Rib Fracture Plating

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Injury 2013.

Overview:

- Incidence of Rib Fractures and Flail Injury
- Mortality & Long-Term Morbidity
- Historical Perspective
- Current Evidence: ORIF for Rib Fractures
- Conclusions

Incidence of Rib Fractures in Blunt Trauma

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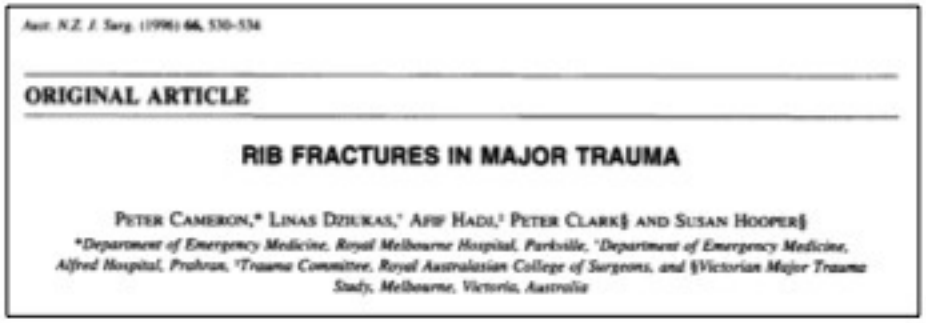
- Rib fractures:
  - 10 to 39% of patients with blunt chest trauma

- Flail Injury:
  - 2.5-5.8% patients with rib fractures

Liman et al 2003. Eur J Card Thor Surg.
Sirmali et al 2003. Eur J Card Thor Surg.
Civil 1999. Aust NZ J Surg.
Cameron et al 1996. Aust NZ J Surg.
Ziegler and Agarwal 1994. J Trauma.

Rib Fracture - Associated Mortality



Aust. N.Z. J. Surg. (1996) 66, 530–534

ORIGINAL ARTICLE

RIB FRACTURES IN MAJOR TRAUMA

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1996: 9.8%

1999: 4%

Rib fractures: Relationship with pneumonia and mortality*

Karen J. Brasel, MD, MPH; Clare E. Guse, MS; Peter Layde, MD, MS; John A. Weigelt, MD

ELSEVIER

European Journal of Cardio-thoracic Surgery 24 (2003) 133–138

CARDIO-THORACIC SURGERY

www.elsevier.com/locate/ejcts

A comprehensive analysis of traumatic rib fractures: morbidity, mortality and management

Mehmet Sırmalı*, Hasan Türüt, Salih Topçu, Erkmen Gülhan, Ülkü Yazıcı, Sadi Kaya, Irfan Taştepe

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2003: 5.7%

Flail Injury - Associated Mortality

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Invited Commentary

Rib Fracture Fixation: Controversies and Technical Challenges

RAMINDER NIRULA, M.D.,* JOHN C. MAYBERRY, M.D.†

*From the *Department of Surgery, Burns/Trauma/Critical Care Section, University of Utah, Salt Lake City, Utah and the †Department of Surgery, Trauma/Critical Care/Acute Care Surgery, Oregon Health and Science University, Portland, Oregon*

Age 18-44: 9.6%

Age >84yo: 22.5%

Complications of Flail Chest Injury

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- Increased incidence of respiratory failure requiring mechanical ventilation
- Prolonged duration of mechanical ventilation and thus ICU stay
- Chronic chest wall deformity and loss of respiratory volume
- Chronic chest wall pain

Am Surg 2010. Nirula & Mayberry.

Long-Term Pain and Disability

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The Journal of TRAUMA® Injury, Infection, and Critical Care

Rib Fracture Pain and Disability: Can We Do Better?

Mahlon A. Kerr-Valentic, BS, Melanie Arthur, PhD, Richard J. Mullins, MD, Tuesday E. Pearson, and John C. Mayberry, MD

J Trauma 2003. Kerr-Valentic et al.

