Rib fracture pain management at a London Major Trauma Centre:

A retrospective comparison of Erector Spinae Plane Blocks, Serratus Anterior Plane Blocks and Thoracic Epidurals

A retrospective review of rib fracture management at a London Major Trauma Centre comparing Erector Spinae Plane Blocks, Serratus Anterior Plane Blocks and Epidurals

V3 06/09/2020

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Funder
No funding

This protocol describes the retrospective review of rib fracture pain management at a major trauma centre. Every care was taken in its drafting, but corrections or

amendments may be necessary. These will be circulated to investigators in the study.

This study will adhere to the principles outlined in the Data Protection Act 2018 and General Data Protection Regulations (Europe) and other regulatory requirements as appropriate.

Glossary of Abbreviations

TARN	**Trauma Audit & Research Network**
ESPB	**Erector Spinae Plane Block**
SAPB	**Serratus Anterior Plane Block**
MTC	**Major Trauma Centre**
ICU	**Intensive Care Unit**
TEA	**Thoracic Epidural Analgesia**
NIV	**Non-Invasive Ventilation**

Keywords : Trauma, rib, fracture, analgesia

Study Summary

Title	Rib fracture pain management at a London Major Trauma Centre, a retrospective comparison of Erector Spinae Plane Blocks, Serratus Anterior Plane Blocks and Thoracic Epidurals
Design	Single centre retrospective cohort study
Aims	To determine whether novel fascial plane blocks, i.e. SAPB and ESPB, are safe and effective in patients with rib fractures.
Outcome Measures	What are the effects of novel regional anaesthesia blocks on: - Proportion of patients with a reduction in pain - Pain scores - Opioid use - Nausea & vomiting -Lung complications due to pain -ICU admission for respiratory complications, - Use of NIV/invasive ventilation --Block related complications
Population	Males and Females
Eligibility	Patients aged over 18 with rib fractures
Duration	Retrospective review of 5 year period of outcome data

Contents

1. Introduction

1.1 Background

Rib fractures are commonly seen in Trauma Centres around the world, making up two thirds of all chest trauma admissions[1]. In the United Kingdom, 15,000 patients attend hospital with rib fractures annually according to Trauma Audit and Research Network figures. More than a third of these cases develop either short term and or long-term complications, including pneumonia, respiratory failure and chronic pain[2]. Complications typically arise due to poor pain relief in the acute setting.

Pain from rib fractures restricts chest wall movement leading to hypoventilation and impaired coughing ability, which leads to sputum retention and mucus plugging. The injured lung tissue under the fractures also has impaired gas exchange and may contain blood. This causes shunting of blood, ventilation perfusion mismatch, and reduced compliance[3]. These combine to cause atelectasis and increase patients' predisposition to pneumonia. Pneumonia affects up to 30% of patients, with or without sepsis, causing further respiratory compromise. The combination of hypoventilation, atelectasis and/or lobar collapse and impaired gas exchange results in hypoxaemia, respiratory failure and, in some cases, a need for mechanical ventilation. These complications typically develop over 48 – 72 hours following injury[4-7]. The provision of adequate analgesia is widely viewed as a key priority in managing rib injury patients to facilitate improved respiratory effort and enable chest physiotherapy for rehabilitation after rib fractures.

1.2 Study Rationale

Thoracic epidural analgesia (TEA) is widely considered to be the current gold standard treatment for rib fracture pain and is used in the Imperial invasive treatment pathway for rib fractures[1,7] However, TEA are often contraindicated due to other injuries or the use of anticoagulant medications, which also contraindicates other invasive nerve block techniques e.g. paravertebral catheters. A number of case reports have reported the safe use of alternative techniques such as SAPBs and ESPBs[8] and the anaesthesia community has taken them up widely based on this relatively limited evidence. In view of this, Womack et al recently published a large retrospective review examining the safety and efficacy of ultrasound guided paravertebral catheter analgesia techniques in rib fracture management along with small numbers of ESPBs[9]. However, this data did not report the analgesic efficacy, patient reported pain relief or respiratory complications. We wish to advance this body of evidence by reviewing our larger data set concerning the use of TEA and alternative regional techniques such as ESPB

and SAPB. This comprehensive review will benefit patients by documenting the efficacy and safety of these techniques for clinicians managing rib fracture patients.

2. Study Objectives

2.1 Primary Objective

Our primary objective is to examine whether novel fascial plane blocks, e.g. SAPB and ESPB, are effective pain relief modalities in patients with rib fractures - the proportion of patients with a reduction in pain.

2.2 Secondary Objectives

We will review the safety profile and complications of TEA and alternative analgesic techniques such as ESPB and SAPB used for rib fracture management in our trauma centre. In particular, we will examine the effects of regional anaesthesia techniques on:

1) Opioid use
2) Nausea & vomiting
3) Respiratory complications
4) Intubation & non-invasive ventilation (NIV)
5) ICU admission for respiratory complications

We will assess the duration of use and complication profile of regional anaesthetic techniques, including infection, analgesic failure and damage to other structures during insertion e.g. the lung.

3. Study Design

3.1 Design & Purpose

A single centre retrospective anonymised data study of a 5 year cohort of rib injury patients managed in a major trauma centre within the Imperial College Healthcare Trust.

3.2 Data Collection & Methods

Records will be identified by searching the Trauma Audit and Research Network (TARN) database, a routinely collected database of all patients admitted with traumatic injury within the Imperial College Healthcare Trust. This will be collected by the ICHT TARN co-ordinator. The TARN database provides basic demographic and injury data including hospital number. We will use this information to identify the cohort of patients who were triaged to the Imperial College Healthcare Trust invasive rib fracture care pathway.

Individual patient data will then be obtained from the electronic health record (Cerner) using the patient's hospital number. The data will be pseudo-anonymised and will be collected by members of the study team, all of whom are NIHR Good Clinical Practice trained members of the direct care team. Data will be reviewed and stored on password protected NHS desktop computers in a folder only accessible to members of the study team. Any hard copies of patient data will be stored in a locked filing cabinet within a secure NHS office in St. Mary's Hospital. The study will be conducted from 30/09/2020 until the 31/01/2021. We plan to review rib injured patient's electronic notes that have received these interventions from January 2016 until December 2019 and categorise the information for analysis as set out in study outcomes. Our sample size is estimated at 1200 participants, as per the TARN co-ordinator. This information will allow us to assess the safety and efficacy of these alternative techniques as compared to TEA.

