniques, mechanical stabilization, perioperative care, and multidisciplinary decision-making.[12]

2 OBJECTIVES

The main objective of this systematic review is to evaluate current evidence on pain management strategies for adult patients with traumatic pelvic fractures, with specific emphasis on hemodynamically unstable or physiologically vulnerable patients requiring acute trauma resuscitation, hemorrhage control, mechanical stabilization, emergency surgery, interventional radiology, or intensive care. The first secondary objective is to compare systemic analgesic approaches, including opioids, ketamine, acetaminophen, nonsteroidal anti-inflammatory drugs, and multimodal regimens, in terms of analgesic effectiveness, hemodynamic safety, respiratory effects, and feasibility during early trauma care. The second

secondary objective is to assess the role of regional anesthesia and fascial plane techniques as adjuncts to systemic analgesia in pelvic fracture patients, with attention to anatomical coverage, contraindications, procedural limitations, anticoagulation, and neurologic monitoring. The third secondary objective is to examine the analgesic implications of mechanical pelvic stabilization, including pelvic binders, external fixation, pelvic C-clamps, and definitive fixation, particularly when pain control depends on reduction of pathologic fracture motion. The fourth secondary objective is to analyze how pain management interacts with hemorrhage-control pathways, airway management, critical-care sedation, mobilization, and multidisciplinary trauma coordination. The fifth secondary objective is to identify gaps in the literature, assess the certainty of evidence using structured methodology, and propose clinically oriented priorities for future research in analgesia for unstable traumatic pelvic fractures.

3 METHODOLOGY

This systematic review was designed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses framework. A comprehensive search strategy was planned for PubMed, Scopus, Web of Science, Cochrane Library, LILACS, ClinicalTrials.gov, and the International Clinical Trials Registry Platform. Search terms combined controlled vocabulary and free-text terms related to pelvic fracture, pelvic ring injury, acetabular fracture, unstable trauma, hemorrhagic shock, pain management, analgesia, opioid, ketamine, regional anesthesia, nerve block, fascial plane block, external fixation, pelvic binder, and trauma resuscitation. No language restriction was applied, and records were screened with priority given to human studies published during the last five years, with expansion to the last ten years allowed if fewer than ten eligible studies were identified.

Eligible studies included randomized controlled trials, prospective cohort studies, retrospective cohort studies, case-control studies, cross-sectional studies, registry-based analyses, systematic reviews with extractable primary data relevance, and clinically relevant case series addressing pain management, analgesic exposure, regional techniques, stabilization-related analgesia, perioperative care, or resuscitation-related analgesic decision-making in traumatic pelvic fractures. Adult human studies were prioritized, but pediatric, animal, or in vitro data would have been considered only for separate descriptive tables if clinically relevant human evidence was insufficient. Studies were excluded if they addressed elective pelvic surgery without trauma, isolated chronic pelvic pain, nontraumatic fragility fractures without acute trauma context, obstetric pelvic pain, oncologic pelvic pain, or analgesia unrelated to pelvic fracture management. Small sample studies were not excluded

a priori but were interpreted as lower-certainty evidence when imprecision, confounding, or incomplete outcome reporting limited inference.

Two independent reviewers screened titles and abstracts, assessed full-text eligibility, and resolved disagreements through consensus or consultation with a third reviewer. The extraction form included author, year, country, study design, population characteristics, fracture type, hemodynamic status, intervention, comparator, analgesic regimen, stabilization strategy, pain outcomes, opioid consumption, respiratory outcomes, hemodynamic outcomes, procedure-related complications, transfusion requirements, intensive-care outcomes, mortality, and limitations. Duplicates were removed before screening, and multiple publications from the same cohort were examined to avoid double counting. Study selection was summarized through a PRISMA flow process, including records identified, records screened, full-text articles assessed, exclusions with reasons, and final included studies.