Long-Term Pain and Disability

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Patients:

- Prospective evaluation of 40 patients out to 120 days
- 18 patients ≤2 rib #; 22 patients ≥3 rib fractures
- Compared to a chronically ill reference population

Results:

- At 30 days, 70% still using narcotics
- As a group, more disabled at 30 days
- Mean lost work days: 70

Surgical Management of Flail Injury: an Historical Perspective

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- **Early 20th century:**
  - Towel-clip devices, traction
  - Tapes, sandbags and other splints
- **Mechanical Ventilation:**
  - Revolutionised the management of ventilatory failure
  - Focus of chest wall fracture management shifted to treatment of the underlying lung
  - Advances in ventilatory support and anaesthesia have contributed to improved survival

Internal Fixation of Rib Fractures

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- First described over 50 years ago:
  - 1950's: wire suture fixation and intramedullary wire fixation
- Potential use recognised in the setting of:
  - Prolonged mechanical ventilation
  - Severe chest wall defects and deformity
  - Cases where thoracotomy was indicated for other reasons
- Increased use over the last 10-15 years associated with:
  - Recognition of significant short and longer term complications of flail chest injury
  - Advances in the development of devices used primarily for the internal fixation of boney fractures elsewhere in the skeleton

Current Opinion

The Journal of TRAUMA® Injury, Infection, and Critical Care

Surveyed Opinion of American Trauma, Orthopedic, and Thoracic Surgeons On Rib and Sternal Fracture Repair

John C. Mayberry, MD, L. Bruce Ham, MD, Paul H. Schipper, MD, Thomas J. Ellis, MD, and Richard J. Mullins, MD

J Trauma 2009. Mayberry et al.

Current Opinion

- 405 surgeons: 238 Trauma, 97 Orthopaedic and 70 Thoracic
- Only 104 surgeons had performed rib ORIF (56% of thoracic surgeons, 21% of trauma surgeons)
- Flail Chest as an indication for rib ORIF: 44%
- 84-97% had no knowledge of two randomised trials
- Of the 17-32% strongly opposed to rib ORIF, 82-95% stated that a randomised trial confirming efficacy would be necessary to change their negative opinion.

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Randomised Trials

The Journal of TRAUMA® Injury, Infection, and Critical Care

Surgical Stabilization of Internal Pneumatic Stabilization?
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Prospective Randomized Controlled Trial of Operative Rib Fixation in Traumatic Flail Chest

Silvana F Marasco, MSurg, FRACS, Andrew R Davies, FRACP, FCICM, Jamie Cooper, FRACP, FCICM, MD, Dinesh Varma, FRANZCR, Victoria Bennett, BNSc, CCRN, Rachael Nevill, BNurs, Geraldine Lee, MPhil, Michael Bailey, PhD, MSc (statistics), Mark Fitzgerald, FACEM

doi:10.1510

Surgical versus conservative treatment of flail chest. Evaluation of the pulmonary status

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Received 21 April 2005; received in revised form 28 July 2005; accepted 2 September 2005

Tanaka et al, 2002. Japan.

Aim: *Evaluate clinical efficacy of surgical stabilisation compared to internal pneumatic stabilisation*

Method:

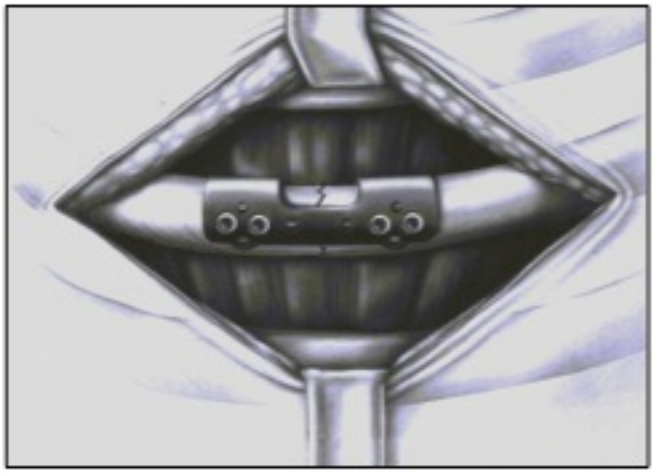
- Randomised, controlled
- Single institution, Level I Trauma centre
- Randomisation day 5:
  - Non-operative management via standardised protocol
  - Surgical fixation
  - (Other than surgey, all patients managed equally)

Tanaka et al, 2002. Japan.

- **Inclusion criteria:**
  - Flail chest injury
  - Mechanical ventilation for acute respiratory failure
  - Age ≥14 years
- **Exclusion criteria:**
  - Fractures of <6 ribs
  - Severe CHI and/or spinal cord injury
  - Pre-existing heart, lung, liver or renal disease
  - Questionnaire not completed

Tanaka et al, 2002. Japan.

- **Surgical technique:**
  - Performed within 14 days from injury
  - Judet struts
  - Minimal access incisions
  - Minimal intercostal dissection
  - Only ribs 4-10



- **Follow-up:**
  - Regular clinical review: weekly for 4 /52, then 2, 3, 6 and 12 months
  - Questionnaire: 6 and 12 months

Tanaka et al, 2002. Japan.

