Flail Chest –To plate or not to plate?

Don‘t Additionally Harm the Patient

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Don‘t Plate It!

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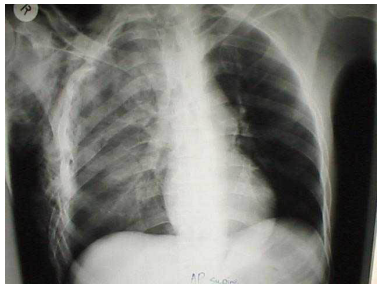
Flail Chest

Multiple adjacent at least double broken ribs frequently accompanied with lung contusions



Main Features of Flail Chest

- Pain
- Thoracic wall instability
  - Paradoxical movement of the unstable segment
- Impairment of gas exchange
  - Lung contusions potentially leading to ARDS
  - „Pendelluft“??

Reasons for Impairment of Gas Exchange

- Pain/pain treatment related hypoventilation, formation of atelectasis
- Pulmonary right-left shunt due to lung contusions/ARDS
- „Pendelluft ???“ (movement of air back and forth between the lungs, resulting in increased dead space ventilation)
  - besides of most massive flail chest experimentally and clinically irrelevant

Shinouzuka N. et al. Pendelluft is not the major contributor to respiratory insufficiency in dogs with flail chest. J Anesth 1995;9:252

Outcome

- In patients without pulmonary contusion pulmonary function recovers within 6 months, even in the presence of severe residual chest wall deformity.
- In patients with pulmonary contusion decreased functional residual capacity (FRC) and decreased supine paO2 for years afterward independend from stabilisation

Kishikawa M, Yoskioka T: Pulmonary contusion causes long-term respiratory dysfunction with decreased functional residual capacity. *J Trauma.* 312:1203-8, 1991

Evidence Based Therapy

- Pain control (optimal way: thoracic epidural analgesia)
- Chest physiotherapy
- NIV (CPAP)
  - Significantly lower mortality compared to invasive MV (IMV)
  - Significantly lower nosocomial infection rate compared to IMV

Therefore: IMV should be avoided

Gunduz M, Unlugenc H, Ozalevli M, et al: A comparative study of continuous positive airway pressure (CPAP) and intermittent positive pressure ventilation (IPPV) in patients with flail chest. *Emerg Med J.* 22:325-9, 2005

Evidence Based Therapy

- Operative management of flail chest still is highly controversial
- Intervention at the wrong time may be interpreted as „second hit“ by the organism

Survey 2009

- 33% of surgeons reported that operative management of FC was warranted after failure to wean from MV at 7 days, 29% felt that operative managementwas indicated for failure to wean at 14 days
- Only 8% of surgeons felt operative management was indicated for patients with FC who did not require mechanical ventilation

Mayberry JC, Ham LB, Schipper PH, et al. Surveyed opinion of American trauma, orthopedic, and thoracic surgeons on rib and sternal fracture repair. *J Trauma.* 2009;66:875–879

META-ANALYSIS

Operative Management of Rib Fractures in the Setting of Flail Chest

A Systematic Review and Meta-Analysis

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Findings?

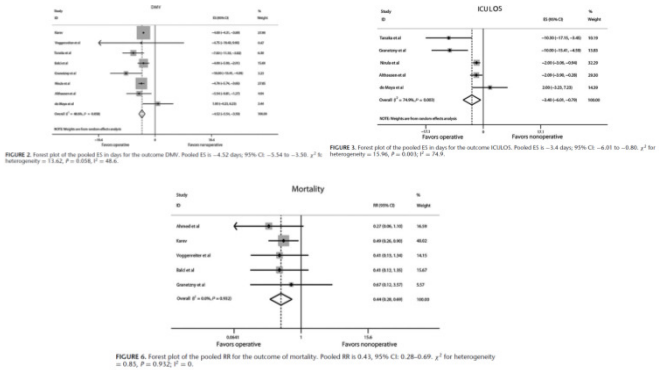

FIGURE 2. Forest plot of the pooled ES in days for the outcome DMV. Pooled ES is −4.52 days; 95% CI: −5.54 to −3.50. χ^2 for heterogeneity = 13.62, $P = 0.058$, $I^2 = 48.6$.

FIGURE 3. Forest plot of the pooled ES in days for the outcome ICULOS. Pooled ES is −3.4 days; 95% CI: −6.01 to −0.80. χ^2 for heterogeneity = 15.96, $P = 0.003$; $I^2 = 74.9$.

FIGURE 6. Forest plot of the pooled RR for the outcome of mortality. Pooled RR is 0.43, 95% CI: 0.28–0.69. χ^2 for heterogeneity = 0.85, $P = 0.932$; $I^2 = 0$.

Conclusions?

