Trends in Prehospital Pain Management: Two Decades of Point-of-Injury Care

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ABSTRACT **Background:** Pain control in trauma is an integral part of treatment in combat casualty care. More soldiers injured on the battlefield need analgesics for pain than life-saving interventions (LSIs). Early treatment of pain improves outcomes after injury, while inadequate treatment leads to higher rates of post-traumatic stress disorder (PTSD).

Objectives: To describe the experience of the Israel Defense Forces (IDF) Medical Corps with prehospital use of analgesia.

Methods: All cases documented in the IDF-Trauma Registry between January 1997 and December 2019 were examined. Data collection included analgesia administered, mechanism of injury, wound distribution, and life-saving interventions performed.

Results: Of 16,117 patients, 1807 (11.2%) had at least one documented analgesia. Demographics included 91.2% male; median age 21 years. Leading mechanism of injury was penetrating (52.9%). Of injured body regions reported, 46.2% were lower extremity wounds. Most common types of analgesics were morphine (57.2%) and fentanyl (27%). Over the two decades of the study period, types of analgesics given by providers at point of injury (POI) had changed. Fentanyl was introduced in 2013, and by 2019 was given to 39% of patients. Another change was an increase of casualties receiving analgesia from 5–10% until 2010 to 34% by 2019. A total of 824 LSIs were performed on 556 patients (30.8%) receiving analgesia and no adverse events were found in any of the casualties.

Conclusions: Most casualties at POI did not receive any analgesics. The most common analgesics administered were opioids. Over time analgesic administration has gained acceptance and become more commonplace on the battlefield.

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Pain management is an essential part of medical care. Many organizations, including the World Health Organization, have emphasized the importance of proper analgesia [1]. In 1995, the American Pain Society aggressively pushed the concept of pain as the fifth vital sign [2]. Both physiological and psychological complications resulting from insufficient pain management are well known and have been shown to have a direct effect on a patient's prognosis. Interestingly, co-morbidities associated with ongoing pain are highly prevalent within the military population. Post-traumatic stress disorder (PTSD), addiction, and depression are a few examples of psychological co-morbidities that reinforce the necessity for rapid pain treatment [3,4]. Unlike most civilian prehospital settings, the military medical system is tasked with managing pain in an austere combat environment while implementing lifesaving interventions. These additional challenges pose multiple obstacles for rapid analgesic administration. Early analgesia can reduce the possible development of central sensitization and chronic pain, thereby indirectly reducing the development of pain-associated co-morbidities [5,6]. Unfortunately, there is a continued lack of attention and knowledge of pain management in combat settings. Nevertheless, insight into both optimal analgesics and optimal procedures for their administration for combat casualties is an ongoing necessity [7-10].

In the past decade, more than 50,000 service members were wounded on the battlefields of Iraq and Afghanistan [11]. Although the number of causalities treated for pain in combat has increased throughout the decade, multiple factors limit our knowledge and methods of proper implementation of analgesia in the combat setting. Pain and co-morbidities experienced by military members injured in combat challenge the military medical system but also offer a unique opportunity to enlighten the

medical community about the use of prehospital analgesics as a pain management intervention in austere and unconventional settings. Such early intervention can increase performance of casualties may indirectly alter wound healing and recovery time while deterring long-term physiological and psychological co-morbidities, not only at the point of injury (POI) but throughout a service member's career [6]. Moreover, proper treatment of injuries, includes addressing pain at the earliest time possible [12,13].

Currently, as POI pain management is understood to be a fundamental part of emergency treatment to both medical and military society, it is explored wildly in both animal models and clinical settings in a constant race to develop new and improved pain relief methods. Numerous protocols for prehospital pain management are used in civilian and military settings. The Prehospital Trauma Life Support, the Committee of Tactical Combat Casualty Care (CoTCCC), and the American College of Emergency Physicians have all adopted protocol guidelines for pain management [3,14,15]. Ideally, analgesics should be administered at first encounter with a medical provider. The body's natural physiological responses to intense pain are increased heart rate, increased respiratory rate, and release of a multitude of endogenous substances (e.g., prostaglandin, substance P, and bradykinin). The prolonged activation of the sympathetic nervous system and neuroendocrine system, initially allowing these physiological responses to acute pain, can be detrimental. Polytrauma plus pain on the battlefield may impact demand on the body and can negatively affect the mission and efficiency of evacuation.