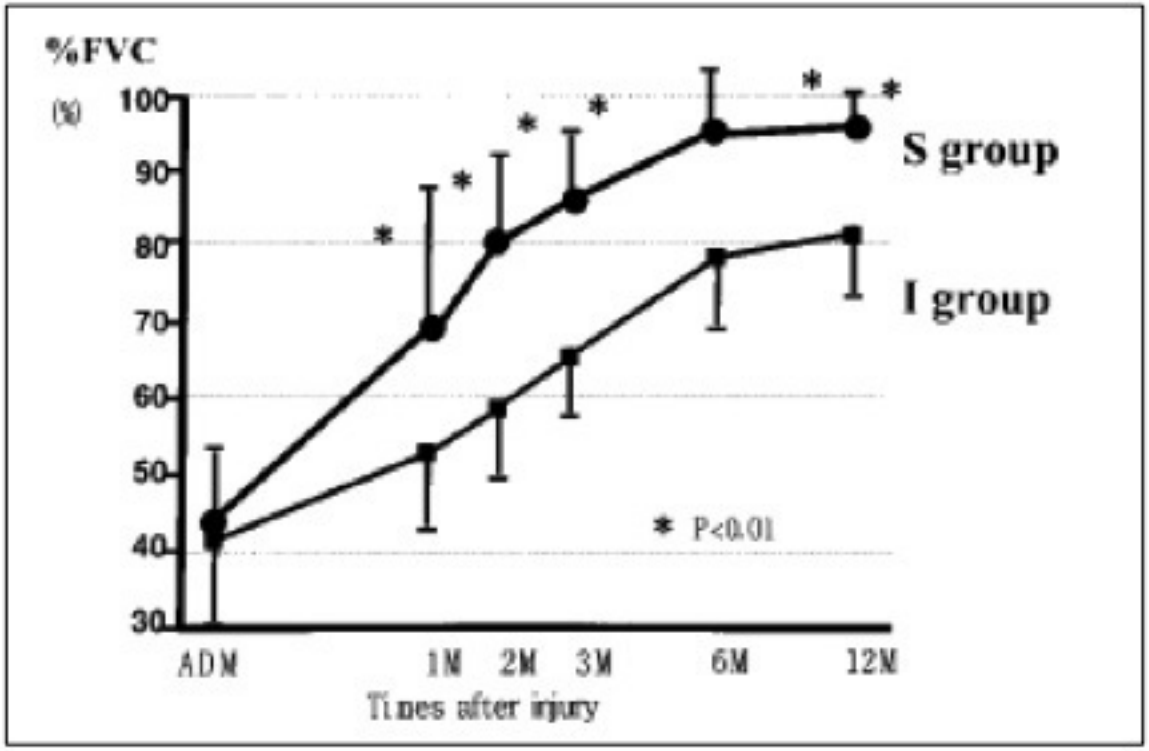
Results:

- 37 patients enrolled from 148 patients treated with flail chest between Apr 1992 and Mar 1998
- Surgical Group: n=18; Non-operative group: n=19.
- Surgical group: stabilisation at 8.2+/- 4.1 days
- Demographics, mean lung contusion score: no difference.

Tanaka et al, 2002. Japan.

	Surgical:	Non-Operative:	P value:
Pneumonia D7	5%	16%	ns
Pnuemonia D21	22%	90%	<0.05
Mech Ventilation	10.8±3.4 days	18.3±7.4 days	<0.05
ICU	16.5±7.4 days	26.8±13.2 days	<0.05
Tracheostomy D7	zero	26%	ns
Tracheostomy D21	16.7%	78.9%	<0.05
Expenses	US$13,455±$5,840	US$23,423±$1,380	<0.05

Tanaka et al, 2002. Japan.



Spirometry:

%FVC (mean ± SD) * p<0.05

Tanaka et al, 2002. Japan.

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Questionnaire:

	Surgical:	Non-Operative:	P value:
Chest tightness	33%	84%	<0.05
Thoracic pain	39%	89%	<0.05
Dyspnoea on effort	28%	63%	<0.05
Return to work	11/18	1/19	<0.05
Return to high activity	13/18	1/19	<0.05

Tanaka et al, 2002. Japan.

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Limitations:

- Results of non-operatively treated group seemed sub-optimal compared to current standards
- Small study size

Conclusion:

- Judet strut stabilisation may be preferentially applied for severe flail chest patients in whom prolonged ventilation is expected

Granetzny et al, 2005. Egypt and Germany.

