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The Effectiveness of Rapid Response Teams in Enhancing Acute Trauma Pain Management in Emergency Medical Care Settings: A Comprehensive Review

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Abstract

Background: Effective management of trauma-related pain is critical in emergency care, as inadequate pain relief can lead to long-term complications such as chronic pain syndrome, post-traumatic stress disorder, and decreased quality of life. Despite the high prevalence of pain in trauma patients, significant gaps in pain management persist in emergency departments.

Methods: This review synthesizes the literature on the efficacy of rapid response teams in managing acute trauma pain in emergency settings. A comprehensive analysis of existing studies was conducted, focusing on pain assessment methods, analgesic protocols, and patient outcomes.

Results: Findings reveal that a multimodal analgesic approach, incorporating opioids, non-steroidal anti-inflammatory drugs (NSAIDs), and adjunct therapies such as ketamine and nitrous oxide, significantly improves pain relief outcomes. However, it was noted that nearly 74% of trauma patients experience moderate to severe pain upon discharge from emergency departments, primarily due to delays in analgesia administration and insufficient pain assessment protocols. The study highlights the need for enhanced training for healthcare providers and the implementation of standardized pain management protocols.

Conclusion: The integration of rapid response teams in emergency departments can enhance the management of trauma-related pain through prompt assessment and tailored analgesic strategies. By addressing barriers to effective pain relief and fostering a culture of proactive pain management, healthcare systems can improve patient outcomes, reduce the incidence of chronic pain syndromes, and enhance the overall quality of care.

Keywords: Trauma pain management, emergency care, rapid response teams, multimodal analgesia, patient outcomes.

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1. Introduction

Pain is recognized to hinder respiratory function, immunological response, and wound healing, hence exacerbating patient outcomes by elevating metabolic demand in individuals with severe injuries. Insufficient management of acute pain after trauma postpones job resumption diminishes quality of life and heightens the risk of sequelae, including post-traumatic stress disorder [1]. An unmet need persists in the management of trauma-related pain throughout the patient's lifespan. Inadequate pain management is the primary risk factor for the onset of chronic pain syndrome, a very debilitating illness. Approximately two-thirds of patients report at least moderate pain twelve months post-injury. At the same time, three-quarters indicate that pain disrupts daily activities, and work, and causes cognitive, psychological, and emotional disturbances, notably diminished self-esteem and the onset of depression [2]. These repercussions elevate the likelihood of distress, which further exacerbates the pain and initiates a detrimental loop of trauma, pain, and stress feedback.

In pain management, the primary objective is to achieve a tolerable level of pain, defined as a level that is agreeable to the patient and enables minimal functionality [3]. Approximately 38 million individuals in Europe annually attend emergency departments due to stressful incidents, with over 5 million requiring hospitalization. Pain is a primary complaint in at least 90% of cases [4], however, patients frequently report insufficient alleviation from trauma pain [5,6]. Multicenter research [7] done in the United States and Canada revealed that 74% of patients were released from emergency departments with moderate to severe pain, consistent with rates found in European studies [6].

Research indicates that as many as two-thirds of trauma patients may endure a delay of up to one hour for analgesia in emergency departments, and even when they obtain pain-relieving medicine, its efficacy correlates with the intensity of their suffering [8]. The enduring repercussions of poorly managed acute pain are believed to be many and significant, both in the short and long term. These repercussions include an elevated danger of infection, diminished comfort, and advancement to chronic pain syndrome, a notably debilitating ailment with considerable economic and societal ramifications [9].

The management of trauma pain in Europe, both in the prehospital environment and in the emergency department, mostly involves paracetamol, non-steroidal anti-inflammatory medications (NSAIDs), nitrous oxide (N2O), and opioids [4,10,11]. The present application of these analgesics may be deemed insufficient. For instance, prospective data from Norwegian and Italian emergency departments indicated that only 14% and 32% of patients experiencing moderate to severe pain got analgesics, respectively [11,12].

The deficiency in effective pain treatment impacts not only the patient but also the whole emergency department, as healthcare staff are required to address more severe pain, resulting in resource implications. An unmet need exists for the safe, prompt, and effective treatment of trauma pain in emergencies. Nonetheless, obstacles to efficient pain treatment in the emergency department exist, mostly owing to the absence of robust national standards for pain management, postponed or nonexistent pain assessments, hesitance to use opioid analgesics, and delays in the provision of analgesia [5,6,13]. All these challenges result in insufficient and unproductive outcomes. There exists an unaddressed need for novel analgesic modalities, broader use of existing analgesics that mitigate certain limits of current treatment alternatives, and the formulation of pain management regimens.