The Israel Defense Forces-Trauma Registry (IDF-TR), which is part of the Israel Defense Forces-Medical Corps (IDF-MC), is responsible for all trauma-related clinical practice guidelines (CPGs). In 2013 the IDF-MC published a revised pain management CPG, adding oral transmucosal fentanyl (Actiq®) to providers armamentarium and emphasized the efficacy of low dose ketamine for pain management.

Knowledge concerning the efficacy, safety, and usability of the analgesics in a combat environment remains incomplete and elusive. Nonetheless, military healthcare providers should be trained on combat-related POI pain management using this current knowledge but cautioned on its limitations. In this study, we reviewed all cases of POI pain treatment documented in the IDF-TR.

PATIENTS AND METHODS

IDF-TR

The IDF-TR is a prehospital military trauma registry containing data on all traumatic casualties (civilian or military) cared for by military medical teams since 1997 as part of the Trauma and Combat Medicine Branch (TCMB) of the IDF-MC. Medical providers collect data at the POI in the form of casualty cards containing concise data regarding location, mechanism, treatment, casualty status, and means along with the destination of evacuation. Until 2013 casualty cards were collected by the TCMB and subsequently entered on the registry by designated personnel. Since 2013, data are entered into the IDF-TR within a few hours from injury by the treating physician or paramedic. Recorded data are then reviewed for discrepancies by designated personnel in the TCMB. During war times and high-intensity conflicts, such as the Second Lebanon War (2006) and operation Protective Edge (2014), these data, as well as additional data gathered by TCMB debriefing teams deployed to the field and to receiving hospitals, were entered into the IDF-TR by the TCMB staff.

There is a specific field in the IDF-TR for capturing whether pain analgesia was used. Some of the data fields in the IDF-TR are mandatory, such as caregiver identity and profession, procedure success, placement site, perceived complication, and tactical setting of placement. Others, including pain medications and scores, are not obligatory.

