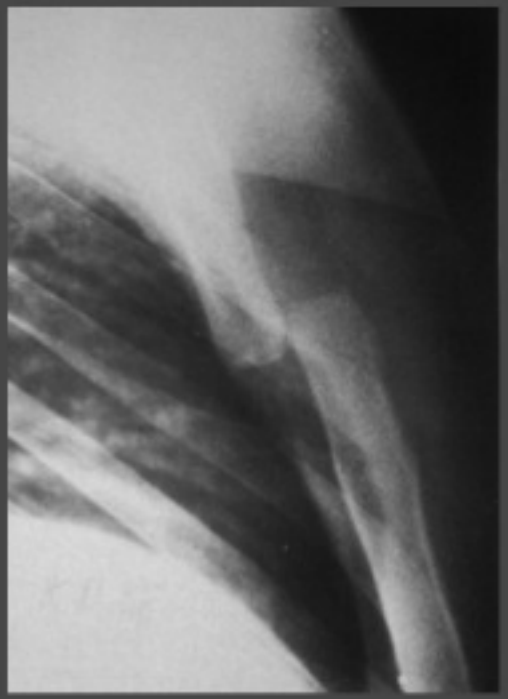
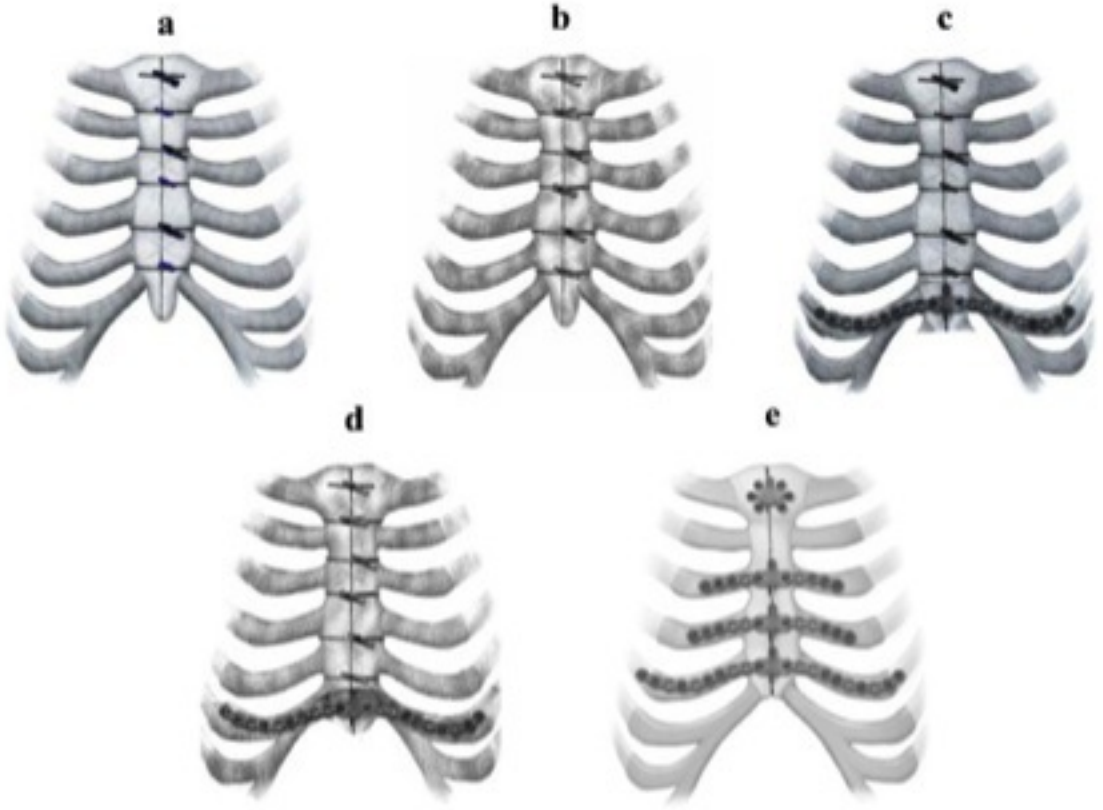
STERNAL FRACTURES: IS THERE A ROLE FOR STERNAL PLATING?

Indran Ramanathan PhD FRACS
Cardiothoracic Surgeon
Green Lane CTSU
Auckland City Hospital

Injury 2014, Eden Park, Auckland

Scope of the Problem





a) wires alone,

b) cables alone,

c) wires + 1-plate,

d) cables + 1-plate,

e) 4-plates.

Epidemiology

- Occur in 3-8% of blunt trauma patients
  Anthanassiadi et al World J Surg 2002
- Less than 1% of all US ED trauma patients
  Knobloch et al Ann Thorac surg 2006
- Mechanism: MVA (60-80%), seatbelted driver

Most Common Cause of Sternal Fractures?

