CHEST WALL INJURIES

NORDTER Trauma Radiology
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CHEST WALL INJURIES

- Incidence of blunt chest trauma
- Mechanism of injury
- Anatomy of the chest wall
- Rib and costochondral fracture types
- Underlying intrathoracic injuries and deceleration injuries (through cases)
- Examples of associated injuries (sternum etc.)
- Different modalities in chest trauma
- Clinical aspects
- Key points
**Pattern of injuries (ISS >16)**

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Ihre Klinik</th>
<th>TR-DGU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kopf</td>
<td>48.2% (n = 41142)</td>
<td>48.2% (n = 41142)</td>
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<tr>
<td>Gesicht</td>
<td>11.2% (n = 9583)</td>
<td>11.2% (n = 9583)</td>
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<tr>
<td>Hals</td>
<td>1.3% (n = 1071)</td>
<td>1.3% (n = 1071)</td>
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<tr>
<td>Thorax</td>
<td>45.3% (n = 38677)</td>
<td>43.3% (n = 38677)</td>
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<tr>
<td>Abdomen</td>
<td>14.9% (n = 12721)</td>
<td>14.9% (n = 12721)</td>
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<tr>
<td>Wirbelsäule</td>
<td>27.9% (n = 23830)</td>
<td>27.9% (n = 23830)</td>
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<tr>
<td>Arme</td>
<td>28.5% (n = 24315)</td>
<td>28.5% (n = 24315)</td>
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<tr>
<td>Becken</td>
<td>13.6% (n = 11632)</td>
<td>13.6% (n = 11632)</td>
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<tr>
<td>Beine</td>
<td>27.7% (n = 23669)</td>
<td>27.7% (n = 23669)</td>
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</table>


Nordter 2016/Chest wall injuries
INCIDENCE OF BLUNT CHEST TRAUMA

• A retrospective review of 1461 consecutive whole body CT (WBCT) trauma studies in a single large level 1 trauma center
• A period of 36 months (January 1st 2013 – December 31st 2015)

Incidence of blunt chest trauma was 39% (574/1461)

- Male 425; 74.0%, mean age 46.6 (range 18-91)
- Female 149; 26.0%, mean age 48.9 (range 18-97)

Nummela MT, Bensch FV, Koskinen SK 2016 (unpublished data)
### MOI in chest trauma (mechanism of injury)

- Fall from height 36%
- MVA 27%
- Motor cycle and bicycle accidents 23%

<table>
<thead>
<tr>
<th>Mechanism of injury</th>
<th>n</th>
<th>%</th>
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<tbody>
<tr>
<td>Fall</td>
<td>207</td>
<td>36%</td>
</tr>
<tr>
<td>MVA</td>
<td>157</td>
<td>27%</td>
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<tr>
<td>MCA</td>
<td>75</td>
<td>13%</td>
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<tr>
<td>BCA</td>
<td>58</td>
<td>10%</td>
</tr>
<tr>
<td>Compression</td>
<td>21</td>
<td>4%</td>
</tr>
<tr>
<td>Assault</td>
<td>16</td>
<td>3%</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>29</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>574</td>
<td>100%</td>
</tr>
</tbody>
</table>

Nummela MT, Bensch FV, Koskinen SK 2016 (unpublished data)
CHEST WALL INJURIES

Trauma mechanism:
- Direct blunt stroke
- Crush injuries/compression
- Deceleration (chest wall intact, intrathoracic injuries)

Modality of choice: CT
- Chest x-ray
- Ultrasound
- MRI
CHEST WALL ANATOMY/muscles

Anterolaterally less muscle volume

Muscle volume protects

Front:
- Pectoralis major (cut)
- Pectoralis minor
- Serratus anterior
- Internal intercostal
- External intercostal

Nordter 2016/Chest wall injuries
Muscle volume protects

**Back:**
- Latissimus dorsi
- Rhomboid muscles
- Trapezius
CHEST WALL ANATOMY/muscles

Anterolaterally less muscle volume

Obesity/musculature hides chestwall movement
87 year old woman with Alzheimer’s disease and atrial fibrillation. Warfarin dosage was increased recently, INR 1.8 (target level 2-3) resulting in INR 5.8. Tripped and fell in unknown circumstances, a large hematoma on the chest.
87 year old woman with Alzheimer’s disease and atrial fibrillation. INR 5.8, hemoglobin level dropped down to Hb 74 g/l.
87 year old woman with Alzheimer’s disease and atrial fibrillation. INR 5.8, hemoglobin level dropped to Hb 74 g/l.

CT ordered: No intrathoracic bleeding

Pectoralis major & minor torn
RINGLIKE STRUCTURE

- Flexible ring
- Multiple injuries
- Compression vs. blunt direct stroke

Rib cage vs.
- Pelvis
- Facial bones
- Atlas (C0 vertebra)
It’s not just about the chest!