STUDY DESIGN

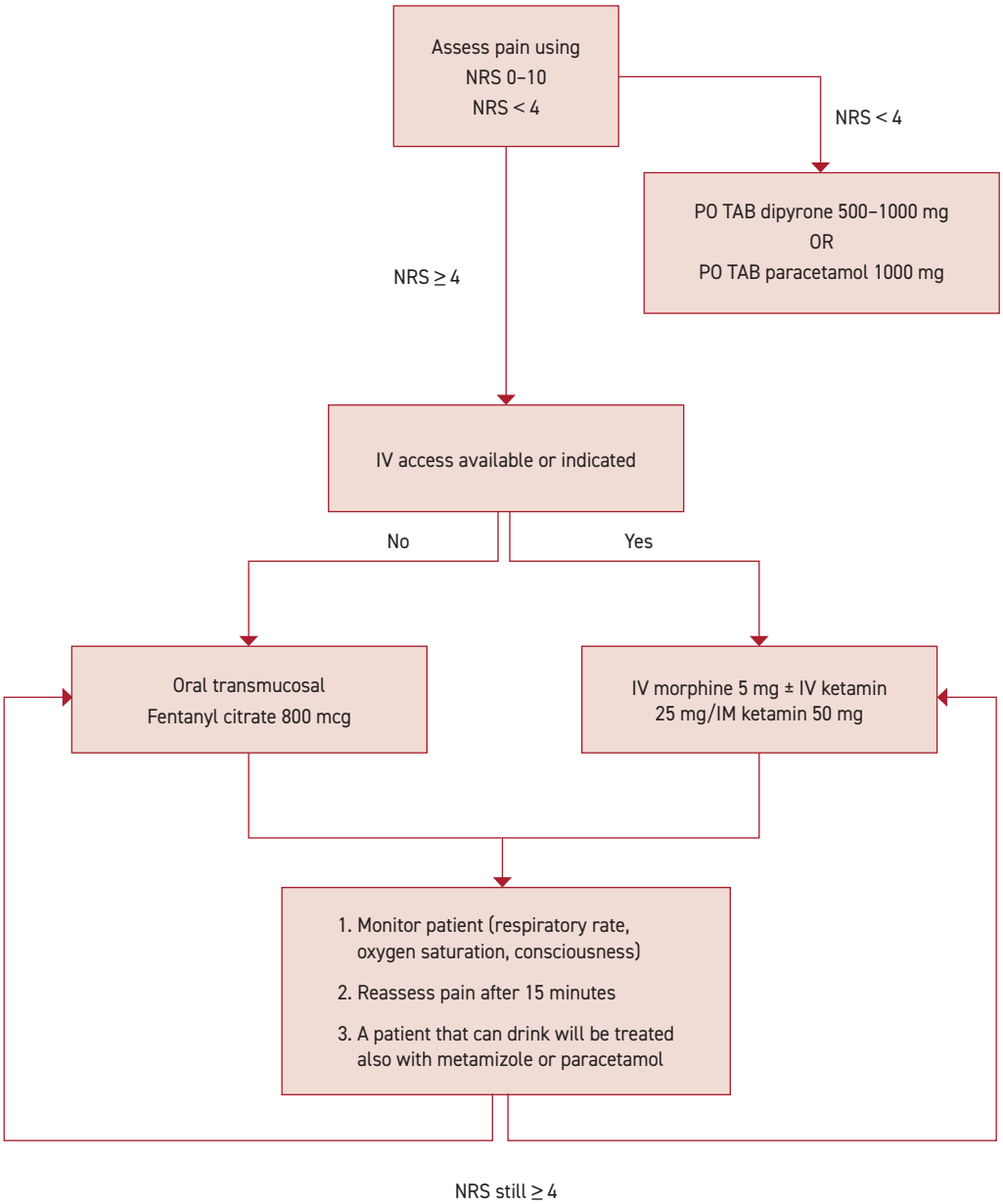
This study was conducted as a retrospective case series of all documented cases known to be treated with an analgesic by IDF medical providers in the prehospital setting from January 1997 to December 2019. The IDF-MC ethics review board approved this study and waived the need for informed consent (#1484).

Casualties were considered eligible for pain medication when documented to be conscious, alert, and with more than a minor traumatic injury. Unconscious and unresponsive patients were excluded from this study as well as those receiving medication to induce anesthesia before LSIs, such as intubation. Patients were identified by documentation of prehospital analgesic use in the IDF-TR, including morphine, ketamine, fentanyl, and oral analgesics such as paracetamol and dipyrone. Routes of administration were defined as intravenous (IV), intramuscular (IM), transmucosal (TM), and oral administration (PO). An individual episode was ascribed when a patient received a dose of analgesia via any route of administration (i.e., initial drug administration, a second dose of the same drug, a subsequent different drug, or the same drug via an alternative route). IDF-MC pain management CPG is shown in Figure 1.

Prehospital data collection included demographic information, mechanism of injury, vital signs, Glasgow Coma Score (GCS), and life-saving interventions (LSIs). Regional wound distribution was demarcated based on projected body surface area and grouped into main body regions: head and neck; trunk including the chest, abdomen, and pelvis; and extremities, which were subdivided into upper and lower. Mechanism of injury (MOI) was grouped into three main categories: penetrating, which includes penetrating injuries from explosion (e.g., improvised explosive device, landmine, mortar, shrapnel, bomb, grenades) and gunshot wound (to include shrapnel originating

Figure 1. Israel Defense Forces-Medical Corps pain management clinical practice guideline (June 2013)

IM = intramuscular, IV = intravenous, NRS = Numeric Rating Scale, PO = oral administration



from gunshots); blunt; and other (e.g., inhalation, burns).