Risk of bias was assessed according to study design. Randomized trials were planned for evaluation with the revised Cochrane Risk of Bias tool version 2, nonrandomized intervention and observational studies with the Risk Of Bias In Non-randomized Studies of Interventions tool, and diagnostic or imaging-related studies, if present, with the Quality Assessment of Diagnostic Accuracy Studies 2 tool. The certainty of evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation approach, considering risk of bias, inconsistency, indirectness, imprecision, and publication bias. Because heterogeneity was expected in fracture classification, analgesic protocols, hemodynamic definitions, co-interventions, and outcome measurement, the primary synthesis was planned as a structured qualitative synthesis rather than a pooled meta-analysis.

The review was justified by the lack of a unified evidence synthesis specifically focused on pain management in traumatic pelvic fractures in unstable patients. Existing literature often evaluates hemorrhage control, pelvic fixation, trauma mortality, or general orthopedic analgesia, while analgesia-specific outcomes in unstable pelvic trauma are inconsistently reported. This review therefore aimed to integrate direct and indirect evidence across emergency medicine, anesthesiology, orthopedic trauma, general trauma surgery, and critical care. The final synthesis was organized to distinguish evidence directly applicable to unstable pelvic fracture patients from evidence extrapolated from broader trauma or perioperative populations.

4 RESULTS

The database search identified 486 records. After duplicate removal, 392 records were screened by title and abstract. A total of 331 records were excluded because they did not address traumatic pelvic fractures, acute trauma analgesia, hemodynamic instability, perioperative pelvic trauma care, regional anesthesia, hemorrhage-control pathways, or clinically relevant outcomes related to pain management in unstable trauma patients. Sixty-one full-text articles were assessed for eligibility, and 41 were excluded because they focused exclusively on elective pelvic surgery, chronic nontraumatic pelvic pain, fragility fractures without acute trauma context, pediatric-only populations without transferable acute-care relevance, technical fixation outcomes without analgesic or resuscitative implications, or nonclinical experimental models. Twenty studies met the inclusion criteria and were included in the final qualitative synthesis.

No randomized controlled trial was identified that specifically compared analgesic strategies exclusively in hemodynamically unstable traumatic pelvic fracture patients. The final evidence base therefore consisted of trauma guidelines, systematic reviews, narrative reviews, retrospective studies, cohort studies, protocol-based studies, and clinically relevant analyses addressing pelvic trauma resuscitation, hemorrhage control, fixation timing, regional anesthesia, systemic analgesia, ketamine-based trauma analgesia, and outcome domains relevant to pain management. No animal or in vitro study was included in the main table because sufficient clinically relevant human evidence was available for qualitative synthesis.

Table 1

Included studies ordered from oldest to newest

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Perumal et al., 2021	The study evaluated patients with pelvic fractures and hemodynamic instability, focusing on acute management pathways involving resuscitation, pelvic stabilization, preperitoneal packing, and angioembolization rather than a direct analgesic comparator.	The outcomes assessed included mortality, hemorrhage-control strategy, timing of intervention, stabilization approach, and acute trauma decision-making.	The study concluded that unstable pelvic fractures require early multidisciplinary hemorrhage control and mechanical stabilization, which indirectly influence pain control by reducing fracture motion and physiological deterioration.
Torrie et al., 2022	The review evaluated trauma patients receiving	The outcomes assessed included	The review concluded that regional anesthesia may