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Aim: *Compare two methods of chest wall stabilisation via conservative packing and strapping and surgical fixation*

Method:

- Prospective, randomised study involving patients at two university clinics.

Granetzny et al, 2005. Egypt and Germany.

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Inclusion criteria:

- Flail chest with paradoxical movement

Exclusion criteria:

- Head injury
- Associated injuries that may be affected by GA
- Severe trauma to other systems
- Fractures limited to ribs 1-3

Surgical technique:

- Kirschner and stainless steel wires

Granetzny et al, 2005. Egypt and Germany.

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Groups:

- I: Conservative: strapping and packing >5cm anterior and posterior, 1 rib above and 1 rib below flail segment, 7-10 days.
- II: Operative: surgical fixation within 24-36 hours

Follow-up:

- Post-operative:
  - clinical examination
- 2 months post discharge:
  - Clinical examination
  - Pulmonary function tests

Granetzny et al, 2005. Egypt and Germany.

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Results:

- 40 patients:
  - Surgical group: n=20
  - Conservative group: n=20
- Significant difference in mean age: 40.5±8.2 years v's 36±14.9 years ($p<0.001$)
- Demographics and associated injuries otherwise the same
- Methods of fixations:
  - Kirschner wires and stainless steel wires: 70%
  - Stainless steel only: 30%

Granetzny et al, 2005. Egypt and Germany.

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	Conservative:	Operative:	P value:
# Ventilation:	35%	45%	ns
Mean Ventilation:	12 days	2 days	0.014
Mean ICU stay:	14.6 days	9.6 days	<0.001
Mean LOS:	23.1 days	11.7 days	<0.001
Mortality: all causes	15%	10%	ns

Granetzny et al, 2005. Egypt and Germany.

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Table 6
Morbidity and mortality in 40 patients with traumatic flail chest after management

Complications	Group I No. (%)	Group II No. (%)	P-value
No complications	8 (40%)	13 (65%)	n.s.
Chest infection	10 (50%)	2 (10%)	P=0.014
Empyema	2 (10%)	1 (5%)	n.s.
Pulmonary embolism	1 (5%)	0 (0%)	n.s.
Mediastinitis	0	2 (10%)	n.s.
Wound infection	0	2 (10%)	n.s.
Chest wall deformity	9 (45%)	1 (5%)	P=0.008
Scoliosis	5 (25%)	0 (0%)	P=0.047
Mortality	3 (15%)	2 (10%)	n.s.

Not significant (n.s.).

Granetzny et al, 2005. Egypt and Germany.

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Spirometry:

- FVC, TLC and FEF_{75} all significantly better in surgical group

Table 7
Pulmonary function tests in the survivors of 40 patients with traumatic flail chest 2 months after management

Pulmonary functions	Group I Mean ± S.D.	Group II Mean ± S.D.	P value
FVC (%)	66.5 ± 6.5	75.0 ± 5.4	P < 0.001
FEV_1 (%)	75.0 ± 0.4	75.5 ± 8.7	n.s.
TLC (%)	85.8 ± 11.3	90.7 ± 4.2	P < 0.001
PEFR (%)	91.8 ± 1.7	92.2 ± 2	n.s.
FEF_{75} (%)	60.4 ± 13.3	65.6 ± 13.8	P < 0.001

Forced vital capacity (FVC), Forced expiratory volume in the first second (FEV_1), Total lung capacity (TLC), Peak expiratory flow rates (PEF), Forced expiratory flows at 75% of the vital capacity (FEF_{75}), not significant (n. s.).

Granetzny et al, 2005. Egypt and Germany.

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Limitations:

- Conservative group: outdated technique
- Small study

Conclusions:

Surgical fixation allows for:

- Stability without deformity
- Decreased chest infection
- Less impairment of pulmonary function at 2 months
- Shorter ventilation times, ICU stay and LOS

Marasco et al 2013. Australia.

Aim: *To investigate the effect of ORIF of rib fracture on mechanical ventilation time and ICU stay.*

Method:

- Prospective, randomised controlled trial
- Mechanically ventilated patients with flail rib injury
- Single institution: major adult trauma centre

Groups:

- Operative group
- Non-operative group

Marasco et al 2013. Australia.