2. Intensity of Pain and Therapeutic Interventions

In managing acute pain in wounded individuals, medications should be rapidly and easily administered, possess a short half-life, have great efficacy, and exhibit low adverse effects. The selection of pharmaceuticals and suitable administration techniques must take into account the response to and need for ongoing analgesia throughout the illness progression and recovery stages. Common analgesics used in

emergency department settings in Europe include opioids, nitrous oxide, paracetamol, and nonsteroidal anti-inflammatory drugs (NSAIDs) [6,13]. The analgesics used are customized based on the nature of the injury, pain intensity, or triage protocol in the emergency department [10,13,14].

Regional blocks, such as local anesthetic and peripheral nerve blocks, may be used in the management of trauma pain [15,16]. These interventions may diminish the need for supplementary analgesic therapy [17]. While not often addressed in the literature reviewed, non-pharmacological methods are significant in alleviating trauma pain; these methods include limb immobilization and the use of dressings or cold packs, which may be utilized with pharmaceutical treatment [18-22]. Certain therapeutic solutions include limits that may impede successful pain alleviation in emergencies.

Pain evaluation is complex, since using a one-dimensional measuring tool may fail to adequately represent the multidimensional characteristics of pain. To evaluate treatment efficacy and determine the need for more medication, it is advantageous to have a consistent measuring technique that maintains the same scale used for the first pain evaluation. The scientific community concurs with the use of one-dimensional assessment scales that correlate pain intensity with the appropriate therapy type [23-27]. In pediatric pain management, the guidelines permit the utilization of the FLACC, Wong-Baker, and NRS algometric scales, contingent upon the child's age, as supported by the literature. Additionally, analgesics may be administered according to team protocols if the score exceeds 4 [28,29].

The evaluation of a patient experiencing acute trauma pain might be intricate owing to factors such as the patient's age, emotional condition (anxiety, psychomotor agitation), and/or alterations in consciousness. In a trauma patient, pain is categorized as mild to moderate with an NRS score of 1 to 3, responding to paracetamol and/or NSAIDs; moderate to severe with a score of 4 to 6, responding to mild opioids and/or NSAIDs and paracetamol; and severe with a score of 7 to 10, responding to treatment with strong opioids and NSAIDs [30-35].

3. Acute Traumatic Pain

Opioids provide efficient analgesia for severe trauma pain and may be administered via several routes, including intravenous (IV), intranasal (IN), intraosseous (IO), subcutaneous (SC), and oral (PO). Morphine is predominantly used in emergency settings for acute pain in Europe; however, other opioids, including fentanyl and oxycodone, are also often employed [36]. Owing to alterations in pharmacokinetics and pharmacodynamics associated with aging, opioids should be initiated at a reduced dosage, about 25–50% of the dosage given to younger patients [37].

Opioids regulate pain signals in both the ascending and descending pathways of the brain and spinal cord, as well as at the supraspinal level, akin to endogenous opioid peptide ligands. The administration stimulates the brain's reward system in the ventral tegmental region and frontal cortex; hence, frequent usage heightens the danger of tolerance and dependency. They are very potent analgesics that operate by using their strong affinity for mu receptors in the central nervous system. At the spinal cord level, they interact with particular receptors situated in the pre-and postsynaptic synapses inside the dorsal horn. At the pre-synaptic level, opiates bind to G proteins, reducing the release of some pain neurotransmitters (e.g., substance P), which diminishes neuronal excitability at the post-synaptic level by inhibiting cyclic adenosine monophosphate (cAMP) [38].

The physiology of pain may explain the efficacy of opioids as analgesics. The physiology of pain indicates that a noxious signal from the periphery, such as trauma, is conveyed by primary afferents to the dorsal root ganglion and subsequently to the dorsal horn of the spinal cord. The pain signal ascends from the spinal cord via the ascending pain pathways to the spinothalamic tract inside the central nervous system. The brain transmits a signal via descending channels that regulate the incoming signal [39].