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
	regional anesthesia and analgesia, including patients with major orthopedic and polytrauma injuries, compared with conventional systemic analgesic approaches.	analgesic efficacy, opioid reduction, feasibility, safety, contraindications, and trauma-specific limitations of regional anesthesia.	reduce opioid exposure in trauma patients, but pelvic trauma requires individualized selection because block coverage, coagulopathy, neurologic assessment, and positioning may limit applicability.
Rossaint et al., 2023	The guideline evaluated bleeding trauma patients, including those with pelvic trauma and hemorrhagic shock, managed with damage-control resuscitation, transfusion protocols, coagulation support, and procedural hemorrhage control.	The outcomes assessed included mortality, bleeding control, transfusion strategy, coagulopathy correction, shock management, and time-sensitive trauma interventions.	The guideline concluded that analgesic decisions in unstable pelvic trauma must remain compatible with hemorrhage control, hemodynamic preservation, and rapid damage-control care.
Klugh et al., 2024	The study evaluated severely injured adult trauma patients treated with subdissociative ketamine infusion as part of acute pain management, compared with multimodal pain regimens without ketamine emphasis.	The outcomes assessed included opioid exposure, pain control, adverse events, and feasibility of ketamine use in severe trauma care.	The study concluded that subdissociative ketamine may reduce opioid requirements in severely injured patients, supporting its potential role as an adjunct when opioid-related respiratory or hemodynamic concerns are relevant.
Madsen et al., 2024	The review evaluated patients with high-energy pelvic ring injuries and bleeding pelvic trauma, focusing on emergency management, damage-control resuscitation, pelvic stabilization, packing, angioembolization, and definitive care pathways.	The outcomes assessed included acute mortality, exsanguination risk, stabilization strategy, hemorrhage-control sequence, and emergency treatment algorithms.	The review concluded that management of unstable pelvic ring injuries should prioritize early stabilization and hemorrhage control, with analgesia integrated into resuscitative rather than isolated orthopedic care.
Zheng et al., 2024	The meta-analysis evaluated patients with hemodynamically unstable	The outcomes assessed included all-cause mortality,	The meta-analysis concluded that life-saving hemostatic interventions may

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
	pelvic fractures treated with external fixation, angioembolization, extraperitoneal pelvic packing, or combined hemostatic interventions.	effectiveness of hemostatic procedures, intervention sequencing, and survival-related outcomes.	reduce mortality in unstable pelvic fracture patients and should be considered essential components of pain-relevant stabilization.
Sawauchi et al., 2024	The systematic review evaluated unstable pelvic ring injuries over several decades, comparing evolving diagnostic and therapeutic strategies in patients with high-energy pelvic trauma.	The outcomes assessed included changes in treatment algorithms, stabilization methods, hemorrhage-control strategies, mortality, and management trends.	The systematic review concluded that modern care has shifted toward structured, multidisciplinary, and time-sensitive management, which supports early integration of analgesia with stabilization and resuscitation.
Gänsslen et al., 2024	The review evaluated outcomes after pelvic ring injuries, including long-term functional impairment, pain-related disability, mobility limitation, and quality-of-life consequences after different injury patterns and treatments.	The outcomes assessed included functional scores, chronic pain, return to activity, radiologic outcomes, and long-term disability.	The review concluded that pelvic ring injuries frequently produce persistent pain and functional impairment, emphasizing the importance of acute pain control, stabilization quality, and follow-up planning.
Dabetic et al., 2025	The review evaluated polytrauma patients with pelvic fractures managed through modern trauma systems, including resuscitation, fixation strategies, imaging, vascular control, and multidisciplinary decision-making.	The outcomes assessed included mortality, treatment timing, hemorrhage control, stabilization strategy, and overall trauma-system outcomes.	The review concluded that pelvic fracture management in polytrauma depends on coordinated trauma systems, and analgesic care should be embedded within these multidisciplinary pathways.
Gänsslen et al., 2025	The review evaluated patients with unstable hemodynamics and unstable pelvic ring injuries treated with pelvic packing and associated stabilization methods.	The outcomes assessed included survival, bleeding control, indications for packing, interaction with external fixation, and acute management strategy.	The review concluded that pelvic packing remains an important option for unstable pelvic fracture patients and that pain management must be coordinated with urgent mechanical and hemostatic interventions.

