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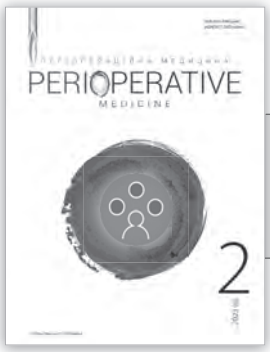

Огляд/*Review*

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Pain management for multiple rib fractures: a narrative review

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Abstract. *Trauma is a leading cause of death in people younger than 40 years, and on the third place after cardiovascular and oncological disease overall. Chest trauma is a finding in up to 60 % of patients with multiple trauma and has a mortality rate as high as 20–25 %. Rib fractures are the most common findings in patients with thoracic trauma with mortality rates among hospitalised patients between 10 and 22 %. The mortality rate is higher in elderly patients and patients with flail chest. The incidence of pneumonia in the elderly population with three to four and more than six rib fractures is 31 % and 51 %, respectively. Pain due to rib fractures is challenging to manage but effective analgesia reduces hypoventilation, promotes deep breathing, sufficient coughing, clearance of secretions, and better adherence to chest physiotherapy. Therefore, high-quality analgesia is not only increasing patient comfort but also is very important in preventing complications and improving the outcome. The purpose of this review is to analyse the modern literature regarding pain management for a patient with rib fractures and extract the best evidence-based practice.*

Keywords: *rib fractures, pain relief for rib fractures, regional analgesia rib fractures, multimodal analgesia, erector spinae plane block*

Introduction

Trauma is a leading cause of death in people younger than 40 years, and in third place after cardiovascular and oncological disease overall (1). Chest trauma is a finding in up to 60 % of patients with multiple trauma and has a mortality rate as high as 20–25 % (1). Rib fractures are the most common findings in patients with thoracic trauma with mortality rates among hospitalised patients between 10 and 22 % (2). The mortality rate is higher in elderly patients and patients with flail chest (2). The incidence of pneumonia in the elderly population with three to four and more than six rib fractures is 31 % and 51 %, respectively (3). Pain due to rib fractures is challenging to manage but effective analgesia reduces hypoventilation, promotes deep breathing, sufficient coughing, clearance of secretions, and better adherence to chest physiotherapy (4) Therefore, high-quality analgesia not only increases patient comfort but is also very important in preventing complications and improving the outcome. The purpose of this review is to analyse the modern literature regarding pain management for a patient with rib fractures and extract the best evidence-based practice.

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Literature search

For the literature search powers of Patricia Bowen Library & Knowledge Service were used. The search included Medline and Embase databases. After review of the findings and further literature search by the authors, a total of 91 papers were included in the article. Randomized controlled trials (RCTs), reviews, prospective, retrospective studies, and relevant references were included. The search strategy is presented in the Figure 1.

Anatomical considerations

The ribs are the bony framework of the thoracic cavity. There are 12 pairs of ribs and each rib articulates with the two thoracic vertebrae by the costovertebral joint except for the first rib which articulates only with the first thoracic vertebra. The ribs are classified as true, false and floating. The true ribs (1–7) directly articulate with the sternum, and the false ribs (8–10) articulate with the sternum as they connect with the seventh costal cartilage. The 11th and 12th ribs do not articulate with the sternum and, therefore, are called floating ribs (5). The inferior aspect of the rib has a groove which contains the intercostal nerve, artery and vein (6). The first three ribs are protected by the clavicle and scapula, and the 11th and 12th ribs are more mobile. Therefore, the most common ribs to fracture are 4th to 10th. The most common place of fracture is the posterolateral curve as it is the weakest point (7).

Pathophysiology

Morbidity and mortality due to rib fractures are a result of three main problems: hypoventilation due to pain, impaired gas exchange in the damaged lung underlying the fractures, and altered breathing mechanics. (4) Rib fractures can immediately deteriorate ventilation as a result of significant damage to the chest wall. Furthermore, fractured ribs can cause lung tissue damage resulting in pneumo- or haemothorax. The pulmonary mechanics can be changed resulting in a reduction of total lung capacity, dynamic compliance and ventilation perfusion matching. Ventilatory failure is further impaired by contusions of the lung tissue, especially with inadequate analgesia (6). Pneumonia occurs in one-third of patients over 65 years of age, and some studies report that mortality and morbidity doubles at the age after 65 years (8). However, a recent study (9) indicates that morbidity and mortality in elderly patients with isolated rib fractures are not as high as reported previously if the fractures are the result of a fall from standing (9).