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Inclusion Criteria:

- Ventilator dependant without prospect of weaning in 48 hours
- Flail segment (>2 consecutive ribs fractured in >1 place)

Exclusion Criteria:

- Age >80yo
- Spinal injury
- Open rib fracture
- Severe traumatic brain injury
- Uncorrected coagulopathy
- Sepsis

Marasco et al 2013. Australia.

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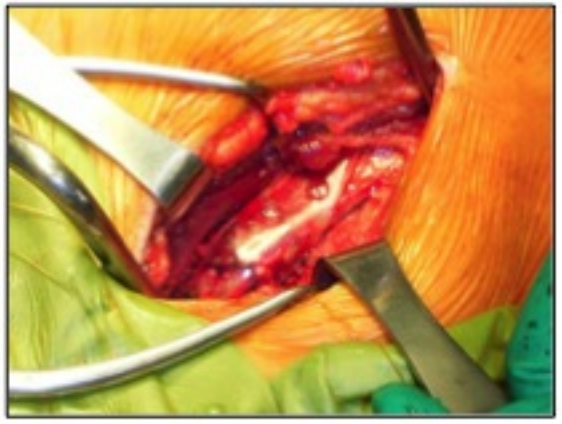
Surgical technique:



- Surgery within 5 days of injury
- Ribs between 3-10 fixed
- 1 or 2 incisions
- Muscle sparing where possible
- Periosteum preserved
- Ant and lat ribs fixed in preference to post ribs
- Inion resorbable (Inion OTPS) plates and bicortical screws

Marasco et al 2013. Australia.

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Primary end-points:

- Duration of mechanical ventilation
- Duration of ICU stay

Secondary end-points:

- Number of respiratory complications
- Rate of failed extubation
- Rate of tracheostomy
- Readmission to ICU
- Duration of hospital stay
- Cost assessment

Follow-Up:

- 3 moths: clinical assessment, spirometry, CT scan
- 6 months: Health status questionnaire (SF-36)

Marasco et al 2013. Australia.

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Results:

- Enrolment period Jan 2007-Dec 2011
- 230 patients with flail chest- 146 assessed for eligibility
- 46 randomised: (23 per group)
- Non-smokers:
  - Non-operative group: 78%
  - Operative group:43% (P<0.02)
- Demographics otherwise the same

Marasco et al 2013. Australia.

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Operative group:

- 23 patients assigned; 1 patient was not operated on due to developing sepsis (included as an intention to treat)
- 22 patients operated on
- 49%- 4 ribs fixed
- 9%- bilateral ORIF
- Most commonly anterior and lateral: 1 patient posterior ORIF

Marasco et al 2013. Australia.

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	Non-operative:	Operative:	P value:
ICU stay (mean hrs) (post-randomisation)	372	255	0.03
Total ICU (mean hrs)	456	317	0.02
Mean hours of non-invasive ventilation (post extubation)	67	22	0.03
Tracheostomy	70%	39%	0.04

Multivariate analysis: adjusting for non-thoracic surgical interventions.

Marasco et al 2013. Australia.

Cost Savings:

- Total ICU stay (median hours)
  - Operative: 324
  - Non-operative: 448.

Difference of 124 ICU hours = 5.17 days

- Cost: A$4,109/day = A$21,243
- Average cost of procedure: A$6,800
- Cost saving per operation: A$14,443

Marasco et al 2013. Australia.

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3 month Follow-up:

- Spirometry: no significant difference
- Limitations in daily activities: 60% (non-operative) v's 48% (operative) due in the majority to non-thoracic injuries

6 month Follow-up:

- Quality of Life questionnaire: no difference

Marasco et al 2013. Australia.

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Limitations:

- Single institution

Conclusions:

- Clinical benefits and cost savings for operative fixation of flail rib fractures
- Further trials required into non-ventilator dependent patients

Summary

- Three studies show early clinical benefits of operative fixation of rib fractures in selected patients.
- Two studies demonstrated a significant cost saving for patients managed with operative fixation
- Two studies showed improved spirometry results post-discharge, after operative fixation
- Lack of popularity and acceptance of rib fixation as a viable option for patients with severe rib injury may previously been due to :
  - Lack of understanding off the evidence
  - Lack of familiarity with the procedure
  - Lack of specific prostheses (until recently)

Conclusion

The operative fixation of rib fractures has been shown to improve short term and long term clinical outcomes in patients with flail chest injury, and has been shown to reduced the cost of care for these patients. It is a valid treatment option in selected patients.

Further trials are required to assess the effect of rib fracture fixation in non-ventilated and less severely injured patients.

Thank-you! ka.martin@alfred.org.au

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