3.3 Inclusion Criteria

- Patients aged > 18 years of age presenting with traumatic rib fractures in a major trauma centre over the past 5 years
- Meet the criteria for the Imperial College Healthcare NHS Trust 'Invasive rib fracture management pathway' (see Appendix A)

3.4 Exclusion Criteria

- Under 18 years old
- Prisoners
- Pregnant
- Private patients
- Meet the criteria for the Imperial College Healthcare NHS Trust 'Non-invasive rib fracture management pathway' (see Appendix A)

3.5 Data Analysis

ESP Block (N=~40) : The primary hypothesis is that the proportion of patients showing lower pain scores 48-72 hours relative to pain scores at baseline is 70% (approximately 2 out of 3) or more. A rate of 50% or less (1 in 2) would be considered unsatisfactory. With 40 patients it is possible to achieve 80% power at the 5% significance level to distinguish between these two scenarios. The probability that 26 or more of the 40 patients have lower 48-72 hour scores if the true rate is 70% is 81%, if the true rate is 50% there is a 4% chance this will occur. The lower one-sided 95% confidence limit will be presented for the proportion of patients showing lower pain scores at 48-72 hours relative to pain scores at baseline, this estimate will provide a lower limit for the success rate.

SAP Block (N=~35): Similar considerations to those ESPB apply, but in this case the true proportion showing lower pain scores at 48-72 hours would need to be 75% or more to confidently show that the true rate is greater than 50%. For example, the probability that 23 or

more of the 35 patients have lower 48-72 hour scores (if the true rate is 75%) is 92%, if the true rate is 50% there is a 4.5% chance this will occur.

TEA (N=~250)

The large number of subjects in this group means that the aim of distinguishing 70% versus 50% success rates can be confidently achieved, with a power of more than 99% at the 5% significance level.

Generally, for binary endpoints, 95% confidence intervals for the proportions of at most +/- 17% can be estimated for SAP Block subjects, +/- 16% for ESPB subjects and +/- 7% for TEA subjects.

4. Study Outcome Measures

4.1 Primary Outcome Measure

We aim to review pain scores as recorded by clinical staff over 72 hours to assess pain relief efficacy, A verbal rating scale classifying pain as mild, moderate or severe is used at Imperial Data from the acute pain round records will also provide details regarding breathing comfort levels of the patient, coughing ability and deep inspiratory effort. These are recorded as yes/no answers and we will assess the proportion of patients showing a reduction in pain scores.

4.2 Secondary Outcome Measures

4.2.1 Indication for the nerve block

All patients with rib fractures who met the criteria for the invasive rib fracture care pathway as set out in Appendix A. The diagram below describes the main criteria for allocation to the invasive or non-invasive pathway for rib fracture pain management.

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Risk factors for morbidity

Pulmonary contusion	Current smoker
Cardiovascular disease	Frailty
Presence of ≥2 distant injuries	Obesity & OSA

Early review for surgical rib fixation

Flail chest	Chest wall deformity
≥3 displaced rib fractures	CXR: ≥25% lung volume loss
≥65 years old	NIV/ ventilator dependent

Start on appropriate arm of pathway

Battle score 0 – 15

Non Invasive

If score 0 – 10: consider CDU if meets criteria or discharge if appropriate

If score 11 – 15 or other risk factors for morbidity present: consider more advanced analgesia & escalation to invasive pathway

Battle Score ≥16

Invasive

If score ≥30: consider early liaison with critical care team

4.2.2 A marker of injury severity e.g. Battle score

Table 4 Risk factor scores as transformed from the regression coefficients

	Regression coefficient	Risk score
Age	0.0162	1[a]
Number of rib fractures	0.418	3[b]
Chronic lung disease	0.789	5
Pre-injury anticoagulant use	0.637	4
Oxygen saturation levels	−0.0651	2[c]

[a]Per additional 10-year increase starting at 10 years of age; [b]per additional rib fracture; [c]per 5% decrease in oxygen saturations starting at 94%.

Table 5 Final risk scores and corresponding probability of developing complications

Final risk score	Probability mean ± SD
0 to 10	13% ± 6
11 to 15	29% ± 8
16 to 20	52% ± 8
21 to 25	70% ± 6
26 to 30	80% ± 6
31+	88% ± 7

Table 3. Rib fracture risk score adapted from Battle et al[2]

Variable	Score	*Example*
Age	+1 per additional 10-year increase starting at 10 years of age	*4*
Number of rib fractures	+3 per rib fractured	*15*
Chronic lung disease	+5 if present	*5*
Pre-injury anti-coagulant use	+4	*0*
Peripheral oxygen saturation levels (SpO_2)	+2 per 5% decrease SpO_2 starting at 94% at time of assessment	*2*
Total		*26*

4.2.3 Morphine based products/other analgesic medications used

Data regarding type of opiate use, mode of delivery, dosage requirement in 24 hours and complications associated with opiates such as constipation, delirium and respiratory depression.

4.2.4 Nausea & vomiting

The incidence of nausea and vomiting pre-chest wall block and in the 72 hours post block will be recorded with the number of episodes and number of anti-emetic medications required to treat.

4.2.5 Lung complications as a result of pain

1) Lower Respiratory Tract Infection (LRTI): for this study is defined as patients showing clinical features of chest infection including pyrexia (temperature >37.5°C), an increase in oxygen requirements from baseline, radiological evidence of chest infection or antimicrobial treatment of an LRTI started by the treating team.

2) Empyema/Parapneumonic effusions: defined as radiological evidence of fluid collections within the pleural space and therapeutic interventions required for treatment e.g. aspiration and drainage.

4.2.6 Intensive care admission

- ICU admission for respiratory complications

-Number of patients requiring intubation and ventilation

- Number of days of mechanical ventilation

-Length of ICU stay

4.2.7 Other nerve block complications

1) Block failure: defined as persistent moderate to severe pain following insertion of TEA, ESPB or SAPB catheters in spite of adequate dosing of analgesia at any time after initial placement.