A flail chest may occur with fractures of more than 3 ribs in more than 2 places. It can create a significant disturbance to respiratory physiology and is characterised by the independent or paradoxical movement of the flail segment with respect to the rest of the chest wall. The presence of a flail chest alone has a reported mortality rate of 33 % (10) since the resulting paradoxical chest movement further inhibits effective ventilation. In patients with isolated rib fractures, the prevalence

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2	exp Rib Fractures/	3690
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8	4 or 5 or 6 or 7	722226
9	3 and 8	572
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3	1 or 2	2958
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7	*epidural analgesia/	1828
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9	exp analgesic agent/	1189789
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11	3 and 10	555
12	limit 11 to english language	525
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Fig. 1. Search strategy. Pain Management of Rib Fractures; Louise Levitt. [06/11/2023], Isleworth, UK: Patricia Bowen Library & Knowledge Service

of chronic pain is estimated at 28 % at six months, with chronic disability estimated as high as 40 % (11).

Rib fractures severity scoring

The most important factors that correlate with morbidity and mortality in patients with rib fractures are age, number of ribs fractured, and presence of a flail chest segment (12), (13), (10). Seven or more fractured ribs have a mortality rate of 29 % (14).

Based on the above factors Easter created a formula which allows to recognise high-risk patients and, consequently, offer them a higher level of care (13).

Rib fracture score = (breaks × sides) + age factor

'Breaks' is the total number of fractures — each fracture counts even if it is the same rib.

Sides: unilateral 1, bilateral 2

Age factor: (51 – 60 = 1; 61 – 70 = 2; 71 – 80 = 3; > 80 = 4)

Unfortunately, it is a poor discriminant for both respiratory morbidity (pneumonia and requirement for tracheostomy) and mortality; as such, it is not useful as a single predictor of outcome (6). Maxwell et all (15) found that Easter's scoring system was not strongly valid as a predictor but was a useful screening tool to heighten the awareness of risk.

A few other scoring systems have been developed such as chest trauma score (CTS), RibScore (6), and STUMBLE. STUMBLE (STUdy of the Management of BLunt chest wall trauma) score (also referred to as the Battle score) (Figure 2) is often used in the UK and has been validated in a few studies (16), (17). It accounts five factors (18): age at attendance, number of rib fractures, chronic lung disease, use of pre-injury anticoagulants and oxygen saturation (SpO_2) (18). This is the first score which included clinical variables, specifically chronic lung disease and anticoagulation unlike the previous scores based on the age and anatomical findings alone (19), (20). The score has a sensitivity of 80 %, a specificity of 96 %, a positive predictive value (PPV) of 93 % and a negative predictive value (NPV) of 86 % for predicting complications following blunt chest wall trauma (16). The authors suggest that the patient with the STUMBLE score ≥ 11 will require hospital admission, and with the score ≥ 26 intensive care admission should be considered (18). In the authors' hospital, all patients with rib fractures are scored using this score which determines further management and the place of care for the patients.

	Score	
Age	1 point for each decade: 10–19 scores 1, 20–29 scores 2, etc	
Number of rib fractures	3 points per rib fracture	
Pre-injury anticoagulants	No	0
	Yes	4
Chronic lung disease	No	0
	Yes	5
Oxygen saturation levels	100–95%	0
	94–90%	2
	89–85%	4
	84–80%	6
	79–75%	8
	74–70%	10
Risk score	Probability of developing complications as reported by Battle et al.	
0–10	13%	
11–15	29%	
16–20	52%	
21–25	70%	
26–30	80%	
31+	88%	

Fig. 2. STUMBLE Score. Source: (16)

Another predictor of the severity of trauma is forced vital capacity (FVC). Patients with FVC ≥ 15 with no pneumothorax, haemothorax, or bilateral fractures with severe pain are expected to have a relatively early discharge (21). For patients with FVC < 15 enhanced care unit or ICU are advisable (21), (22–24).