Opioid drugs replicate natural opioids and function by binding to G protein-coupled opioid receptors, therefore activating them (agonist action, intrinsic activity), while individual variations exist in receptor binding and signal transduction. Opioids suppress incoming signals along afferent pain pathways or alleviate pain by interacting with descending pain pathways. Responses are inherently unique and fluctuate

based on emotional state, prior experiences, and hereditary factors. The pharmacokinetic and pharmacodynamic properties of opioids elucidate the variances among available medications and inform the selection of an initial treatment strategy and subsequent titration in a multimodal approach [40].

The correlation between opioid levels and their effects is sometimes inconsistent, rendering it ineffective for forecasting both effectiveness and undesirable consequences [40]. The concentration/effect ratio is ineffective since the analgesic effect often lags after the peak concentration. Following a bolus administration of morphine, a consistent correlation between plasma morphine concentration and analgesic efficacy over time is absent; conversely, with fentanyl, the analgesic response diminishes swiftly as plasma concentration declines post-bolus dosages. The variations may significantly depend on the medication's lipid solubility and the proportion of the drug that is ionized at physiological pH.

Fentanyl has more lipophilicity than alfentanil, but alfentanil is 100 times more soluble than morphine. At a pH of 7.4, fentanyl is less than 10% ionized, alfentanil is over 90%, and morphine is around 20% [41]. Increased lipid solubility and a greater fraction of the medication in its ionized form enhance its ability to traverse the blood-brain barrier, therefore impacting the central nervous system. Different genetic variants, such as poor or ultra-rapid metabolizers, might influence opioid metabolism, resulting in individuals exhibiting either diminished or heightened responses than anticipated.

Genetic variations in patient response are more prevalent with codeine, but may also manifest with other opioids [43,44]. Consequently, under the multimodal approach, opioid rotation—switching from one opioid to another—can be advantageous when a patient fails to get the required analgesic effect from a certain formulation, since the patient may react more favorably to an alternative opioid [45].

The concurrent use of other central nervous system depressants (e.g., benzodiazepines, skeletal muscle relaxants, gabapentin, etc.) should be avoided; oral administration of opioids is designated for subsequent phases after the initial phase to sustain analgesic continuity or when pain is managed. Long-acting formulations (e.g., extended-release and transdermal treatments) are unsuitable for managing acute pain and should be used only in the post-acute period. Clinicians need to begin opioid tapering, especially during transitions to lower levels of care, aiming for the cessation of opioid medication at hospital discharge in opioid-naïve patients before admission [46].

Clinicians must tailor their choice of opioid therapies to individual patient factors, including organ dysfunction (e.g., avoiding morphine in patients with renal impairment) and the required duration of action (e.g., utilizing fentanyl for premedication in brief procedures like chest tube insertion, while reserving morphine or hydromorphone for breakthrough pain management). Dosing and tapering protocols for trauma patients differ according to the nature of the injury, organ impairment, surgical timelines, and several other clinical and demographic variables.

Ketamine, a derivative of phencyclidine, functions as a rapid N-methyl-d-aspartate (NMDA) antagonist and is very efficacious in the early treatment of trauma patients [47]. The standard dosage of ketamine for acute pain management in clinical settings is an intravenous (IV) bolus of 0.3 to 0.5 mg/kg, with or without an infusion typically ranging from 0.1 to 0.2 mg/kg per hour, depending upon the length of the patient's analgesic needs. Ketamine is a highly lipophilic compound characterized by fast dispersion and prompt penetration of the central nervous system. It has modest plasma protein binding (10–50%), an alpha half-life of 2–4 minutes, a beta half-life of 2–4 hours, and a substantial volume of distribution (160–550 liters). The liver metabolizes ketamine via cytochromes CYP 2B6 and CYP3A4, yielding (R, S)-nor ketamine, which is further converted to 6-hydroxynorketamine and 5,6-dehydronorketamine [48,49]. The metabolites possess a half-life of up to three days and exhibit significant analgesic and depressive properties. Bioavailability and efficacy differ based on the route of administration: intravenous administration yields a bioavailability of 100% with peak effect occurring within 1–2 minutes; intramuscular administration has a bioavailability of 93% with maximum effect reached in 5 to 10 minutes; oral administration presents a bioavailability of 16–29% with peak effect attained within 20 to 120 minutes. The oral administration of ketamine is seen as less advantageous because of its reduced bioavailability and substantial first-pass metabolism in the liver [50].