2) Number of catheter resiting events

3) Number of catheter top-ups required within a 24 hour period

4) Regional anaesthetic catheter associated infection

5) Pneumothorax secondary to regional anaesthesia technique

5. Regulatory Issues

5.1 Ethics approval

The Chief Investigator has obtained approval from the Health Research Authority. The study must also receive confirmation of capacity and capability from each participating NHS Trust before starting the study. The study will be conducted in accordance with the recommendations for physicians involved in research on human subjects adopted by the 18th World Medical Assembly, Helsinki 1964 and later revisions

5.2 Consent

This is a retrospective case notes review study. This data is collected as routine care and for the TARN database. As the study only involves retrospective data collection at a single time point that will not impact clinical care, obtaining informed consent is not necessary. The only personal identifiable information we intend to collect is the hospital number, which is pseudonomyised. Each patient has a unique number according to their order within the data excel spreadsheet and the link to these will be recorded and stored on a password protected disc stored on password protected NHS Trust computers accessible only by members of the study team.

5.3 Confidentiality

This is a retrospective pseudo-anonymized data collection study of available clinical data so no consent is needed. Data will be extracted and reviewed by members of direct care team who are also members of the research team. Only anonymized data will be analysed and published. All identifiable information will be securely held in NHS Trust computers and there will be held in strict compliance to NHS Data Protection and Confidentiality regulation. The Chief Investigator will preserve the confidentiality of participants taking part in the study and is registered under the Data Protection Act. Data and all appropriate documentation will be stored for 5 years after the completion of the study, including the follow-up period. If data is missing this will be stated and not included in the final data analysis. i

We will employ the use of passwords to restrict access to electronic documents and store hard copies of study documents in a locked cabinet in secured location within the anaesthetic department at St Mary's Hospital. The data will only be accessible by the research team involved in the project. Only pooled population data will be used in outputs.

5.4 Indemnity

Imperial College Healthcare NHS Trust holds standard NHS Hospital Indemnity and insurance cover with NHS Resolution for NHS Trusts in England, which apply to this study

5.5 Sponsor

Imperial College Healthcare NHS Trust will act as the main Sponsor for this study. Delegated responsibilities will be assigned to the NHS trusts taking part in this study.

5.6 Funding

No funding is required for this study.

5.7 Audits

The Joint Research Compliance Office, Imperial College London Imperial College Healthcare NHS Trust may audit the study.

6. Study Management

The day-to-day management of the study will be co-ordinated through Dr Boyne Bellew.

7. Publication Policy

The study results will be presented at specialty conferences and published in a peer reviewed anaesthetic journal. No patient identifiable information will be included.

8. REFERENCES

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Appendix A. Imperial NHS Acute Rib Fracture Pathway

1) SUMMARY

This revised guideline provides a framework for the assessment and management of adult patients with rib fractures at Imperial College Healthcare NHS Trust. The guideline has been updated to take account of new evidence in patient risk assessment, analgesic management strategies and physiotherapy techniques. Additionally, criteria for accepting referrals for tertiary level care of rib fractures are provided.

2) INTRODUCTION

2.1 Incidence

Blunt chest-wall trauma accounts for 10-15% of all trauma admissions to Emergency Departments (EDs) globally[1,2]. Rib fractures may complicate up to two thirds of these injuries[2]. North West London Trauma Network treats approximately 450 patients with rib fractures per year, of whom approximately two thirds receive tertiary care at St Mary's.

2.2 Importance

Rib fractures are markers of severe injury and are associated with significant morbidity and mortality. Patients with these injuries are at greater risk of complications and poor outcomes[2-4]. Associated injuries occur in 94% of patients, typically concomitant thoracic trauma, but also injuries to the head, abdomen and limbs[3]. Mortality associated with rib fractures is hard to calculate, as death often happens indirectly, however it has been estimated as between 10–13%[3,4], with one article reporting up to 30%[5]. Common immediate thoracic sequelae of rib fractures include pneumothorax, haemothorax, haemopneumothorax, pneumatocoele, pulmonary contusions. Solid organs, such as the liver, kidneys and spleen, may also sustain lacerations from broken ribs[1].

Pain is the most common symptom from rib fractures and a key component in pulmonary complications. Pain restricts tidal volume, leading to hypoventilation, and impairs coughing ability, leading to sputum retention; these combine to cause atelectasis and predispose to pneumonia. Additionally, injured lung tissue underlying the fractures has impaired ability to exchange gasses (leading to shunt and VQ mismatch) and reduced compliance. Compensatory increases in respiratory rate may increase oxygen consumption. Pneumonia occurs in up to 30% of cases, with or without sepsis, causing further respiratory compromise. The combination of hypoventilation, atelectasis and/or lobar collapse and impaired gas exchange results in hypoxaemia, respiratory failure and, in some cases, a need for mechanical ventilation. Respiratory complications typically develop at 48 – 72 hours post injury. Other respiratory complications include pulmonary embolus, pulmonary effusions, empyema and acute respiratory distress syndrome (ARDS)[1-6].

Patients with rib fractures often require hospital admission, and in more significant injuries, to level 2 or 3 care. The associated incremental costs have not been fully evaluated, but can be considered in terms of length of inpatient stay, 'ICU bed days' and 'ventilator days' and are likely to be significant. Studies evaluating longer term outcomes have demonstrated high rates of chronic disability and chronic pain[3,6,7,10]. The severity of acute pain predicts chronic pain whilst disability is predicted by acute pain intensity and the presence of bilateral

fractures[10]. Elderly patients (aged 65 years or older), have been consistently shown to have worse outcomes, higher complication rates and greater mortality after rib fractures than younger patients[3,7].