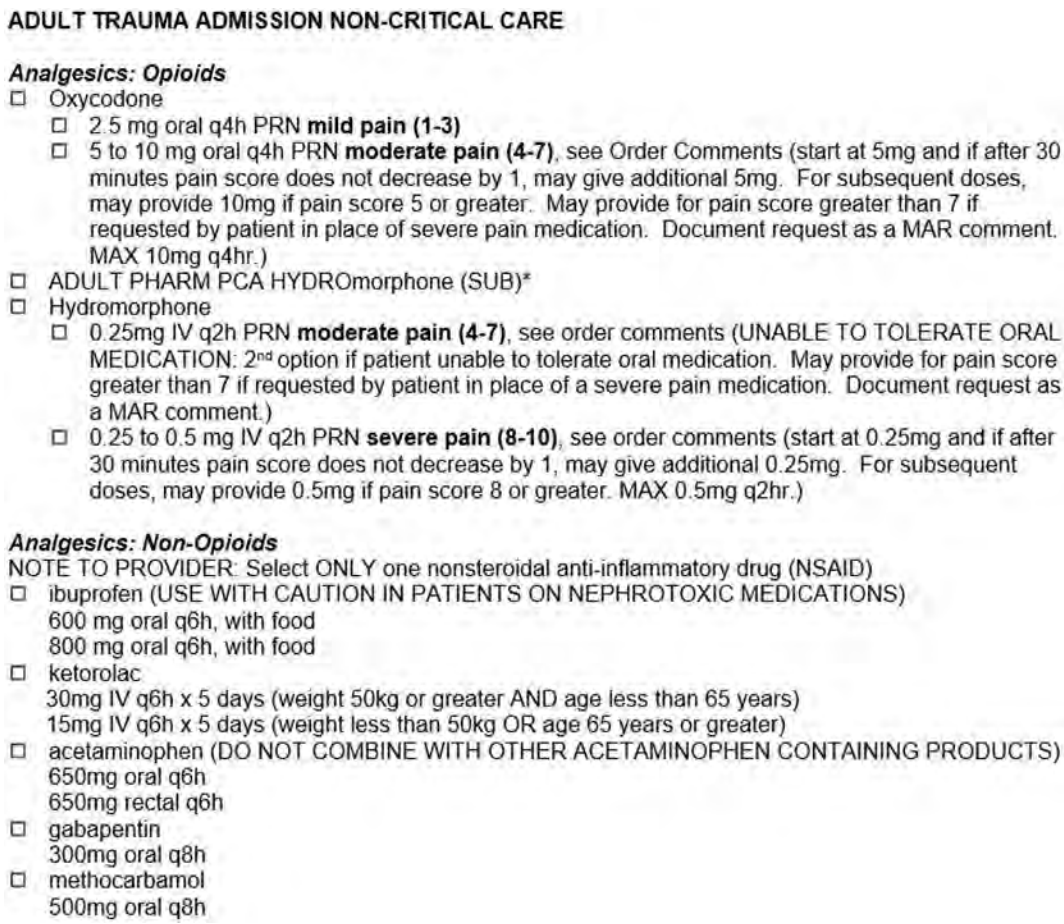
Basic analgesia

The chest wall is extensively innervated by intercostal nerves travelling along the inferior border of the ribs. Consequently, rib fractures result in high-intensity pain which can exacerbate pulmonary complications caused by blunt thoracic trauma. The pain contributes to splinting, guarding, low tidal volumes, decreased mobility, insufficient ability to cough and clear secretions, and inability to participate in chest physiotherapy. These factors can lead to further complications including atelectasis, pneumonia, acute respiratory distress syndrome, and pulmonary embolism (25).

Pain associated with rib fractures is often debilitating and challenging to manage. Historically, pain management for rib fractures consisted of systemic analgesia alone (26). Nowadays it includes a combination of basic multimodal analgesia along with regional techniques, and rib fixation when indicated (3). Improving analgesia

for patients with rib fractures is vital in improving tidal volumes, clearing secretions and preventing atelectasis (27). Chronic pain following rib fractures leads to the long-term use of painkillers, prolonged return to work, and a lower quality of life (28).