Ketamine has a multifaceted interaction with opioid receptors. It mitigates opioid tolerance, opioid-induced hyperalgesia, and central sensitization by engaging central and spinal opioid receptors as well as N-methyl-D-aspartate (NMDA) receptors [51]. Ketamine further stimulates NMDA receptors, resulting in postsynaptic hyperexcitability, central tolerance, and sensitization. Ketamine modifies and diminishes these effects, as seen with NMDA antagonists like MK-801 [52]. Ketamine has a downstream impact by increasing opioid-induced phosphorylation of extracellular signal-regulated kinase 1/2 (ERK 1-2), hence reducing the number of opioids necessary to get the desired therapeutic outcome (sparing effect). This also aids in diminishing unpleasant effects, such as respiratory depression and emesis [53].

The extensive therapeutic index, cardiovascular stability, and absence of respiratory depression make ketamine appealing for use in the prehospital environment [54,55]. Ketamine's dissociation properties provide it an excellent therapy for trauma-related pain; nonetheless, concerns have been expressed about psychiatric manifestations and potential long-term psychotomimetic consequences [56]. Low-dose methoxyflurane, a non-opioid volatile fluorinated hydrocarbon, is delivered by a hand-held inhaler. The use of methoxyflurane for general anesthesia has been halted owing to renal safety issues; nevertheless, the administration of sub-anesthetic doses for brief durations does not correlate with nephrotoxicity [57].

Methoxyflurane has been utilized in emergency contexts in Australia and New Zealand for over three decades and has recently received approval in several European nations (including Belgium, France, Ireland, and the United Kingdom) for the emergency management of moderate to severe pain in alert adults experiencing trauma and related discomfort. A randomized, open-label, active-controlled, multicenter trial in Italy (MEDITA) [59] and a meta-analysis [60] encompassing four randomized clinical trials demonstrated that low-dose methoxyflurane exhibits superior efficacy compared to certain analgesics presently utilized for managing acute musculoskeletal pain resulting from trauma.

The investigation verified the fast onset of analgesia with low dose methoxyflurane. Enhanced analgesia was seen on the primary endpoint (variation in pain intensity) from 5 minutes post-treatment beginning and sustained throughout the 30-minute evaluation. The effective analgesic properties of low dose methoxyflurane were consistently seen across many endpoints, including the duration until pain alleviation and other response metrics. The enhanced pain measures were also corroborated by increased satisfaction among patients, caregivers, and even study researchers [60].

A multimodal analgesic strategy, including two or more pharmacological agents with distinct modes of action, is crucial for alleviating trauma-related pain [46]. It is characterized as the comprehensive use of several tactics, including systemic analgesics, regional analgesic treatments, and non-pharmacological therapies, to influence peripheral and/or central nervous system locations throughout the pain pathway [61]. The principle of multimodal analgesia may be used across the whole treatment continuum, with interventions tailored to each phase of care (Figure 1). **Figure 1.** The multimodal strategy for trauma patients concerning the emergency department route from arrival to the ultimate determination of pain intensity.

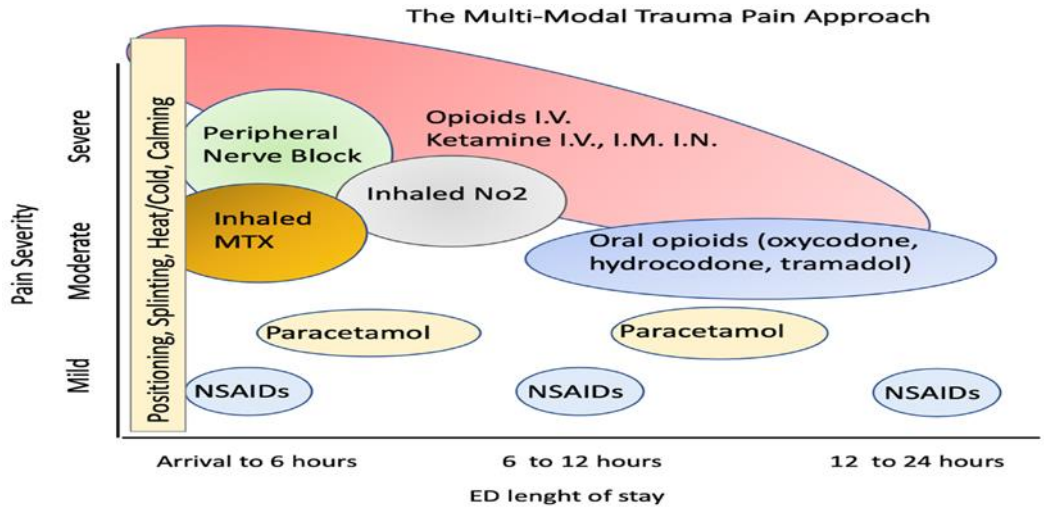

Figure 1. The multimodal strategy for trauma patients concerning the emergency department route from arrival to the ultimate determination of pain intensity.