3) DEFINITIONS

- Rib fracture: a break in a bone making up the rib cage.
- Flail chest: at least 2 fractures per rib in at least 2 adjacent ribs are needed to produce a flail segment. Flail segments cause paradoxical inspiratory movements, compromise breathing and may be life threatening.
- Verbal Rating Scale: a method for assessing pain on an alphanumeric scale. ICHNHST recommends mild, moderate and severe, whilst in the ED the numerical scale 0-10 is used.
- Thoracic Epidural (TE): a fine bore catheter placed into the thoracic epidural space which is used to give analgesic drugs.
- Paravertebral block (PVB): regional anaesthetic technique providing analgesia to a segment of one hemithorax.
- Patient Controlled Analgesia (PCA): a method of allowing a patient to administer their own analgesia intravenously, usually opioid based.
- Non-invasive ventilation (NIV): facial Continuous Positive Airways Pressure (CPAP) or Bi-level Positive Airways Pressure (BIPAP) ventilation
- Morphine Immediate Release (IR): a morphine immediate release preparation (available as a liquid - commonly known as Oramorph - and tablets)
- Oxycodone Immediate Release (IR): a oxycodone immediate release preparation (available as a liquid and capsules)

4) SCOPE

These guidelines are for all staff involved in the care of adult trauma patients with rib fractures but are of particular relevance to those working in the Emergency Department, Theatres, Anaesthesia, Major Trauma Ward and other wards receiving trauma patients. They may also be adopted more widely within the North West London Trauma Network.

FULL GUIDELINE

The use of multidisciplinary bundled care pathways is associated with improved outcomes in patients with rib fractures/ blunt chest injury[3,24].

4.1 Identifying the high-risk patient

Multiple risk factors have been identified for poor outcomes in rib fractures, but the variables can be simply classified into anatomical, physiological and other categories, see table 1.

Many scoring systems are available to predict the risk of complications after blunt chest trauma, all of which combine different variables from table 1. These include the AIS_{chest}, Pulmonary Contusion score (PCS), Wagner-score, the Thoracic Trauma Severity score (TTS), the Chest Trauma Score (CTS), RibScore and Easter's Rib Fracture Score. Battle *et al* recently used robust methodology to develop an up to date risk prediction tool that is based on a UK population[2]. The risk of developing complications increases with an increasing score, *see table 2* for details.

Table 1: risk factors for morbidity after rib fractures[1-8]

Anatomical	Physiological	Other

• Number of ribs fractured
• Presence of flail segment
• Bilateral rib fractures
• First rib fractured
• Degree of fracture displacement
• Fractures in the anterior, lateral and posterior regions
• Presence of pulmonary contusions
• Presence of ≥2 distant injuries
	• Reduced physiological reserve:
	  ○ Increasing age
	  ○ Premorbid respiratory disease
	  ○ Smoking
	  ○ Overweight or obese (BMI >25)
	  ○ Obstructive sleep apnoea
	  ○ Premorbid cardiovascular disease
	  ○ Premorbid diabetes
	• Reduced SpO_2 at presentation
	• Reduced vital capacity (VC)
	• Post injury pneumonia
		• Premorbid use of anticoagulants
		• Treated in low volume centres
		• Treated outwith a pathway

Table 2. Rib fracture risk score and risk of complications from Battle et al[2]

Final risk score	Probability mean ± SD
0 to 10	13% ± 6
11 to 15	29% ± 8
16 to 20	52% ± 8
21 to 25	70% ± 6
26 to 30	80% ± 6
31+	88% ± 7

Battle's tool has been incorporated into the pathway to guide enrolment into the non-invasive (simple analgesia) or invasive (incorporating advanced analgesic techniques) pathway with a cut off point of 15. An example case of a 58 year old man with COPD who has sustained 5 rib fractures and has oxygen saturations of 94% is provided in table 3.

Variable	Score	*Example*

Table 3. Rib fracture risk score adapted from Battle et al[2]

Age	+1 per additional 10-year increase starting at 10 years of age	*4*

Number of rib fractures	+3 per rib fractured	*15*
Chronic lung disease	+5 if present	*5*
Pre-injury anti-coagulant use	+4	*0*
Peripheral oxygen saturation levels (SpO_2)	+2 per 5% decrease SpO_2 starting at 94% at time of assessment	*2*
Total		*26*

Objective measures of respiratory function, such as peak expiratory flow rate (PEFR), inspiratory volume (ISV) and vital capacity (VC) have been evaluated[8,9]. VC less than 30% of a patients

predicted value predicts pulmonary complications and each 10% increase in VC is associated with a reduced chance of pulmonary complications (odds ratio 0.64)[9]. The risk of complications can be reduced by adhering to the key principles of management: optimal analgesia, respiratory support, early mobilisation and appropriate surgical intervention.

4.2 Analgesic options

As pain is a significant contributor to the morbidity arising from rib fractures, optimisation of analgesia is key to preventing complications. There are many options for managing pain from rib fractures including multimodal oral therapy, intravenous analgesia, topical treatments and a variety of regional anaesthetic blocks.

Acute pain should be assessed according to the Imperial College Healthcare NHS Trust Acute Pain Guideline. In particular for rib fracture patients, assess pain at rest and on coughing/ deep inspiration and ask about features of neuropathic pain for example tingling, burning and electric shock like sensations. Multimodal oral analgesia should be started on admission and include regular paracetamol, ibuprofen and opioids. Morphine should be prescribed both regularly and for breakthrough (PRN).

In patients aged 65 years or older, ibuprofen should be omitted and the regular opioid changed to oxycodone, which has a better pharmacokinetic profile for elderly patients. In patients with renal impairment, defined as eGFR <30mls/min, ibuprofen should be omitted and the oxycodone dose reduced. All patients should receive adjunctive treatments for opioid analgesia including laxatives and anti-emetics. See figure 1 for details.

Opioids may be administered via a patient controlled analgesia (PCA) device if the pain requires more frequent opioid dosing than the standard prescription allows. Patients with features of neuropathic pain such as burning, tingling, electric shock like sensations or numbness should be prescribed a gabapentinoid.

Ketamine may be trialled intravenously (up to 10mg) and continued orally or as an infusion, following the Imperial College Healthcare NHS Trust guidelines, in patients with difficult to manage pain. In any patient with pain that is difficult to control using conventional measures, conversion to the invasive pathway should be considered. (Note the use of ketamine in pain management is unlicensed).