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
Balogh et al., 2025	The study evaluated patients with hemodynamically unstable pelvic fractures, emphasizing the relationship between unstable pelvic injury patterns, hemorrhage, early treatment priorities, and clinical outcomes.	The outcomes assessed included mortality, hemorrhage severity, resuscitation requirements, intervention timing, and complications.	The study concluded that unstable pelvic fractures remain high-risk injuries in which pain management must not delay hemorrhage control, resuscitation, or stabilization.
Shen et al., 2025	The review evaluated unstable pelvic ring fractures managed with evolving reduction techniques, including open reduction, closed reduction, navigation-assisted techniques, and robotic or minimally invasive approaches.	The outcomes assessed included reduction quality, fixation accuracy, operative invasiveness, complications, and functional recovery.	The review concluded that improved reduction techniques may reduce tissue trauma and support recovery, although direct evidence on acute pain outcomes remains limited.
Oochit et al., 2025	The systematic review evaluated polytraumatized patients with pelvic ring fractures treated with early definitive fixation compared with late definitive fixation.	The outcomes assessed included mortality, complications, intensive-care outcomes, length of stay, respiratory outcomes, and short-term recovery.	The systematic review concluded that fixation timing may influence early recovery and complications, with potential indirect relevance to pain control, mobilization, and reduction of prolonged immobilization.
Grechenig et al., 2025	The study evaluated critically unstable patients receiving emergency pelvic stabilization, focusing on acute stabilization in severe pelvic trauma.	The outcomes assessed included feasibility, stabilization timing, hemodynamic implications, mortality, and acute trauma workflow.	The study concluded that rapid pelvic stabilization is central in critically unstable patients and may contribute to pain reduction by limiting pelvic motion while supporting hemorrhage control.
Li et al., 2025	The meta-analysis evaluated patients with hip fracture pain treated with pericapsular nerve group block compared with other analgesic strategies, providing indirect regional anesthesia evidence	The outcomes assessed included pain scores, opioid consumption, procedural pain, mobility-related pain, and adverse events.	The meta-analysis concluded that pericapsular nerve group block can improve acute fracture analgesia, although extrapolation to unstable pelvic ring injuries should be cautious because

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
	relevant to pelvic and proximal femoral trauma.		anatomical pain generators differ.
Samet et al., 2025	The review evaluated current research and future directions for regional anesthesia in acute trauma care, including peripheral nerve blocks and trauma-specific analgesic pathways.	The outcomes assessed included analgesic effectiveness, opioid-sparing effects, safety, feasibility, implementation barriers, and research priorities.	The review concluded that regional anesthesia is a promising trauma analgesia strategy, but unstable pelvic fracture patients require careful selection because anticoagulation, positioning, and neurologic monitoring may restrict use.
Lima et al., 2026	The systematic review and meta-analysis evaluated ketamine for pain control in acute bone fractures, comparing ketamine-based analgesia with opioid or conventional analgesic approaches.	The outcomes assessed included pain intensity, rescue analgesia, adverse events, opioid use, and emergency-care feasibility.	The systematic review concluded that ketamine can be effective for acute fracture pain and may be particularly relevant when opioid-sparing analgesia is desirable in severe trauma.
Fatahi et al., 2026	The study compared ketamine and morphine for acute musculoskeletal trauma pain in emergency and trauma settings.	The outcomes assessed included analgesic response, onset of pain relief, adverse events, patient tolerance, and comparative effectiveness.	The study concluded that ketamine and morphine may provide comparable analgesia for acute musculoskeletal trauma pain, supporting ketamine as a potential alternative or adjunct in selected unstable patients.
Shu et al., 2026	The secondary analysis evaluated pain outcomes after modern external ring fixation compared with internal fixation in severe open fracture care, providing indirect evidence on fixation method and pain trajectories in major limb trauma.	The outcomes assessed included pain outcomes, fixation strategy, functional recovery, and treatment-related morbidity.	The study concluded that fixation strategy may influence pain and recovery patterns, supporting the broader principle that mechanical stabilization is relevant to analgesic outcomes in severe trauma.
Yang et al., 2026	The systematic review evaluated external fixation for unstable pelvic ring fractures,	The outcomes assessed included fixation effectiveness,	The systematic review concluded that external fixation remains an important

Reference	Population / Intervention / Comparison	Outcomes	Main conclusions
	focusing on effectiveness and safety in patients requiring stabilization.	complications, safety profile, stability, and clinical outcomes.	stabilization method for unstable pelvic ring fractures, although direct reporting of analgesic endpoints remains insufficient.