4. The Patient's Trajectory for Trauma Pain Management in the Emergency Department

The emergency department (ED) pathway of a trauma patient, who is rescued by an ambulance team, accepted in triage, evaluated by the emergency physician, and subjected to diagnostic tests and treatment for reported injuries, must navigate numerous challenges that regrettably result in interruptions and insufficient analgesia during the diagnostic and therapeutic process in the ED (Figure 1). These challenges are due to the constraints of existing medicines, healthcare workers' perceptions of opioids, the absence of proven recommendations for pain management in emergency departments across most nations, and insufficient pain assessment in emergency contexts. A substantial cultural shift among emergency health providers is necessary to enhance trauma pain care and adopt a patient-centered approach [62,63].

The particular medication advised for pain management in the emergency department may differ based on the trauma type, pain intensity, team proficiency, and the attending physician's expertise and experience [6,13]. A multimodal pharmaceutical strategy is typically the most suitable and considered treatment upon first presentation to the emergency department. By combining various medications with distinct properties and modes of administration, the pharmacological effects of each medication are amplified through their synergistic use, employing diverse mechanisms of action and integrating various effects from arrival at the emergency department until transfer to a standard ward or discharge (Figure 1).

The ideal treatment protocol upon arrival at the emergency department, following non-pharmacological interventions such as positioning and splinting of fractures, should incorporate intravenous opioids, ketamine, along judicious doses of inhaled analgesics and a peripheral nerve block for cases involving peripheral or localized injuries. This multimodal strategy must then be adjusted in later stages based on the intended results, including the potential for administering effective long-term analgesic therapy, using agents such as mild opioids and NSAIDs (Figure 1).

The selection of analgesics may be limited by their availability and the trust of practitioners in their use. The administration route of analgesics in trauma pain treatment may have several restrictions. Intravenous (IV) analgesia is often the predominant method of delivery in emergencies, delivering fast pain relief. Administering IV analgesia might be challenging in some situations, such as at the site of a traffic accident [64,65]. Challenges may occur while trying to provide intravenous therapy in cold weather within the prehospital environment or to patients with challenging venous access, resulting in additional discomfort for the persons and delaying the initiation of analgesia. Additionally, in many nations, such as Denmark, numerous paramedics lack the authorization to provide intravenous medicine [66].

Intravenous and other medication delivery methods may exacerbate pain in patients already experiencing trauma pain and are hence unsuitable in some instances. Furthermore, the administration of some

analgesics, while useful for pain management, may be unsuitable in cases of substantial edema or hypovolemia, conditions often seen in seriously wounded patients [67]. The method of intra-muscular injection precludes dosage titration or modification, potentially leading to inadequate and uncertain analgesia. Moreover, the intraosseous route of administration necessitates the insertion of an intraosseous needle, which is uncomfortable for the patient and hardly used in practice. Numerous wounded patients eligible for local anesthetic or regional nerve blocks often do not obtain such treatment owing to the limited prevalence of these practices, as well as the inadequate proficiency and experience of surgeons in using these treatments [6,13].

Intranasal (IN) medication delivery in trauma is much less intrusive than intravenous (IV) administration; yet it may provide challenges in cases of severe face injuries, epistaxis, nasal congestion, and dysphagia [68]. In these people, IN administration may provide a poor analgesic dosage, rendering the treatment of traumatic pain ineffective during the early phase of intervention (Figure 1). Recent technological advancements enable continuous localized analgesia, offering pain relief for many days instead of only hours. Locoregional analgesia offers more rapid pain relief compared to systemic analgesia alone, reduces opioid use, and decreases hospital length of stay [69]. Recent advancements in ultrasound-guided localized analgesia have facilitated the incorporation of this technique into contemporary clinical practice (Figure 1). These blocks are technically less complex than conventional neuraxial blocks and nerve plexus blocks. The fascial block procedures, except the quadratus lumborum block, are seen as viable options, especially for patients undergoing treatment with antiplatelet and anticoagulant medications [70].