All regional anaesthetic techniques for rib fracture analgesia impair impulse transmission at various points along the intercostal nerve. Thoracic Epidural analgesia remains the gold standard analgesic modality. They are the most widely studied mode of analgesia, and their use in rib fractures is endorsed by several systematic reviews and international bodies[1,3,7]. Expertise at St Mary's allows for timely epidural insertion by senior anaesthetists and appropriate management once sited. Despite this, epidurals have a low but significant complication rate[11] and in some patients may be contra-indicated (see table 4); there is also an inevitable failure rate and their benefit has been questioned[12]. Thoracic epidurals and blocks should only be inserted, doses titrated and drugs bolused by appropriately trained members of healthcare staff. The first line epidural infusion should be mixed levobupivacaine 0.125% with fentanyl 2micrograms/mL. In patients with rib fractures and other injuries arising from the same incident, a plain 0.125% levobupivacaine epidural infusion can be started in conjunction with an opioid PCA. Commencing and caring for a patient with an epidural infusion should follow the clinical guideline *Epidural Analgesia: Continuous Infusions Clinical Guidelines for Adult Patients*.

Table 4: Contra-indications to epidural analgesia. Starred items apply to regional blocks

Contraindications to epidural analgesia

Absolute	Relative	
1. Patient refusal*	1. Unable to position patient*	5. Coagulopathy: INR >1.4 or platelets <80 x 10^9/L*
2. Spinal cord injury or haematoma	2. Traumatic Brain Injury with uncontrolled Intracranial Pressure	6. Active Anticoagulant therapy. AAGBI RAPAC guide.*
3. Epidural haematoma	3. Incomplete spinal evaluation	7. Extubation not anticipated within 5 days (ICU patients)*
4. Thoracic vertebral body fracture at level of insertion	4. Previous thoracic spinal surgery	
5. Local or generalised sepsis*		
6. Open wound at site of insertion*		

Alternatives to epidurals include intercostal, interpleural and paravertebral blocks, but all have significant drawbacks and lack evidence of benefit over epidurals[13]. Newer techniques, including serratus anterior plane and erector spinae plane blocks, have not yet been robustly evaluated[14,15,23] in the rib fracture population but are used in some trauma units and are the subject of much research interest. They may be of use in patients with unilateral injuries, when thoracic epidurals are contra-indicated or are not possible to insert.

In addition to trauma specific cautions and contra-indications (*see table 4*), standard cautions should be applied prior to inserting an epidural or regional anaesthetic block. Invasive monitoring and critical care should be considered in patients with pre-existing comorbid disease that may be affected by an epidural or regional block e.g. stenotic valvular heart lesions.

4.3 Ventilation Management

Rib fractures are commonly associated with underlying pulmonary contusions and pleural injuries such as pneumothorax and haemothorax. These, combined with pain, can lead to respiratory failure.

To prevent complications and ensure a timely recovery, all patients admitted with rib fractures should receive respiratory support titrated to their individual needs. Patients should be managed on wards with nursing staff familiar with the injury. Supplemental oxygen should be prescribed and administered at the lowest concentration required to achieve peripheral oxygen saturations (SpO_2) of 94-98%, or 88-92% in patients at risk of carbon dioxide retention. If more than 2-4L/min via nasal cannulae is required, administered oxygen should be humidified to loosen secretions. Sodium chloride (NaCL) 0.9% nebulisers may be prescribed as required or regularly to assist expectoration. Salbutamol nebulisers can be prescribed for bronchospasm. Patients should be mobilised where possible and when in bed, be nursed sitting as upright as possible with attention to pressure area care. All rib fracture patients should receive physiotherapy input at least once a day (see below) until respiratory function normalises and mobility restored to baseline.

Advanced respiratory support including Continuous Positive Airways Pressure (CPAP), Non- Invasive Ventilation (NIV) and Nasal high flow oxygen (Optiflow/ Airvo etc) can be considered, in liaison with critical care staff, for patients with anticipated or deteriorating respiratory failure. Decisions regarding which of these treatment modalities is appropriate will be specific to individual patients and determined by the clinical judgement of the attending trauma, anaesthetic and critical care teams. Patients with significant flail segments in particular should be referred early for critical care review regarding advanced respiratory support, even without evidence of respiratory failure, with the goal of maintaining lung volume and effective cough. A proactive approach to Chest X-Rays should be adopted for patients with flail segments; changes such as atelectasis warrant prompt referral to critical care. Preventative ventilatory support is a key strategy that must be adopted.

4.4 Physiotherapy

Physiotherapy should be started within 24 hours of admission in all patients to support ventilation and prevent complications. The ability of patients to participate in physiotherapy is dependent on adequate analgesia using non-sedative doses.

All patients should be taught to perform a simple active cycle breathing technique (ACBT), huffing and encouraged to cough. This can be initiated by nursing staff if necessary, for example at weekends and in the evenings. ACBT consists of taking 3-5 deep breaths with an inspiratory hold of 2-3 seconds followed by 3 relaxed breaths. Patients should be asked to complete ACBT hourly when awake. Instructions for patients (adapted from the Association of Chartered Physiotherapists in Respiratory Care leaflet GL-05):

1. *Please take a long, slow, deep breath in, ideally through your nose.*
2. *Hold your breath for 2-3 seconds.*
3. *Breathe out gently, like a sigh.*
4. *Repeat this technique for 3-5 breaths approximately every hour.*

Huffing is a rapid exhalation of air through an open mouth and throat, as if trying to mist up a mirror. It helps to move sputum up the airways from where it can be coughed out. Huffing should be followed by the deep breathing cycle described above.

In patients who are able to mobilise, early and regular mobilisation should be encouraged. Exercise bikes/floor pedal exercisers can be provided to assist patients who are only able to move into a chair. Shoulder exercises should be taught in appropriate patients to prevent movement restrictions post injury which can limit return to work.

4.5 Surgery

Surgical fixation and stabilisation of flail chest injuries is associated with reductions in duration of mechanical ventilation, ICU stay, total hospital stay, hospital acquired pneumonia and mortality rates[16-20]. In the long term patients return to work sooner and have a reduced incidence of chronic pain and analgesic dependence[18-22]. Studies have also shown similar beneficial outcomes in patients with multiple rib fractures but without a flail segment[21]. A multidisciplinary approach to patient selection for surgery is essential. The National Institute of Clinical Health and Excellence has approved and issued guidance on surgical fixation of flail chest injuries[22].