LSIs were defined according to IDF-MC clinical practice guidelines (CPGs) to include cricothyroidotomy, needle thoracostomy, chest tube thoracostomy, and application of tourniquets and hemostatic dressing, as well as concurrent use of crystalloids, tranexamic acid, and reconstituted freeze-dried plasma administered by advanced lifesaving (physician or paramedic) providers [16-20]. Adverse events were defined as an undesired effect of the medication used, which lead to a decrease in consciousness level; representing either as a decreased level of alertness (lack of response to a verbal command or pain stimulation) and/or a decrease in the GCS following analgesic treatment. Adverse events were also defined as a change in hemodynamic status to include a drop of more than 30 mmHg (millimeter of mercury) in blood pressure.

STATISTICAL ANALYSIS

Continuous data are presented as medians and interquartile ranges (IQRs); categorical data are presented as absolute numbers and percentiles. Data analysis was performed using R version 3.61 (R Core Team, Vienna, Austria).

RESULTS

PATIENT AND INJURY CHARACTERISTICS

From January 1997 to December 2019, a total of 18,434 trauma patients were recorded in the IDF-TR of whom 16,117 were considered eligible for our study. Overall, 1807 (11.2%) were treated with an analgesic at the prehospital settings (median number of episodes one, interquartile range [IQR] 1–2). In this cohort, the median age was 21 years (IQR 19–25); 1622 patients (91.2%) were male. The leading mechanisms of injury were penetratinginjuries (956 patients [52.9%]) and blunt injury (687 patients [38%]). Other mechanisms included motor vehicle collisions and other injuries. The predominant body regions injured were the lower extremities (885 [46.2%]) and upper extremities (567 [31.4%]) followed by the trunk (484 [26.8%]) and head, face, neck (438 [24.3%]).

ANALGESICS ADMINISTERED

For the 1807 patients who received an analgesic, a total of 2204 episodes of analgesics administered were recorded (1.2 episodes per casualty). Intravenous morphine was most frequently administered (1062 episodes [48.2%]). The median doses for all routes (IV, IM, TM, and PO) of administration are shown in Table 1.

ANALGESICS USE OVER TIME

Percentages of casualties treated with pain medication through the study years, as well as the percentage of medication used each year, are shown in Figure 2. Until 2010, the percentage of casualties treated with pain medication was between 5% and 9%, while in 2010, an increase in the percentage of treated patients was observed, reaching 34% of casualties in 2019. When comparing drugs administered pre and post introduction of pain management CPG (June 2013), a change was seen with the increasing use of fentanyl, becoming the most common medication as well as the reappearance of low dose ketamine as analgesia.

LIFE-SAVING INTERVENTION AND ADVERSE EVENTS

A total of 824 LSIs were performed on 556 patients (30.8%) receiving analgesia. Tranexamic acid was the most common medication used for LSIs, 304 times to reduce bleeding. Tourniquets were the most common LSI device applied (277 times) and hemostatic dressings were used 96 times. No adverse events due to the administration of analgesia were found in any of the casualties. Figure 3 shows LSIs performed on casualties who were also treated with pain medication.

DISCUSSION

In this retrospective study, we evaluated pain management at POI and represented the IDF-MC experience on the battlefield during the past two decades. In this context, some noteworthy observations merit discussion, and information collected can be used to understand pain management in the prehospital environment better.

Similar to other studies, only a minority of patients received prehospital analgesia. Previously published data from the IDF-MC examining the years 1997–2014 showed less than 20% of casualties receiving pain medication [21]. The work of Bowman et al. [22] and Gerhardt et al. [23] regarding U.S. combat casualty showed only 6.7% and 15%, respectively, of casualties having a documented prehospital analgesic administration. Higher percentages were described in studies by Schauer et al. [10] and

Table 1. Analgesics and median doses for routes of administration, with the mechanism of injury for each medication