Multimodal analgesia is prescribed to all patients using the World Health Organization pain ladder which includes paracetamol, nonsteroidal anti-inflammatory drugs, and gabapentinoids followed by oral or parenteral opioids (3). There is a wide choice of medications that can be used and it is imperative that the hospitals have local guidelines on the prescription of multimodal analgesia for patients with rib fractures. Shakira et al (29) have published a multimodal pain regimen (Figure 3) which can be used as guidance for multimodal analgesia for this category of patients. If adequate analgesia is not achieved with the basic multimodal analgesia, then iv morphine can be titrated using small blouses of up to 0.1–0.2 mg/kg, followed by strong oral opioids (e.g. a slow-release morphine sulphate or oxycodone). In case the above interventions fail or the patient still requires a high amount of morphine boluses a morphine iv patient-controlled analgesia should be started as long as the patient is able to operate it (4). Additional pain control regimens such as ketamine (30), magnesium (31) or tramadol could be applied for patients who fail to respond to the standard multimodal analgesia or where regional analgesia is not applicable or contraindicated. Lidocaine can also be used as an adjunct to multimodal analgesia and has been reported to improve pain and reduce opioid consumption (32–35). In a double-blind randomised controlled trial (34) Patton et al have shown that intravenous lidocaine infusion had a beneficial effect on pain score, patient satisfaction and total morphine consumption, however, the results have not reached statistical significance. Lidocaine patches can also be used and can improve analgesia for patient with rib fractures (36, 37). However, a shortcut review by Williams (38) has concluded that there is currently no evidence to support the use of topical LP to improve pain control and reduce opiate analgesic use, in patients with traumatic rib fractures. An ongoing randomised controlled study



ADULT TRAUMA ADMISSION NON-CRITICAL CARE

Analgesics: Opioids

- ☐ Oxycodone
  - ☐ 2.5 mg oral q4h PRN **mild pain (1-3)**
  - ☐ 5 to 10 mg oral q4h PRN **moderate pain (4-7)**, see Order Comments (start at 5mg and if after 30 minutes pain score does not decrease by 1, may give additional 5mg. For subsequent doses, may provide 10mg if pain score 5 or greater. May provide for pain score greater than 7 if requested by patient in place of severe pain medication. Document request as a MAR comment. MAX 10mg q4hr.)
- ☐ ADULT PHARM PCA HYDROmorphone (SUB)*
- ☐ Hydromorphone
  - ☐ 0.25mg IV q2h PRN **moderate pain (4-7)**, see order comments (UNABLE TO TOLERATE ORAL MEDICATION: 2nd option if patient unable to tolerate oral medication. May provide for pain score greater than 7 if requested by patient in place of a severe pain medication. Document request as a MAR comment.)
  - ☐ 0.25 to 0.5 mg IV q2h PRN **severe pain (8-10)**, see order comments (start at 0.25mg and if after 30 minutes pain score does not decrease by 1, may give additional 0.25mg. For subsequent doses, may provide 0.5mg if pain score 8 or greater. MAX 0.5mg q2hr.)

Analgesics: Non-Opioids

NOTE TO PROVIDER: Select ONLY one nonsteroidal anti-inflammatory drug (NSAID)

- ☐ ibuprofen (USE WITH CAUTION IN PATIENTS ON NEPHROTOXIC MEDICATIONS)
  600 mg oral q6h, with food
  800 mg oral q6h, with food
- ☐ ketorolac
  30mg IV q6h x 5 days (weight 50kg or greater AND age less than 65 years)
  15mg IV q6h x 5 days (weight less than 50kg OR age 65 years or greater)
- ☐ acetaminophen (DO NOT COMBINE WITH OTHER ACETAMINOPHEN CONTAINING PRODUCTS)
  650mg oral q6h
  650mg rectal q6h
- ☐ gabapentin
  300mg oral q8h
- ☐ methocarbamol
  500mg oral q8h

Fig. 3. Multimodal analgesia for rib fractures pain. Source: (29)

(39) RELIEF (The Randomised Evaluation of early topical Lidocaine patches In Elderly patients admitted to hospital with rib Fractures) when finished might bring more light on the topical lidocaine use for patients with rib fractures.