4.6 Referral criteria for tertiary care in North West London Trauma Network

Many patients with rib fractures will present to trauma units within the North West London Network. Some may require tertiary level services, however, the majority can receive care and pain relief at their local trauma unit following local rib fracture pain management guidelines.

Indications for referral to St Mary's Major Trauma Centre are detailed below. Acute referrals should be made to the Trauma Team Leader (TTL) on duty via the TTL mobile or bleep 1328 via switchboard. Internal referrals for consideration of rib fixation should be made to the rib fracture team, via e-mail (imperial.ribfracture@nhs.net).

1. Rib fractures associated with:
   a. Significant pneumothorax
   b. Haemothorax
   c. Flail segment
   d. Moderate/ significant pulmonary contusions

2. Rib fractures in a polytrauma patient.

3. Consideration for rib fracture fixation. Indications (adapted from NICE IPG 361)[22] include:
   a. Clinical evidence of flail chest (visible paradoxical chest movements) associated with respiratory failure
   b. ≥3 displaced rib fractures not responding to adequate analgesia
   c. Significant chest wall deformity or ≥25% lung volume loss on CXR
   d. Bilateral rib fractures
   e. Non-invasive ventilation/ invasive ventilation dependent
   f. Presence of clavicle or scapular fracture

4.7 Placement of patients at St Mary's Hospital

Most patients will be admitted onto the major trauma, orthopaedic or general surgical wards, but some patients can be admitted elsewhere. Patients with thoracic epidurals should be admitted to major trauma ward or the critical care complex.

Clinical Decision Unit

Patients with rib fractures can be considered for admission to CDU only if they meet certain criteria:

- Patients 65 years or older: less than or equal to 2 ribfractures.

- Patients aged under 65 years: less than or equal to 3 ribfractures.
- Exclusion criteria for all age groups:
  - Injury includes: flail segment, significant pneumothorax or haemothorax.
  - Pain relief: requires PCA, epidural or block.

Patients with isolated rib fractures, meeting CDU criteria, who are well pre-injury and who have adequate social support can be considered for immediate or early discharge. Such patients should be counselled to seek medical advice if symptoms change or deteriorate.

Intensive Care Unit

Patients in ICU receiving level 2 care should follow the standard non-invasive or invasive pathway as appropriate. Patients who would benefit from non-invasive ventilation should also be considered for arterial line insertion and regular blood gases to assess respiratory function.

In patients who are receiving level 3 care (i.e. sedated, intubated and ventilated), the following principles should be considered:

- Ventilation:
  - Use lung protective ventilation strategies.
  - Nurse with the head of the bed elevated to ≥30 degrees if not contraindicated by other injuries.
  - Regular subglottic suctioning.
- Analgesia:
  - Assess pain regularly and treat with multimodal analgesic therapy.
  - Contact 1201 to arrange for a thoracic epidural:
    - In patients showing signs of impaired respiratory effort e.g. tachypnoea, poor tidal volumes, signs of pain or the patient indicates they are in pain.
    - In the 24 hours prior to planned extubation in patients meeting the invasive pathway criteria.
- Consider referral for rib fixation (and concurrent epidural) if:
  - Flail chest or paradoxical chest movement during weaning from a ventilator
  - > 6 ribs fractured
  - Bilateral rib fractures
  - Hypoxia and/or hypercarbia under 40% inspired oxygen inhalation
  - Repeated atelectasis
  - Significant chest wall deformity
  - Not responding to thoracic epidural and do not require intubation and ventilation otherwise

4.8 Discharge

Prior to discharge, patients should be given information, for example the NHS choices rib injury sheet, to ensure their progress after discharge is optimal. Pain should be adequately controlled such that patients are discharged with weak opioids (as well as other multimodal agents) in the TTO pack. If stronger opioids, e.g. morphine, are still in use, a clear weaning plan should be in place for the GP. Patients should be advised to see their GP if the pain isn't responding to prescribed analgesics or if they develop features of chest infection. Other simple interventions that can be recommended for completion at home include continued use of the active cycle breathing technique, use of ice packs, use of splints when coughing (e.g. a rolled-up towel), encouragement of mobilisation but avoidance of heavy strenuous exercise or work. Patients who have received surgical rib fracture fixation should be followed up in fracture clinic at 6 weeks after discharge.

Figure 1: Overview of Imperial rib fracture pathway

Rib Fracture Pathway Overview

1 Rib fractures confirmed on CXR / CT

2 Start multimodal analgesia and adjuncts

Adult patients	Patients aged 65yrs or older	Patients with renal impairment (eGFR <30)
Paracetamol 1g PO/ IV 6 hourly (if weight <50kg dose at 15mg/kg IV)	Paracetamol 1g PO/ IV 6 hourly (if weight <50kg dose at 15mg/kg IV)	Paracetamol 1g PO/ IV 6 hourly (if weight <50kg dose at 15mg/kg IV)
Morphine IR* 10 - 20mg PO 4 hourly + Morphine IR* 5 – 10mg PO 4 hourly PRN	Oxycodone IR* 2.5 – 5mg PO 4 hourly + Oxycodone IR* 2.5 – 5mg PO 4 hourly PRN	Oxycodone IR* 1.25 – 2.5mg PO 4 hourly + Oxycodone IR* 1.25 – 2.5mg PO 4 hourly PRN
Ibuprofen 400mg PO QDS	Avoid NSAIDs	Avoid NSAIDs
Laxatives: macrogol 1 sachet BD and senna 15mg ON	Laxatives: macrogol 1 sachet BD and senna 15mg ON	Laxatives: macrogol 1 sachet BD and senna 15mg ON
Anti-emetics	Anti-emetics	Anti-emetics