	Morphine (IM)	Morphine (IV)	Fentanyl (TM)	Ketamine (IV)	Oral analgesia
N (%)	198 (9%)	1062 (48.2%)	595 (27%)	213 (9.6%)	136 (6.2%)
Male gender, % (n)	95.3% (182)	92.1% (964)	90.6% (533)	87.3% (186)	95.6% (130)
Mechanism of injury					
Penetrating	57.1% (113)	57.1% (606)	49.1% (292)	52.1% (111)	48.5% (66)
Blunt	38.9% (77)	31.8% (338)	44.7% (266)	39.9% (85)	46.3% (63)
Other	9.1% (18)	11.6% (123)	9.2% (55)	9.4% (20)	10.3% (14)
Dose	8 mg (4.3)	8.1 mg (5.3)	800 mcg (569) 1600 mcg (26)	41 mg (33)	NA

IM = intramuscular, IV = intravenous, TM = transmucosal

Figure 2. Trends of analgesics used over the study period. The black line marks the percentage of overall casualties receiving analgesia during the same year

IM = intramuscular, IV = intravenous, PO = oral administration

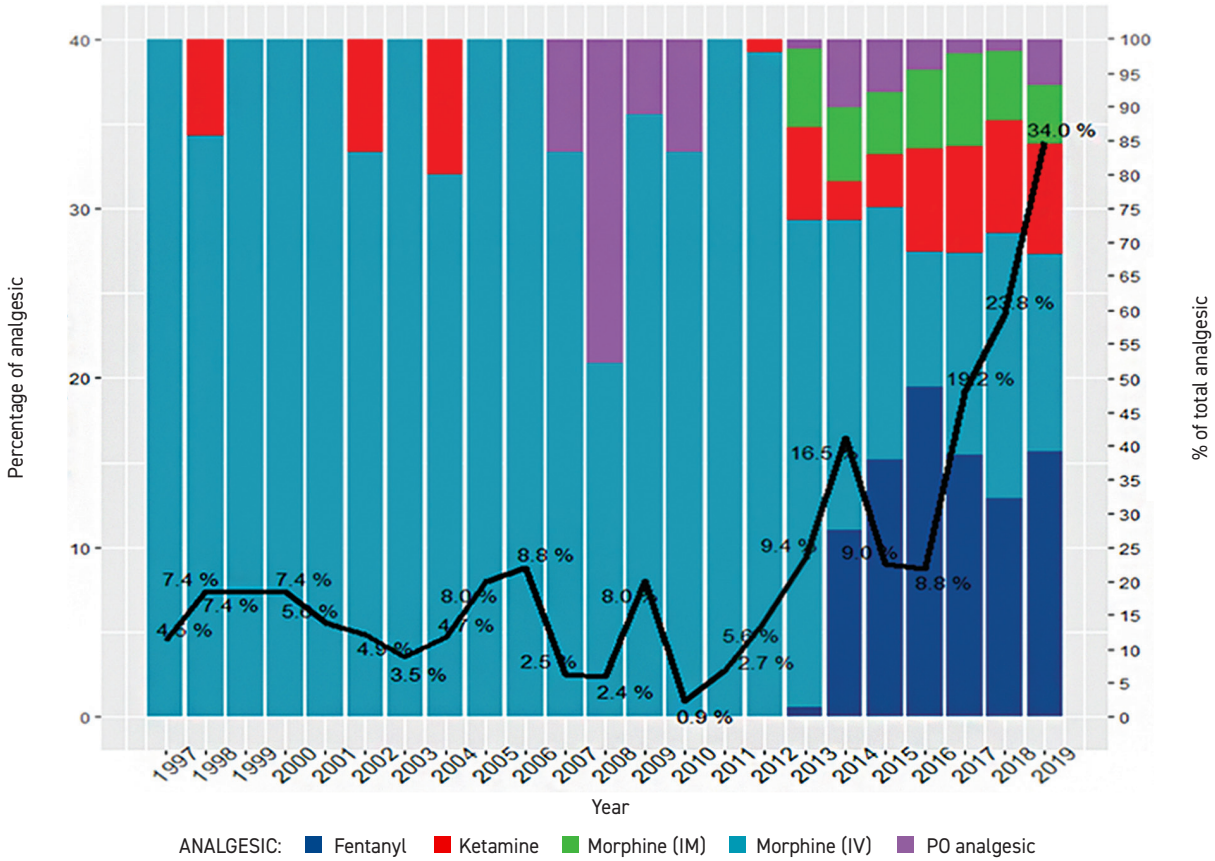
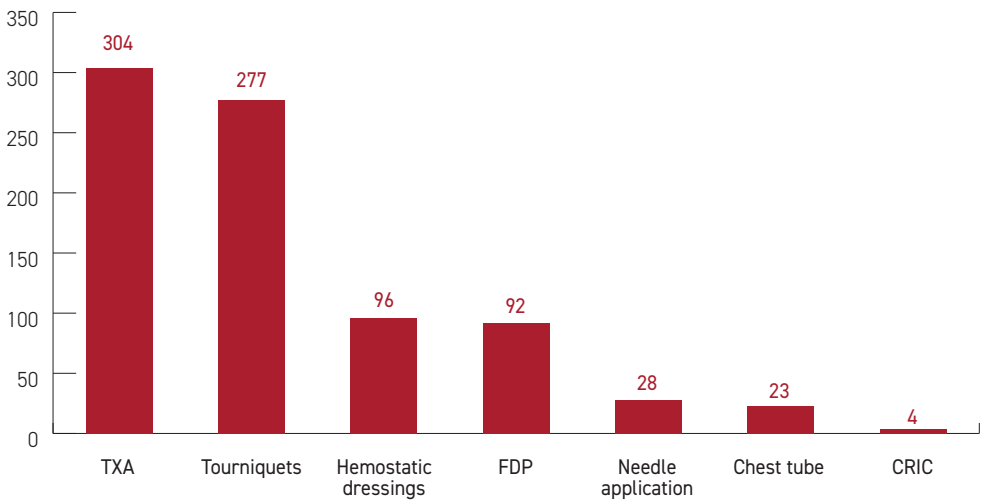