Regional analgesia

In the past, most patients with rib fractures were managed conservatively with only few of them having thoracic epidural or paravertebral blockade (40). Patients with rib fractures are often frail and have comorbidities and changes in pharmacokinetics and pharmacodynamics, and it leads to a higher incidence of side effects and complications from systemic analgesia, especially opioid-induced side effects (26). Regional analgesia is the most effective modality for managing rib fracture pain and should be considered as part of the multimodal regime (4).

Thoracic epidural analgesia

Traditionally, thoracic epidural analgesia was referred to as a gold standard for pain relief for patients with rib fractures (26). It blocks nociceptive inputs from the intercostal nerves by blocking spinal nerves as they emerge from the spinal cord. Local anaesthetic is often injected along with a small dose of an opioid. It allows for improved pain relief, reduced local anaesthetic concentration, and, consequently lower risk of hypotension and local anaesthetic systemic toxicity. However, neuraxial opioids often cause pruritus and nausea (41). Randomised controlled trials and observational studies (42) show that thoracic epidural analgesia reduces pain scores at rest and with coughing compared to iv analgesia. Epidural analgesia was expected to reduce mortality, improve analgesia, and postoperative ventilation, and shorten the length of stay (26). However, it failed to show benefits in mortality compared to iv analgesia (43), (44). A systematic review of randomised controlled trials (44) concluded that there is no firm evidence for the benefit or harm of continuous epidural analgesia compared with other analgesic interventions. Well-powered RCTs with a low risk of bias reporting clinically relevant patient-centred outcome measures are needed. Nevertheless, these findings of systematic reviews should be interpreted with caution because mortality in trauma patients is a multifactorial outcome, and pain relief is only one of numerous contributing factors. The major advantage of epidural analgesia is that it is routinely conducted without ultrasound which is quite important in resource-limited settings.

The elderly patients are often taking anticoagulants and that is a contraindication for epidural blockade (45). It also causes numerous side effects: hypotension, urinary retention, motor blockade, nausea and vomiting, headache, and nerve injury (26). Hypotension is especially likely in a hypovolemic patient. The epidural analgesia failure rate is around 13 % excluding failure to insert the catheter, and the doctor cannot intentionally provide a unilateral block (26), (46).

In light of the above, thoracic epidural analgesia should no longer be considered the gold standard of analgesia for patients with rib fractures (26).

Paravertebral block

Trauma patients are often not good candidates for epidural analgesia because of the presence of concomitant injuries such as spinal cord trauma, thoracic vertebral fractures, unstable pelvis, severe head injury, and coagulopathy (47). Paravertebral block does not have all listed above contraindications (48, 49), and for an elective thoracotomy, it has shown similar pain control and outcomes (47). However, complications rate including withholding analgesia due to hypotension is higher with epidural analgesia (50, 51). In patients with significant and bilateral rib fractures epidural analgesia seems clinically more appropriate (40). However, for patients with unilateral chest wall trauma paravertebral block is often used (40). Unlike epidural analgesia, the paravertebral block as well as other unilateral blocks will always provide analgesia on the correct side. Bilateral paravertebral blocks can also be used although epidural is often preferred due to better simplicity and safety (4). A paravertebral block is a highly effective unilateral block with a lower risk of spinal cord damage than the epidural (4, 49), (52). There is a small risk of pneumothorax (0.5%) (53) which can cause additional difficulties, especially if there is no chest drain. The failure rate is approximately 10 % (47), and the block has also been traditionally performed without ultrasound (53).

Interfascial chest wall blocks

More recently a few newer interfascial chest wall blocks have been developed. They include erector spinae plane block, serratus anterior block, retrolaminar block, paraspinal intercostal block, subrhomboid intercostal block, intercostal block, and interpleural block (3). They use the principle of spreading local anaesthetic in the interfascial plane where it blocks the ventral rami of the spinal nerves (54). They have emerged as attractive alternatives to thoracic paravertebral or epidural blocks

because of their simplicity and safety (54). They are a good component of multimodal analgesia, and catheters may be beneficial for patients with an expected duration of moderate-to-severe pain of more than twelve hours (54). They can be performed not only by the anaesthetic team but also by emergency department doctors, respiratory and intensive care physicians in different clinical settings (55–58). It improves patients' access to adequate pain relief and reduces waiting times until the anaesthetist is available to perform the block. This article will focus on the erector spinae plane block and serratus anterior blocks which are the most extensively reported in the literature for patients with rib fractures (3).