5 RESULTS AND DISCUSSION

Perumal et al. emphasized that pain management in hemodynamically unstable pelvic fracture patients cannot be separated from hemorrhage-control algorithms, because the dominant early threat is preventable death from bleeding rather than pain alone.[13] Their analysis supports the concept that early pelvic stabilization, resuscitation, preperitoneal packing, and angioembolization are not merely surgical or interventional procedures but also pain-relevant interventions because they reduce mechanical instability and tissue displacement.[13] From an analgesic perspective, this reinforces the need to avoid isolated opioid escalation when severe pain may represent persistent pelvic motion, expanding hematoma, or incomplete stabilization.[13] Torrie et al. expanded the discussion by showing that regional anesthesia has an important opioid-sparing role in trauma, although the evidence is stronger for limb and hip fracture populations than for unstable pelvic ring injuries.[14] Their findings are clinically relevant because they position regional anesthesia as an adjunctive strategy rather than a universal solution in pelvic trauma.[14] The main limitation for unstable pelvic fractures is that severe pain may originate from multiple pelvic, sacral, acetabular, visceral, and soft-tissue structures that cannot be consistently covered by a single peripheral block.[14]

Rossaint et al. provided a guideline-level framework in which pain management must remain secondary to, and compatible with, bleeding control, trauma-induced coagulopathy correction, transfusion strategy, and rapid procedural decision-making.[15] In unstable pelvic fracture patients, this means that analgesic choice should not compromise blood pressure, airway safety, neurological reassessment, or timely transfer to angiography, operating room, or intensive care.[15] The guideline indirectly supports multimodal analgesia because it reduces reliance on high-dose opioids while preserving the flexibility required during damage-control resuscitation.[15] Klugh et al. contributed higher-level trauma-specific evidence by demonstrating that subdissociative ketamine infusion can reduce opioid exposure in severely injured patients receiving multimodal pain regimens.[16] Although the trial was not restricted to pelvic fractures, its population is highly relevant because unstable pelvic fracture patients frequently share the same problems of severe injury burden, opioid sensitivity, respiratory

vulnerability, and need for monitored care.[16] This evidence supports ketamine as a rational adjunct in selected unstable patients, particularly when analgesia is required without excessive respiratory depression or opioid escalation.[16]

Madsen et al. reinforced that high-energy pelvic ring injuries require integrated emergency pathways in which stabilization, hemostasis, imaging, operative planning, and resuscitation occur in parallel rather than sequentially.[17] Their review is important for pain management because analgesia in unstable pelvic trauma should be embedded in these pathways instead of being treated as a delayed postoperative issue.[17] The central clinical implication is that analgesia should facilitate stabilization, transport, imaging, and procedures, while never delaying hemorrhage-control measures.[17] Zheng et al. synthesized evidence on hemostatic interventions for hemodynamically unstable pelvic fractures and showed that external fixation, angioembolization, extraperitoneal pelvic packing, and combined strategies are central determinants of survival.[18] Their findings support the view that pain management begins with mechanical and hemostatic control, because untreated instability perpetuates nociceptive input and systemic deterioration.[18] The analgesic relevance of this evidence lies not in pain-score reduction as a measured endpoint, but in demonstrating that definitive control of pelvic instability is necessary before durable pain control can be expected.[18]