Figure 3. Life-saving interventions performed on casualties treated with analgesia

CRIC = cricothyroidotomy, FDP = fibrin/fibrinogen degradation product TXA = tranexamic acid



Shackelford [24] on prehospital pain medication use. The study by Schauer and colleagues on adherence to CoTCCC guidelines reported that 35% of eligible casualties received analgesia, compared with 39% marked in the study by Shackelford and co-authors. These studies included POI and enroute care, thus inflicting comparison.

Yet, a clear trend is seen through the years with an increase in the percentage of casualties receiving pain medication. Such adherence to CPGs is likely multifactorial. One probable reason for the low adherence rate may stem from the fact that pain treatment is not considered a life-saving intervention, the significance of such treatment may not be apparent to the caregiver but can affect a casualty in the long term. Short distance to medical treatment facilities and relatively quick evacuation time from combat areas in Israel and worldwide may influence administration of analgesia as well. Last, we assume that although pain treatment is part of the guidelines, it is not part of basic medical training for physicians and paramedics, in contrast to other LSIs procedures such as airway management and hemorrhage control. Current data demonstrate that future steps need to be improved, such a low adherence rate. The possibility of gaps in the data collection should also be mentioned. One may even claim the increase to 34% of the casualties may be a result of better documentation. Nonetheless, rapid analgesic administration at POI must become a priority.

Our study further underscores the fact that within the scope of available pain medication at prehospital settings, there is not a single drug that can effectively address injuries of different severities and patterns; rather, the specific analgesic must be tailored to each casualty, which complicates decision-making on the battlefield. Presently, the three most commonly used analgesic options for prehospital care worldwide are morphine, fentanyl, and ketamine [3,8,15,25]. Fentanyl was only introduced to the IDF in 2013 and gained increasing popularity to become the most common analgesic in 2015, reaching 39% compared with 31% of casualties receiving morphine, once the most commonly used drug, and sometimes the only drug used. Opioids and other parenteral sedatives have risks of decreased ventilation, hypoxia, and hypercarbia. They are also known to impair the patient's mental status and cognitive state, which interferes with the interpretation of neurologic examinations while transported from POI to the hospital. We hope that the gold standard combat analgesic and delivery system will be found, a single drug that can effectively address injuries of different severities and patterns while allowing safe and effective evacuation of the casualty.