Erector spinae plane block is a novel interfascial plane block which was first described by Forero et al in 2016 for neuropathic pain management in patients with metastatic rib disease and rib fractures (59). Since then, the block has been successfully used for pain relief after numerous procedures including Nuss procedure, thoracotomies, percutaneous nephrolithotomies, ventral hernia repairs, and lumbar fusions (60–64). The block is performed with ultrasound guidance using a linear or curvilinear probe. The probe is placed vertically along a paraspinal line and the needle is inserted between the posterior surface of the erector spinae muscle and the transverse process (Figures 4 and 5). Local anaesthetic is then injected and spreads cranially and caudally blocking the dorsal and ventral rami of the spinal nerves, in this way providing a multi-dermatomal sensory block to the anterior, posterior, and lateral thoracic and abdominal walls (65). An MRI study has shown the transforaminal and epidural spread of the local anaesthetic which might be advantageous for the visceral, including pleuritic pain which often accompanies rib fractures (66). A perineural catheter then can be inserted for prolonged analgesia which is usually required for a patient with rib fractures (67). Erector Spinae Plane block's efficacy for rib fractures has been described in case series (59, 68–72) as well as in retrospective cohort, prospective and randomised controlled studies (68, 73–79). The analgesia is comparable with paravertebral and thoracic epidural blocks with fewer side effects and complications (68, 75, 77, 80). In the authors' institution, erector spinae plane catheter block is a routine intervention for patients with lateral or posterior rib fractures.

Serratus anterior block. The serratus anterior muscle originates from the anterior aspect of the 1 to 7–10 ribs and on the other end is attached to the medial border of the scapula. Superficial and deep potential spaces surround the serratus anterior muscle (81). At the level of the fifth rib, the superficial plane is formed by the anterior surface of the serratus anterior and the posterior surface of the latissimus dorsi muscle. The deep plane is formed from the posterior surface of the serratus anterior muscle and the external intercostal muscles and ribs (82) (Figures 6 and 7). The local anaesthetic can be injected in either of the planes with reportedly similar efficacy

Fig. 4. Probe placement for the ESP block. Source: (91)

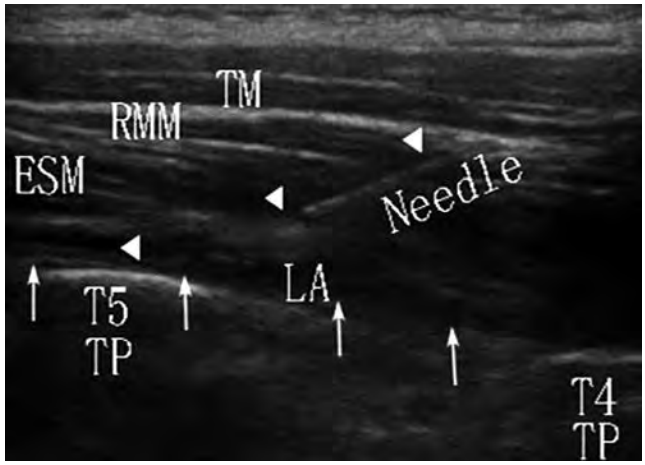


Fig. 5. Sonoanatomy for the ESP block. The needle (triangle indicates) is inserted through the trapezius muscle (TM), rhomboid major muscle (RMM) and Erector Spinae Muscle (ESM), to the transverse process. Source: (91)

and area of sensory loss (82–84). This block is suitable for anterolateral rib fractures but not for posterior rib fractures (3). An advantage of this block is that it is performed in the supine position, consequently, reducing the patient's discomfort from positioning in the lateral or sitting position (3). This block has been reported to be equivalent to a thoracic epidural block for thoracotomy (82, 83, 85). Comparison with erector spinae plane blocks has shown lower pain scores in the erector spinae plane block group but no difference in clinical outcomes (74).