The emergence of compartment syndrome in treated cases may be a consequence, particularly in instances of limb trauma, especially complicated fractures or crush injuries with fragments. Although evidence on this subject is few, the full obstruction of sensory and motor function in the limb may hinder the prompt and accurate identification of compartment syndrome [71]. To mitigate the danger, minimal dosages of analgesics should be used in these instances to attain a partial sensory/motor blockage.

Regional analgesia necessitates investment in the training of practitioners and the structuring of treatment routes. Systemic toxicity of local anesthetics is a potential consequence. Minor symptoms include vertigo, tinnitus, and perioral paresthesia. Instances of more severe occurrences involving seizures or even cardiac arrest have also been documented. Systemic toxicity from the local anesthetic may manifest immediately after block insertion or within 45 minutes following the procedure's conclusion. [72]. The onset of systemic toxicity from the local anesthetic may be mitigated by the rapid introduction of a 20% lipid emulsion [73].

5. Conclusions

Based on the information from the literature, the care of moderate to severe trauma pain in the emergency department might be enhanced by augmenting the use of pain rating scales and formulating and executing effective pain management protocols, particularly using a multimodal pharmacological strategy. These approaches will decrease healthcare expenses for those improperly handled in emergencies. The rising use of analgesics, an expanded array of delivery modalities, and an abundance of accessible drugs will enable the resolution of both cultural and professional hurdles that now impact patient outcomes.

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فعالية فرق الاستجابة السريعة في تحسين إدارة آلام الإصابات الحادة في أقسام الطوارئ: مراجعة شاملة

الملخص

الخلفية :تُعد الإدارة الفعّالة لآلام الإصابات الحادة أمرًا بالغ الأهمية في رعاية الطوارئ، حيث إن عدم تخفيف الألم بشكل كافٍ قد يؤدي إلى مضاعفات طويلة الأمد مثل متلازمة الألم المزمن واضطراب ما بعد الصدمة وانخفاض جودة الحياة. وعلى الرغم من الانتشار العالي للألم بين مرضى الإصابات، لا تزال هناك فجوات كبيرة في إدارة الألم داخل أقسام الطوارئ.

المنهجيات :تقوم هذه المراجعة بتحليل الأدبيات المتعلقة بفعالية فرق الاستجابة السريعة في إدارة آلام الإصابات الحادة في بيئات الطوارئ. تم إجراء تحليل شامل للدراسات الحالية، مع التركيز على طرق تقييم الألم، وبروتوكولات المسكنات، ونتائج المرضى

النتائج :تشير النتائج إلى أن نهج العلاج متعدد الوسائط، الذي يدمج بين الأفيونات ومضادات الالتهاب غير الستيرويدية (NSAIDs) والعلاجات المساعدة مثل الكيتامين وأكسيد النيتروز، يُحسن بشكل كبير من نتائج تخفيف الألم. ومع ذلك، لوحظ أن حوالي 74% من مرضى الإصابات يعانون من آلام متوسطة إلى شديدة عند الخروج من أقسام الطوارئ، ويرجع ذلك أساسًا إلى التأخير في إعطاء المسكنات وعدم كفاية بروتوكولات تقييم الألم. كما أظهرت الدراسة الحاجة إلى تعزيز تدريب مقدمي الرعاية الصحية وتنفيذ بروتوكولات موحدة لإدارة الألم.

الخلاصة :يمكن أن يؤدي دمج فرق الاستجابة السريعة في أقسام الطوارئ إلى تحسين إدارة آلام الإصابات من خلال التقييم السريع واستراتيجيات المسكنات المخصصة. ومن خلال معالجة الحواجز التي تحول دون تخفيف الألم وتعزيز ثقافة الإدارة الاستباقية للألم، يمكن لأنظمة الرعاية الصحية تحسين نتائج المرضى، وتقليل حدوث متلازمة الألم المزمن، وتعزيز جودة الرعاية بشكل عام.

الكلمات المفتاحية :إدارة آلام الإصابات، رعاية الطوارئ، فرق الاستجابة السريعة، تسكين الألم متعدد الوسائط، نتائج المرضى.