We have also found a group of casualties receiving analgesia while also requiring life-saving intervention. Such use validates the fact that pain can be effectively managed on the battlefield, even in life and death situations. One can even claim that pain management early after injury may aid in the success and implementation of LSIs as well as in short- and long-term patient outcome. This hypothesis, however, is not supported by these data and should be carefully evaluated in a follow-up study.

LIMITATIONS

The first limitation concerns the challenge of data collection from the battlefield during combat situations, which may lead to missing data and retrospective gathering. Such incomplete data could be attributed to the fact that analgesia is considered a relatively minor treatment. It is possible that administration of analgesia was not adequately recorded or that in patients presented with minor injuries, administration of analgesia was not recorded properly. The second limitation concerns the retrospective nature of the study. The third limitation concerns the lack of a control group, limiting the possibility of accurately assessing the effect of the procedure on patient outcomes.

The battle that advocates for pain therapy is far from being won. Our work contains the largest dataset ever published regarding the treatment of pain at POI in military and civilian settings. Treatment of pain, once considered negligible, has moved to the frontlines of injured care, and more needs to be done by caregivers and by medical commanders to improve combat casualty care.

CONCLUSIONS

During the study period, rates of casualties receiving analgesia rose, advocating the importance of battlefield pain management, as well as the feasibility of pain treatment at the POI, with only minimal adverse effects. Caregiver education and training as well as continuous data collection form POI are the first steps in shifting to better pain management in the battlefield, while the development of improved treatment options continues.

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The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the U.S. Department of the Army or the U.S. Department of Defense.

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Capsule

A comprehensive analysis of the efficacy and effectiveness of COVID-19 vaccines

He et al. wrote that in general, the current COVID-19 vaccines showed a cumulative efficacy of 66.4%, 79.7%, and 93.6% to prevent SARS-CoV-2 infection, symptomatic COVID-19, and severe COVID-19, respectively, but could not prevent the asymptomatic infection of SARS-CoV-2. Furthermore, the current COVID-19 vaccines could effectively prevent COVID-19 caused by the Delta variant, although the incidence of breakthrough infection of the SARS-CoV-2 Delta variant increased when the intervals post-full vaccination extended, suggesting the waning effectiveness of COVID-19 vaccines. In addition, one-dose booster immunization showed an effectiveness of 74.5% to prevent COVID-19 caused by the Delta variant. However, current COVID-19 vaccines could not prevent the infection of Omicron sub-lineage BA.1.1.529 and had about 50% effectiveness to prevent COVID-19 caused by Omicron sub-lineage BA.1.1.529. Furthermore, the effectiveness was 87.6% and 90.1% to prevent severe COVID-19 and COVID-19-related death caused by Omicron sub-lineage BA.2, respectively. One-dose booster immunization could enhance the effectiveness of COVID-19 vaccines to prevent the infection and COVID-19 caused by Omicron sub-lineage BA.1.1.529 and sub-lineage BA.2. Two-dose booster immunization showed an increased effectiveness of 81.8% against severe COVID-19 caused by the Omicron sub-lineage BA.1.1.529 variant compared with one-dose booster immunization. The effectiveness of the booster immunization with RNA-based vaccine BNT162b2 or mRNA-1273 was over 75% against severe COVID-19 more than 17 weeks after booster immunization, whereas the heterogenous booster immunization showed better effectiveness than homologous booster immunization. The current COVID-19 vaccines could effectively protect against COVID-19 caused by Delta and Omicron variants but was less effective against Omicron variant infection. One-dose booster immunization could enhance protection capability, and two-dose booster immunization could provide additional protection against severe COVID-19.

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