Sawauchi et al. demonstrated that management of unstable pelvic ring injuries has evolved toward structured, multidisciplinary, time-sensitive treatment algorithms.[19] This evolution is relevant to analgesia because modern trauma systems increasingly recognize that pain, agitation, hypoventilation, and inability to cooperate with imaging or procedures can destabilize care when not actively managed.[19] However, the review also highlights that analgesic endpoints remain poorly standardized in pelvic trauma literature, making direct comparison between analgesic strategies difficult.[19] Gänsslen et al. addressed long-term outcomes after pelvic ring injuries and showed that persistent pain, functional limitation, and quality-of-life impairment are common after severe pelvic trauma.[20] Their work underscores that acute analgesia should not be understood only as short-term symptom control, because inadequate stabilization, prolonged immobilization, nerve injury, and poorly controlled early pain may influence rehabilitation trajectories.[20] This connection between early trauma care and long-term pain reinforces the importance of multidisciplinary planning from the emergency phase through definitive fixation and follow-up.[20]

Dabetic et al. reviewed pelvic fractures in polytrauma and emphasized that outcomes depend on trauma-system organization, rapid diagnosis, resuscitation quality, fixation strategy, and coordinated specialist involvement.[21] This is directly applicable to analgesia because unstable pelvic fracture patients often require simultaneous input from trauma

surgery, orthopedic trauma, anesthesiology, emergency medicine, radiology, transfusion medicine, and intensive care.[21] Pain management is therefore safest when incorporated into shared protocols that define monitoring, escalation, contraindications to regional anesthesia, and opioid-sparing adjuncts.[21] Gänsslen et al. focused on pelvic packing in patients with unstable pelvic ring injuries and unstable hemodynamics, reinforcing the importance of direct hemorrhage control when shock persists despite initial measures.[22] In such patients, analgesia must be fast, titratable, and compatible with emergent procedures, because definitive pain relief is unlikely while pelvic bleeding and instability remain uncontrolled.[22] This supports a pragmatic model in which systemic analgesia is used initially, regional techniques are considered only when safe and feasible, and stabilization remains the core intervention.[22]

Balogh et al. highlighted the continuing high-risk nature of hemodynamically unstable pelvic fractures, with mortality driven by hemorrhage, physiological exhaustion, associated injuries, and delays in definitive control.[23] Their findings are important because they caution against analgesic strategies that obscure clinical deterioration or create avoidable hypotension in already unstable patients.[23] The study supports a trauma-first analgesic philosophy in which the clinician titrates pain relief while continuously reassessing perfusion, mental status, respiratory function, transfusion needs, and procedural priorities.[23] Shen et al. examined advances in reduction techniques for unstable pelvic ring fractures and emphasized improved accuracy, minimally invasive approaches, navigation, and evolving fixation technologies.[24] Although acute pain was not the central outcome, better reduction and less invasive fixation may plausibly reduce tissue trauma, mechanical pain, and postoperative rehabilitation barriers.[24] The indirect implication is that analgesic outcomes should be incorporated into future studies of reduction and fixation quality, because pain is a patient-centered endpoint that remains underreported in technical orthopedic literature.[24]

Oochit et al. compared early versus late definitive fixation in polytraumatized patients with pelvic ring fractures and showed that timing may influence complications, intensive-care outcomes, and recovery.[25] This evidence has analgesic relevance because prolonged unstable immobilization can maintain nociceptive stimulation, impair nursing care, increase opioid exposure, and delay respiratory and functional recovery.[25] Nevertheless, early fixation must be balanced against physiology, because unstable patients may require damage-control stabilization before definitive reconstruction is safe.[25] Grechenig et al. addressed emergency pelvic stabilization in critically unstable patients and reinforced the principle that rapid mechanical control is essential in severe pelvic trauma.[26] From a pain-management standpoint, emergency stabilization is a form of causal analgesia because it reduces abnormal pelvic motion and limits ongoing soft-tissue strain.[26] This supports the clinical

practice of combining early systemic analgesia with urgent stabilization rather than relying on pharmacological treatment alone.[26]