Local anaesthetic dosing regimen. Interfascial blocks eg erector spinae or serratus anterior are often performed using a catheter technique. Usually, the first large bolus of local anaesthetic is given followed by continuous infusion. However, these blocks to be effective require a large volume of local anaesthetic to be injected at the same time to provide a wide spread of local anaesthetic and dermatome cover (86). T Datchinamourthy et all (87) have shown that erector spinae plane block with

Fig. 6. Point of application of the serratus anterior block. Source: (3)

Fig. 7. Ultrasound anatomy for superficial and deep Serratus anterior plane block. Source: (3)

programmed intermitted boluses compared to continuous infusion provided decreased opioid consumption, better postoperative analgesia and quality of recovery. This data might be with caution extrapolated on the patients with rib fractures, however, further research is needed. In the authors' institution serratus anterior block is a method of choice for patients with anterior rib fractures.

Surgical fixation of ribs

In certain cases, despite all the analgesic interventions, the pain relief may be still not sufficient. A 2012 meta-analysis (28) has shown that surgery can significantly improve pain for non-flail chest fractures. It has been reported that surgical fixation can prevent and even treat chronic pain following rib fractures (88, 89). The indications for rib fixation are listed in Figure 8 (90). However, according to the National Institute for Health and Care Excellence, the only current indication for surgical fixation with a strong evidence base is a flail chest requiring mechanical ventilation (6).

Summary

Pain management for patients with rib fractures can be challenging. It should always consist of multimodal analgesia and regional analgesia should be considered early, especially in high-risk patients. Basic analgesia includes paracetamol, nonsteroidal anti-inflammatory drugs, and opioids. Available regional techniques can safely decrease pain, reduce opioid consumption and associated side effects, and improve patient outcomes. Newer regional interfascial blocks can offer comparable efficacy to traditional techniques like thoracic epidural analgesia with a better safety profile and fewer side effects and complications. Further high-quality evidence and systematic reviews are needed to compare the impact of newer regional blocks on the clinical outcomes of the patients with rib fractures. Surgical fixation of the ribs can improve pain relief and patient outcomes in cases where it is indicated.

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Consensus on clinical indications for rib fixation

Clinical indications

3 or more rib fractures with rib displacement of more than 1 rib cortical diameter

Flail segment

Pulmonary worsening with progressive volume loss on X-ray

Intubation/mechanical ventilation

Use of IV narcotics

Uncontrolled pain when using analgesia or VAS score > 6

Lung impalement

Open chest defect

Stabilization on the retreat of thoracotomy

Pulmonary herniation

Figure 8. Consensus on clinical indications for rib fixation. Source: (90)

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Менеджмент болю при множинних переломах ребер: огляд

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Анотація. *Травми є основною причиною смертності людей молодше 40 років і займають третє місце після серцево-судинних та онкологічних захворювань. Травма грудної клітки виявляється у до 60 % пацієнтів із множинною травмою та має рівень смертності до 20–25 %. Переломи ребер є найпоширенішими у пацієнтів із торакальною травмою з рівнем смертності серед госпіталізованих пацієнтів від 10 до 22 %. Рівень смертності вищий у пацієнтів похилого віку та пацієнтів із флотуючою грудною кліткою. Захворюваність на пневмонію у людей похилого віку з трьома-чотирма і більше ніж шести переломами ребер становить 31 % і 51 % відповідно. З болем через переломи ребер складно впоратися, але ефективна аналгезія зменшує гіповентиляцію, сприяє глибокому диханню, достатньому кашлю, виведенню секрету та кращому дотриманню фізіотерапії грудної клітки. Тому якісне знеболювання не тільки підвищує комфорт пацієнта, але й дуже важливе для запобігання ускладнень і покращення результату. Метою цього огляду є аналіз сучасної літератури щодо лікування болю у пацієнта з переломами ребер і знайдення найкращих доказових практик.*

Ключові слова: *переломи ребер, знеболення при переломах ребер, регіонарна аналгезія переломів ребер, мультимодальна аналгезія, паравертебральний фасціальний блок м'яза розгинача спини*