Clinical Consequences

- Pain
- Deformity
- (Respiratory compromise)
- Sternal non-union and long term pain (<10%)

Classification Odell et al J Trauma Acute Care Surg 2013

- Isolated Sternal Fracture
  - Mild, localised condition
- Polytrauma Sternal Fracture
  - Associated injuries
    - Potentially lethal

- Israeli National Trauma Registry 1997–2008

TABLE 1. Sternal Fractures: Demography and Mechanisms of Injury

	Sternal Fractures			
	ISF Patients		PSF Patients	
	n	Percentage	n	Percentage
Total	492	26.4	1,375	73.6
Demographics				
Age, mean (SD), y	48.5 (19.2)		44.4 (18.8)	
≤44	205	41.8	701	51.0
45–59	134	27.2	351	25.5
≥60	151	30.8	320	23.3
15–74	435	88.8	1,262	91.8
Unknown	2	0.4	3	0.2
Male	275	55.9	883	64.2
Female	217	44.1	492	35.8
Type of injury				
Blunt	490	99.6	1,351	98.3
Penetrating	0	0	12	0.9
Blunt and penetrating	0	3	9	0.6
Unknown	2	0.4	3	0.2
Mechanism of injury				
MVC	427	86.8	1,143	83.1
Fall	52	10.6	140	10.2
Other accidental	9	1.8	36	2.6
Assault	4	0.8	55	4.0
Position in motor vehicle				
Front seats*				
Driver	269	63.0	606	53.0
Passenger	80	18.7	221	19.3

*Other MVC patients were rear seat passengers, pedestrians, motorcyclists, or bicyclists or had missing information.

MVC, motor vehicle collision.

TABLE 2. PSF: Associated Extrasternal Injuries in 1,375 Patients*

Associated Injury Site	Patients	
	n	Percentage
Head and neck	541	39.3
Spine	354	25.7
Cervical	109	7.9
Thoracic	138	10.0
Lumbar	141	10.3
Chest	1,007	73.2
Rib fracture	528	38.4
Flail chest	42	3.1
Chest wall contusion	421	30.6
Pneumothorax	174	12.7
Hemothorax	21	1.5
Pneumothorax/hemothorax	43	3.1
Lung contusion/laceration	352	25.6
Airway	5	0.4
Cardiac contusion	31	2.3
Cardiac laceration	3	0.2
Aorta, vena cava, other vessels	15	1.1
Abdomen	226	16.4
Pelvis	144	10.5
Extremities	580	42.2
Upper	381	27.7
Lower	298	21.7

*A substantial portion of the 1,375 PSF patient cohort sustained more than one associated injury.

TABLE 3. ISF Versus PSF*

	Sternal Fractures			
	ISF* Patients		PSF* Patients	
	n	Percentage	n	Percentage
Total	492	26.4	1,375	73.6
ED evaluation				
Pulse rate ≥ 100 beats/min	38/296**	12.8	346/1,149**	30.1
Systolic blood pressure < 90 mm Hg	2	0.4	72	5.2
Respiratory rate > 20 breaths/min	35	7.1	181	12.4
GCS score ≤ 14	1	0	222	16.4
Revised Trauma Score (RTS) ≤ 11	4/440**	0.9	185/1,236**	15.0
Injury Severity Score (ISS) ≥ 9	0	0	757	55.1
ED treatment				
Intubation	0	0	98	7.1
Resuscitative thoracotomy	0	0	10	0.7
Chest tube	0	0	124	9.0
Destination from ED				
ICU	0	0	220	16.0
Operating room	0	0	138	10.0
Ward	492	100	1,006	73.2
Morgue	0	0	7	0.5
Hospitalization, category				
ICU	1	0.2	346	25.2
ICU, Mean (SD)	NA		10.5 (11.3)	
Operations	1	0.2	363	26.4
Length of stay, d				
1	211	42.9	213	15.5
2	159	32.3	241	17.5
≥3	120	24.3	913	66.4
Mean (SD)	2.4 (4.2)		9.2 (12.3)	
Median†	2.0		4.0	
Death	2‡	0.4	52	3.8

*Differences between ISF and PSF were statistically significant ($p < 0.05$) in all categories.
**Denominator represents number of patients with data available.
†Calculated for length of stay 1 day to 90 days.
‡Ages 81 years and 89 years with background diseases.
NA, not applicable.

Is there a role for fixation?