Li et al. evaluated pericapsular nerve group block for hip fracture pain and demonstrated meaningful analgesic benefits in a fracture population anatomically adjacent to the pelvis.[27] However, extrapolation to unstable pelvic ring injuries must be cautious because hip capsule pain differs from posterior ring, sacral, sacroiliac, pubic, acetabular, visceral, and soft-tissue pain generators.[27] The study is still relevant because it confirms that targeted regional anesthesia can reduce pain and opioid exposure when anatomy, coagulation status, and clinical stability permit safe block placement.[27] Samet et al. reviewed regional anesthesia in acute trauma and emphasized future research directions, implementation barriers, safety concerns, and the need for trauma-specific protocols.[28] Their conclusions align with the pelvic trauma evidence by suggesting that regional anesthesia should be used selectively in unstable patients rather than indiscriminately.[28] Contraindications such as coagulopathy, anticoagulation, evolving neurologic deficits, infection risk, limited positioning, and uncertain anatomical spread are especially important in pelvic fracture care.[28]

Lima et al. synthesized randomized evidence on ketamine for acute bone fracture pain and found that ketamine can be useful in emergency fracture analgesia, although superiority over conventional approaches may vary across settings and outcomes.[29] In unstable pelvic fracture patients, ketamine is most valuable not as a universal replacement for opioids but as an adjunct that may reduce opioid burden while preserving procedural responsiveness.[29] Its use should remain protocolized, monitored, and individualized, especially in patients with severe cardiovascular disease, psychiatric vulnerability, traumatic brain injury, or need for airway control.[29] Fatahi et al. compared ketamine and morphine for acute musculoskeletal trauma pain and found broadly comparable analgesic effects, with ketamine potentially offering faster onset in some scenarios.[30] This finding supports emergency-department and trauma-bay use of ketamine when opioid adverse effects are a concern, but it does not eliminate the need for opioids in patients with severe pelvic fracture pain.[30] In practice, ketamine and opioids should be viewed as complementary agents within a monitored multimodal plan rather than mutually exclusive choices.[30]

Shu et al. provided indirect evidence that fixation strategy can influence pain trajectories and functional recovery in severe fracture care.[31] Although the study did not focus on pelvic trauma, it supports the broader principle that mechanical environment and fixation method affect pain, rehabilitation, and patient-centered recovery.[31] For pelvic fractures, this principle strengthens the argument that analgesia should be evaluated alongside fixation stability, mobilization capacity, and long-term functional outcomes.[31] Yang et al. reviewed

external fixation for unstable pelvic ring fractures and concluded that it remains an important stabilization strategy, although pain-specific outcomes were insufficiently reported.[32] This gap is highly relevant because external fixation may relieve pain by reducing pelvic motion but may also create pin-site discomfort, mobility limitations, and nursing challenges.[32] Future pelvic fixation studies should therefore include acute pain scores, opioid consumption, regional anesthesia use, mobilization milestones, delirium, respiratory outcomes, and patient-reported recovery.[32]

Across the included studies, the strongest and most consistent finding is that pain management in unstable pelvic fractures cannot be separated from stabilization and hemorrhage control.[33] Evidence directly comparing analgesic regimens in this exact population remains limited, but indirect evidence supports a multimodal strategy using titrated opioids, acetaminophen, ketamine in selected patients, and regional anesthesia when anatomy and physiology are favorable.[33] Nonsteroidal anti-inflammatory drugs may be considered cautiously in later phases, but their role in unstable patients is constrained by renal hypoperfusion, bleeding risk, platelet function concerns, gastrointestinal risk, and uncertainty around fracture healing in specific clinical contexts.[33] The most defensible acute approach is therefore staged and physiology-based, beginning with rapid stabilization, hemodynamic resuscitation, and titratable systemic analgesia.[34] Regional techniques may be added after reassessment of coagulation, neurologic status, imaging findings, procedural priorities, and expected pain distribution.[34] Definitive fixation, intensive-care sedation, respiratory support, and rehabilitation planning should then be integrated into a longitudinal analgesic strategy that evolves as the patient stabilizes.[34]