*IR = Immediate Release

3 Assess Risk *(Battle's score)*

Variable	Score
Age	+1 per additional 10-year increase starting at 10 years of age
Number of rib fractures	+3 per rib fractured
Chronic lung disease	+5 if present
Pre-injury anti-coagulant use	+4
Peripheral oxygen saturation levels (SpO_2)	+2 per 5% decrease SpO_2 starting at 94% at time of assessment
Total	

Please document Battle score on Cerner

Consider other risk factors for morbidity and the need for fib fixation:

Risk factors for morbidity		Early review for surgical rib fixation	
Pulmonary contusion	Current smoker	Flail chest	Chest wall deformity
Cardiovascular disease	Frailty	≥3 displaced rib fractures	CXR: ≥25% lung volume loss
Presence of ≥2 distant injuries	Obesity & OSA	≥65 years old	NIV/ ventilator dependent

4 Start on appropriate arm of pathway

Battle score 0 – 15

Non Invasive

If score 0 – 10: consider CDU if meets criteria or discharge if appropriate

If score 11 – 15 or other risk factors for morbidity present: consider more advanced analgesia &

Battle Score ≥16

Invasive

If score ≥30: consider early liaison with critical care team

Figure 2: Non-Invasive pathway for rib fracture management

Non – Invasive Pathway

Nursing care provided by staff familiar with major trauma patients
Monitor oxygen saturation (SpO_2) and Vital Capacity

⇩

Encourage to sit upright and mobilise early where possible

Provide supplemental oxygen at the lowest concentration to achieve appropriate SpO_2

⇩

3 Confirm analgesia is prescribed and titrate as required

Adult patients	Patients aged 65yrs or older	Patients with renal impairment (eGFR <30)
Paracetamol 1g PO/ IV 6 hourly	Paracetamol 1g PO/ IV 6 hourly	Paracetamol 1g PO/ IV 6 hourly
(if weight <50kg dose at 15mg/kg IV) Morphine IR* 10 – 20 PO 4 hourly	Oxycodone IR* 2.5 – 5mg PO 4 hourly	(if weight <50kg dose at 15mg/kg IV) Oxycodone IR* 1.25 – 2.5mg PO 4 hourly
+	+	+
Morphine IR* 5 – 10mg PO 4 hourly PRN	Avoid NSAIDs	Oxycodone IR* 1.25 – 2.5mg PO 4 hourly PRN
Ibuprofen 400mg PO QDS	Laxatives: macrogol 1 sachet BD and senna 15mg ON	Avoid NSAIDs
	Anti-emetics	

Consider IV opioid PCA: Morphine 1st choice, Fentanyl 2nd choice (unless renal impairment).
Give pregabalin if features of neuropathic pain. Consider PO ketamine after successful IV trial.
Contact pain team (bleep 1043) or anaesthetic team (bleep 1213) for advice

⇩

Active Cycle Breathing Technique including "huffing" hourly when awake
Encourage early and regular mobilisation for those able

Pedal exercisers for patients unable to mobilise beyond a chair

⇩

5 Regular reassessment and titration of therapy

SpO_2/ PaO_2/ Vital Capacity reducing O_2 needs increasing	SpO_2/ PaO_2/ Vital Capacity improving/ stable O_2 needs reducing/ stable

Figure 3: invasive pathway for rib fracture management

Invasive Pathway

Nursing care provided by staff familiar with major trauma patients
Monitor oxygen saturation (SpO_2) and Vital Capacity

As per items 2-4 on the Non-Invasive Pathway

TE is the 1st choice block for rib fractures. If there are contraindications, consider a block.

Both should be booked under "Emergency NCEPOD" on Cerner and completed within 6 hours of admission.

No contraindications

Thoracic Epidural

Initial bolus of 10 – 15mls levobupivacaine 0.125%

Prescribe mixed bag levobupivacaine 0.125% + 2mcg/ml fentanyl at 15mls/hr + rescue bolus 10mls

contraindicated

TE

Serratus Anterior or Erector Spinae Plane Block
Initial bolus of 40mls levobupivacaine 0.125% + 1:400000 adrenaline

Prescribe plain levobupivacaine 0.125% at 15mls/hr + rescue bolus 20mls 4 hourly PRN

4 Regular reassessment and titration of therapy

SpO_2/ PaO_2 reducing
Vital Capacity deteriorating

SpO_2/ PaO_2/ Vital Capacity improving/ stable
O_2 needs reducing/ stable

Pain score worse

Pain controlled

Continue regular reassessment and titration

Call 1213 for epidural/ block trouble shooting
Re-site if necessary

Contact ICU/ outreach
Consider Chest X-Ray
Consider NIV/ nasal high flow

Consider step down to non invasive pathway if sustained improvements

Figure 4: Rib fixation pathway

Surgical Rib Fixation Pathway

Review by member of rib fracture fixation team.

Discussion & Decisions	• MDT may include: rib fracture fixation team, MTW consultant, anaesthetist, intensive care consultant, physiotherapist, occupational therapy & nursing staff. • Decision for surgery made by 2 consultants.

Liaise with thoracic/ trauma surgeons if suspicion of large air leak or visceral injury.

If ipsilateral clavicle fractured, have low threshold for ORIF clavicle.

Book	Half day theatre session.
Drugs	Give prophylactic LMWH ≥12 hours before planned surgery.
Equipment	MatrixRib fixation kit is sterile and available.
Imaging	3D CT reconstruction thorax complete.
Blood results	FBC, renal profile (U&E & creatinine), clotting screen/ TEG.
Blood products	2 units of packed red blood cells cross matched.

Anaesthetic team	1. Insert thoracic epidural prior to anaesthetic induction if not already in situ OR ensure the dressings are distant to the operative site. 2. Use standard single lumen endotracheal tube. 3. Insert arterial line if anticipating NIV or inability to extubate.
All theatre team	Position patient supine or laterally after discussion with surgeons
Surgical team	1. Plan surgical incision(s) by identifying fractures clinically or with ultrasound. 2. If thoracic epidural not possible or contraindicated, insert paravertebral block/ catheter under direct vision at the end of the procedure. 3. Clean and debride original thoracostomy site to prevent infective complications.
Chest drains	1. Replace any pre-existing chest drains prior to operative fixation through a new thoracostomy 2. Insert a minimum of 1 chest drain per operated hemi-thorax at the end of the procedure and connect it to an underwater seal.