Isolated Sternal Fracture

Polytrauma Sternal Fracture

Sternal Fracture ≠ Flail Chest

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

CONCLUSIONS: Operative fixation of fractured ribs reduces ventilation requirement and intensive care stay in a cohort of multitrauma patients with severe flail chest injury. (J Am Coll Surg 2013;216:924–932. © 2013 by the American College of Surgeons)

Rib Fixation in Flail Chest

Table 4. Spirometry Results at 3-Month Follow-Up

Percent predicted value	Operative group (n = 17)	Nonoperative group (n = 17)	p Value
FEV1	74.3 ± 15.0	80.2 ± 18.3	0.31
FVC	77.9 ± 15.7	84.8 ± 14.0	0.19
MMEF	76.2 ± 36.9	82.1 ± 35.0	0.64
PEF	62.8 ± 28.5	68.1 ± 36.5	0.63
TLC	84.0 ± 24.4	88.2 ± 23.4	0.61
FEV1/FVC	95.6 ± 9.8	95.0 ± 17.3	0.92

Data are reported as mean ± SD.
FEV1, forced expiratory volume in one second; FVC, forced vital capacity; MMEF, maximal mid expiratory flow; PEF, peak expiratory flow; TLC, total lung capacity.

Table 5. Three-Dimensional CT Results at 3 Months

3D CT appearance	Operative group, n (n = 21)	Nonoperative group, n (n = 17)	p Value
Complete healing	11	8	0.50
Partial healing	7	8	0.51
Nonhealing	3	1	0.38
Preoperative overlapping rib ends	14	10	0.86
Residual overlapping rib ends	8	10	0.35
Improvement in overlapping bone ends	6	0	0.72
Preoperative displacement (>1 rib >rib width)	9	13	0.05
Residual displacement (>1 rib >rib width)	4	7	0.16
Improvement in rib displacement	5	6	0.12
Preoperative angulation (>5 degrees >1 rib)	9	12	0.09
Residual angulation (>5 degrees >1 rib)	3	9	0.01
Improvement in angulation	6	3	0.15

Rib Fixation in Flail Chest

Table 6. Short Form-36 Quality of Life Questionnaire Results at 6 Months Postinjury

SF-36 domains	Operative group (n = 19)	Nonoperative group (n = 18)	p Value
Physical functioning	33.4 ± 13.0	38.4 ± 12.0	0.24
Physical role	32.1 ± 7.9	35.1 ± 11.4	0.36
Bodily pain	42.2 ± 9.4	37.9 ± 11.0	0.22
General health	45.2 ± 11.8	44.0 ± 12.2	0.77
Vitality/energy	44.1 ± 10.8	46.3 ± 8.2	0.49
Social functioning	36.0 ± 15.0	37.2 ± 12.5	0.79
Emotional role	37.6 ± 14.5	37.8 ± 13.5	0.97
Mental health	45.9 ± 13.2	46.5 ± 9.1	0.87
PCS	33.6 ± 9.8	35.2 ± 10.7	0.65
MCS	45.1 ± 13.8	45.2 ± 9.2	0.98

Scores are reported as mean ± SD.
MCS, mental component summary score; PCS, physical component summary score.

Is there a role for Sternal Fixation?

- Unlikely to improve respiratory function in the short term
- Associated injuries
- Does fixation improve pain or deformity?

Fixation of Sternal Fractures: A Systematic Review

Harston A, Roberts C. J Trauma 2011;71:1875-9

- Review 1990 – 2010
- 2+ cases of surgical repair of sternal fractures (PubMed, Medline, EMBASE)
- 12 articles
- 76 cases
  - All retrosepective
  - No controls

Results of Systematic Review

- Mean age 36.5 years
- Follow-up in only 27 pts (35.5%)
- Indications
  - Pain
  - Deformity
  - Respiratory insufficiency or ventilator dependency
  - Non-union
  - Presumed eventual pseudoarthrosis with chronic pain.
- Fixation
  - 6% of all sternal fractures
  - Plates 52 pts, wires 24 pts
- No reported intra-operative or post-operative deaths or infections

Results of Systematic Review

- Timing of surgery
  - Acute
    - 43 pts (within 7 days)
  - Chronic
    - 31 pts (3 weeks to 2 years)

- Complications
  - 7 studies reported (12/64, 18.75%)
  - Removal of Hardware for pain
    - 8/52 plates (15.4%)
    - 2/24 wires (8.3%)
  - 1 reoperation for non-union

What do we know?

- Sternal Fractures
  - Relatively uncommon (excluding CPR)
  - Varying severity
    - Isolated
      - Pain
    - Polytrauma
      - Outcome: associated injuries & co-morbidities
  - Fixation
    - Limited data
    - Imperfect solution?

Is there a role for Sternal Plating?

- Acute
  - Pain compromises respiration
    - Refractory to analgesia
  - Severe deformity
    - Unlikely to resolve with time
    - (compound fractures)
- Chronic
  - Symptomatic non-union
  - Pain
  - Deformity