Comparison with contemporary trauma guidelines and prior reviews suggests that the evidence base is stronger for hemorrhage control than for analgesia-specific decision-making in unstable pelvic fractures.[35] Guidelines consistently prioritize pelvic binders, blood product resuscitation, early recognition of pelvic bleeding, angioembolization, packing, and fixation, while analgesia is often mentioned only as supportive care.[35] This imbalance may reflect the ethical and logistical difficulty of conducting randomized analgesic trials in unstable trauma patients, but it leaves clinicians dependent on extrapolation from general trauma, hip fracture, and perioperative studies.[35] Using the Grading of Recommendations Assessment, Development and Evaluation framework, the certainty of evidence for hemorrhage-control and stabilization principles is moderate to high, whereas the certainty for specific analgesic comparisons in unstable pelvic fractures is low to very low.[36] The main reasons for downgrading are indirectness, heterogeneity, confounding by injury severity, inconsistent pain measurement, limited randomized data, and incomplete reporting of analgesic adverse

events.[36] Clinically, this review supports an evidence-informed but individualized approach in which analgesia is treated as a core component of trauma resuscitation, delivered through multidisciplinary protocols, and continuously adjusted according to physiology, fracture stability, procedural timing, and patient-specific risk.[36]

6 CONCLUSION

Pain management in traumatic pelvic fractures is inseparable from the broader priorities of trauma resuscitation, particularly in hemodynamically unstable patients. The available evidence indicates that durable analgesia depends not only on pharmacological treatment but also on early pelvic stabilization, hemorrhage control, correction of physiological derangement, and coordinated multidisciplinary care. Opioids remain useful for rapid titratable analgesia, but opioid-sparing strategies, especially ketamine-based adjuncts and selected regional anesthesia techniques, may reduce respiratory and sedation-related risks when applied with appropriate monitoring.

The clinical relevance of this review lies in emphasizing that pain should be treated as both a symptom and a marker of pelvic instability, soft-tissue injury, visceral involvement, or ongoing hemorrhage. In unstable patients, analgesic decisions must be compatible with airway safety, blood pressure preservation, transfusion strategy, neurologic reassessment, imaging, transport, surgical stabilization, and interventional radiology. The most practical approach is a staged multimodal plan that begins with stabilization and titratable systemic analgesia, followed by selective regional anesthesia and rehabilitation-oriented pain control once the patient's physiology becomes more favorable.

The main limitation of the literature is the absence of randomized trials specifically designed to compare analgesic strategies in hemodynamically unstable traumatic pelvic fracture patients. Most available evidence is indirect, derived from broader trauma populations, hip fracture analgesia, perioperative orthopedic care, pelvic hemorrhage-control studies, or fixation-focused analyses that do not use pain as a primary endpoint. Heterogeneity in fracture classification, injury severity, timing of intervention, sedation status, mechanical stabilization, coagulopathy, and outcome measurement limits the certainty of conclusions and prevents reliable quantitative synthesis.

Future research should prioritize prospective multicenter studies that incorporate pain-specific outcomes into pelvic trauma protocols. Relevant endpoints should include early pain scores when assessable, opioid consumption, ketamine exposure, regional anesthesia use, delirium, respiratory complications, hemodynamic adverse events, mobilization milestones, intensive-care length of stay, chronic pelvic pain, functional recovery, and patient-reported

quality of life. Trials and registries should also distinguish unstable pelvic ring injuries from acetabular fractures, fragility fractures, isolated hip fractures, and broader polytrauma cohorts to improve clinical applicability.

Evidence-based pain management in unstable pelvic trauma requires individualized, multidisciplinary, and physiology-centered decision-making. The optimal strategy is not a single drug, block, or fixation method, but rather a coordinated sequence of resuscitation, stabilization, analgesia, monitoring, definitive care, and rehabilitation. Integrating anesthesiology, trauma surgery, orthopedic surgery, emergency medicine, interventional radiology, intensive care, nursing, and rehabilitation teams is essential to reduce suffering while preserving survival-focused priorities in one of the most demanding scenarios in acute trauma care.

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