TABLE 3. Pooled Estimates of Average Benefit of Operative Versus Nonoperative Management of Flail Chest

	Risk Estimates		Tests of Heterogeneity		
Outcome	**Pooled Estimate**	**95% CI**	χ^2	P^*	I^2
DMV	−4.52 days	−5.54 to −3.50	13.62	0.058	48.6
ICULOS	−3.40 days	−6.01 to −0.79	15.96	0.003	74.9
HLOS	−3.82 days	−7.12 to −0.54	12.87	0.012	68.9
Mortality	RR 0.44	0.28 to 0.69	0.85	0.932	0.00
Pneumonia	RR 0.45	0.30 to 0.69	5.79	0.215	31.0
Tracheostomy	RR 0.25	0.13 to 0.47	1.05	0.789	0.00

**P* value for χ^2 test of heterogeneity.

According to this metaanalysis operative management of flail chest appears to shorten DMV, ICULOS, and HLOS and to reduce mortality, incidence of pneumonia and need for tracheostomy

Is this conclusion justified?

Study Selection

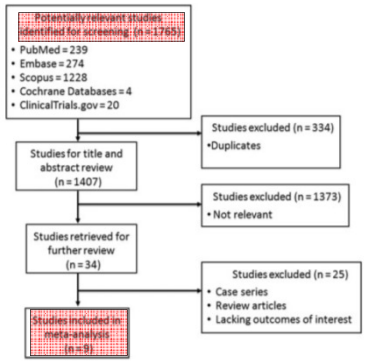

FIGURE 1. Flow diagram of study selection for meta-analysis.

Study Selection

TABLE 2. Characteristics of Studies Comparing Operative to Nonoperative Management of Flail Chest

Author	Location	Study Design	n: Operative Patients	n: Nonoperative Patients	Outcomes Reported	Timing of Operative Intervention	Quality Rating*
Ahmed et al[5]	UAE	Cohort	26	38	DMV, ICULOS, mortality, tracheostomy	12–24 h after ICU admission	Fair
Karev[6]	Ukraine	Cohort	40	93	DMV, pneumonia mortality	Within 24 h of hospital admission	Moderate
Voggenreiter et al[7]	Germany	Cohort	20	22	DMV, pneumonia, mortality	Not specified	Moderate
Tanaka et al[8]	Japan	RCT	18	19	DMV, ICULOS, pneumonia, tracheostomy	Mean 8.2 ± 4.1 d after admission; randomized d 5	Moderate
Balci et al[9]	Turkey	Cohort	27	37	DMV, HLOS, mortality, tracheostomy	All but 2 patients within 48 h of hospital admission	Moderate
Granetzny et al[10]	Egypt	RCT	20	20	DMV, ICULOS, HLOS, mortality	24–36 h after ICU admission; randomized 24 h after admission	High
Nirula et al[11]	USA	Case-control	30	30	DMV, ICULOS, HLOS	Mean 3 d after hospital admission	Moderate
Althausen et al[12]	USA	Case-control	22	28	DMV, ICULOS, HLOS, pneumonia, tracheostomy	Mean 2.3 d after hospital admission	Moderate
de Moya et al[13]	USA	Case-control	16	32	DMV, ICULOS, HLOS, pneumonia	Mean 5 d after hospital admission	Moderate

*See Methods section, Data Extraction and Quality Assessment, for detail on determination of Quality Rating.

9 studies 219 319 538 patients; all were mechanically ventilated

In Fact….

- Metaanalysis compares operative management vs. non-operative management in patients under mechanical ventilation
  - As shown previously, mechanical ventilation increases mortality and pneumonia rates

Moreover…..

- Because of limited data reporting and small sample sizes, the metaanalysis was unable to perform subset analysis in patients with concurrent pulmonary contusion
  - In patients with FC and lung contusions advantages of operative fixation could not be demonstrated in the two studies addressing this issue
    - But: Only these patients may need mechanical ventilation due to a combination of pulmonary dysfunction and altered respiratory mechanics

Voggenreiter G, Neudeck F, Aufmkolk M, et al. Operative chest wall stabilization in flail chest: outcomes of patients with or without pulmonary contusion.*J Am Coll Surg.* 1998;187:130–138

Althausen PL, Shannon S, Watts C, et al. Early surgical stabilization of flailchest with locked plate fixation. J Orthop Trauma. 2011;25:641–647

Therefore….

- The real conclusion of this metaanalysis is:
  - Operative management of flail chest shortens days of mechanical ventilation, ICULOS, and HLOS and reduces mortality, incidence of pneumonia and need for tracheostomy in patients with flail chest without concurring lung contusions who were unnecessarily intubated and mechanically ventilated

Final Conclusions

- There is insufficient evidence that operative stabilisation of FC improves outcome
- As surgery requires intubation and mechanical ventilation it may even harm the patients
- Surgical fixation may be considered in patients with FC without lung contusions, needing mechanical ventilation for any reason if thoracotomy is required anyway

Thank you for your attention