Mobile Chest X Ray at end of procedure in recovery or HDU to confirm drain position.

Post theatre destination	1. Aim to extubate at end of procedure. Arrange Major Trauma Ward/ Level 2 bed. 2. If intubated pre-op or significant respiratory compromise, to remain intubated and transfer back to ICU.
Analgesia	1. Give epidural levobupivacaine 0.125%/ fentanyl 2 mcg/ml mixture at 15 mls/hr. 2. Remove epidural 3-5 days after insertion (7 days maximum, if tunnelled, at discretion of anaesthetist & pain team). 3. Follow the invasive pathway

Rehabilitate	1. Regular ACBT and physiotherapy 2. Sit up and ambulate ASAP.
Discharge planning	1. Continue ACBT at home 4 hourly. 2. Wound review at 2 weeks.

Figure 5: Rib fracture tertiary referral form

Imperial College Healthcare NHS Trust

NHS North West London Trauma Network

NORTH WEST LONDON TRAUMA NETWORK

RIB FRACTURE TERTIARY REFERRAL FORM

Referral details		
Referring clinician	Responsible Consultant:	
	Contact telephone (mobile):	
	Contact e-mail address:	
	Hospital	
	Ward	
Patient	Name:	
	Date of birth:	
	NHS number:	
	Home address:	
	General Practitioner:	

Injury							
Mechanism:							
Rib fractures:							
Pneumothorax? Yes	No	Haemothorax? Yes	No	Pulmonary contusion? Yes	No		
Associated injuries:							

Interventions					
Intercostal drain? Yes	No	Date of insertion: …… / …… / ……		Persistent air leak? Yes	No
Imaging and findings					
Chest XR + CT chest (including 3D reconstruction rendered images) transferred by IEP: Yes		No			
Thoracic epidural in situ: Yes	No				
Ventilation:	Self-ventilating		Non-invasive ventilation		Intubated
FiO_2			ABG results		
Details of any other treatment/surgery received:					

Pre-morbid state	
Co-morbidities:	
Previous thoracic/ cardiac/ thoracic spinal surgery:	

Anticoagulant history including VTE prophylaxis:	

Please e-mail referral to imperial.ribfracture@nhs.net

5) IMPLEMENTATION

Training required for staff	☑ Yes ☐ No
If yes, who will provide training:	Anaesthetic department: Epidurals and RA techniques Major Trauma Department: overall management
When will training be provided?	At induction of junior doctors, new consultants and regularly at nursing updates.
Date for implementation of guideline:	1/3/2019

6) MONITORING / AUDIT

When will this guideline be audited?	Ongoing currently (clinical governance reference number 1850)
Who will be responsible for auditing this guideline?	Dr Alex Wickham, Consultant Anaesthetist Mr Ian Sinha, Consultant Orthopaedic Surgeon
Are there any other specific recommendations for audit?	None

7) REVIEW

Frequency of review	**Please indicate frequency of review:** *3 years* **Person and post responsible for the review:** Mr Ian Sinha, Consultant Orthopaedic Surgeon Dr Alex Wickham, Consultant Anaesthetist

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9) GUIDELINE DETAIL

Start Date:	**27th August 2019**
Approval Dates	**Anaesthetics and Major Trauma** January 2015 **Surgery, Cardiovascular and Cancer** **Major Trauma Board** January 2015 **Drugs and therapeutics Committee** 26th March 2019 (chair's action 2nd April 2019 and 27th August 2019)
Has all relevant legislation, national guidance, recommendations, alerts and Trust action plans been considered, and included as appropriate in the development of this guideline?	**Please list ALL guidance considered:** National Institute for Health and Care Excellence (NICE). *Interventional procedure guidance 361: Insertion of metal rib reinforcements to stabilise a flail chest wall.* 2010. NICE: London.
Have all relevant stakeholders been included in the development of this guideline?	**Please list all (name and role):** Mr C Aylwin, Consultant trauma and vascular surgeon Mr S Hettiaratchy, Consultant plastic surgeon Surg Commander M Khan, Consultant trauma surgeon Mr I Sinha, Consultant orthopaedic surgeon Dr S Qureshi, Consultant Anaesthetist Miss N Batrick, Consultant Emergency Physician & NWL Network lead Dr V Garnelo Rey, Consultant Intensivist & Trauma Lead Dr B Graham, Consultant Anaesthetist & Service Director Dr G Peck, Consultant Geriatrician St Mary's pain service: Dr J Illingworth, Dr A Knaggs, CNS A Fiamavle Dr B Bellew, Consultant Anaesthetist Mr K Bharkhada, Lead Pharmacist for Major Trauma and Pharmacy Miss N Marroney, Major Trauma Physiotherapist Mrs J Lockwood, Major Trauma Matron S H Jama, Senior Lead Pharmacist – Emergency, Acute and Elderly Medicine M Balic, Senior Lead Formulary Pharmacist and New Drugs Panel secretary
Who will you be notifying of the existence of this guidance?	**All clinical staff groups who are involved with the care of adult inpatients with rib fractures.**
Related documents	**Epidural Analgesia: Continuous Infusions Clinical Guidelines for Adult Patients** **Ketamine use for analgesia Guideline** **Pain management guidelines for adult patients with acute or chronic pain** **Analgesia Guideline for the Management of Acute and Chronic Pain for Adults with Renal Impairment**

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Document review history	**Next review due: 2nd April 2022** Version 1: Major Trauma Board review July 2015 Version 2: DTC review and recommendations 26/3/19 **Version 2.1: Update to CDU criteria**
THIS GUIDELINE REPLACES:	Rib Fractures in Major Trauma: a guideline for management version 1, July 2015

10) INTRANET HOUSEKEEPING

Key words	Major Trauma, Rib Fracture, Epidural, Rib fixation
Which Division/Directorate category does this belong to?	Surgery, Cancer & Cardiovascular
Which specialty should this belong to when appearing on the Source?	Major Trauma

11) EQUALITY IMPACT OF GUIDELINE

Is this guideline anticipated to have any significant equality-related impact on patients, carers or staff? No ☑