Ribs also protect the abdominal organs

Liver
Right kidney
Spleen
Pancreas
Left kidney
CHEST WALL ANATOMY/rib cage

7 vertebrosternal ribs
3 vertebrochondral ribs
2 false/floating ribs

A typical rib: more robust posteriorly

Picture copyright: www.anatomychart.info

Nordter 2016/Chest wall injuries
Geometry of human ribs pertinent to orthopedic chest-wall reconstruction.

Outer cortex is thinner laterally and anteriorly.

Fig. 5. Average cortical thickness $t_C$ and exemplary cross-sections. Most posteriorly, inner ($t_{inn}$) and outer ($t_{out}$) cortex thickness were similar, while from 25% to 75% rib length the inner cortex was the thickest.
Fracture types/Anterior fractures

Buckle type fractures - Easy to overlook


27 year old female, MVA. Small pneumothorax on the left anteriorly. Left anterolateral nondislocated fxs on the left, ribs 5-6.

Buckle type fractures - Easy to overlook


1\textsuperscript{st} rib fracture is an indicator of high trauma energy.

27 year old female, MVA. Posterior fx (arrowhead) of the 1\textsuperscript{st} rib on the left (a). Small pneumothorax (arrows) on both sides (b). Dislocated costochondral fx of the right 1\textsuperscript{st} rib (c) (arrowhead).
Fracture types/ First rib fractures

- Anterior nondislocated fractures vs. pseudarthrosis of the first rib
- Degree of ossification varies greatly between individuals

Fig 1. Gas bubbles lining a fracture in the costochondral junction (arrowhead). Sternum (S) fracture on the right (star), a retrosternal hematoma.

Fig 2. 42 year old male, MCA. Fracture was suspected. There is air inside the cleft like costochondral junction (arrows), but no fracture line or air outside the junction.

Gossner J. Pseudarthrosis of the cartilaginous part of the first rib is a common incidental finding on chest CT. Diagn Interv Imaging 2015.
Fracture types/Lateral rib fractures

- Usually multiple consecutive fractures – keep looking!
- Report **duplex fxs**, the degree of **dislocation** and overlapping fragments

62 year old female, fell out of the bus door when a bus drove off the road. Multiple consecutive rib fractures on the right. MIP 50 mm.

Axial image (left) shows decreased muscle volume, soft tissue emphysema.
62 year old female, fell out of the bus door when a bus drove off the road. Pneumothorax on the right (arc). Laceration on the right (arrow).
Fracture types/ Flail chest

“A segment of the chest wall that is flail is unable to contribute to lung expansion”

Definition:

“at least two fractures per rib, in at least two ribs”

“five or more adjacent simple fxs or more than three segmental rib fxs”
Impairment of respiratory function (loss of negative intrathoracic pressure & underlying lung injury)

- CT flail vs clinical flail?
- muscle splint
- obesity/heavy musculature
- shallow breather

**Fracture types/ Flail chest**

Paradoxical movement of the chest wall? Can we see it?
44 year old female from a MVA, hit by a truck. Left flail segment bulging outward.
44 year old female from a MVA. Rear-end collision, she was hit by a truck. Primarily unconscious, intubated.
Flail chest/Additional injuries

44 year old female from a MVA. Splenic injury with pseudoaneurysms. Diaphragmatic injury on the left.
44 year old female from a MVA. Fracture distraction Th5/6.
Flail chest/Additional injuries

44 year old female from a MVA. Fracture distraction Th5/6. Diaphragmatic injury on the left.
Fracture types/ Flail chest

Sternal flail

Definition: bilateral chondrosternal fractures

27-year-old man with a mental illness attempted a backflip from a 4th floor window. Several midchondral fractures (arrowheads) on both sides of the sternum.
27-year-old man with a mental illness attempted a backflip from a 4th floor window. Sternum fractures (arrowheads). Plain radiograph looks normal.
Fracture types/ Costal cartilage fractures

Fig 1: Fracture at the costochondral junction of the 4th rib (arrowhead). 51 year old male, fall from height, survived.

Costochondral

Fig 2: Midchondral fracture of the left 4th rib (arrowhead). 48 year old male, MVA.

Midchondral

Fig 3: A non-dislocated sternochondral fracture of the right 4th rib. 62 year old male, bicycle accident.

Sternochondral

3 locations:
Costochondral
Midchondral
Sternochondral
Fracture types/ Costovertebral dislocation

62 year old male, bicycle accident.
Fracture types/ Costal cartilage fractures

51 year old male, MVA, 80 km/h to a concrete wall. Midchondral nondislocated fracture on the left 7th rib cartilage (arrowheads). Tenderness in the left subcostal angle. **No other injuries.**
Fracture types/Costal cartilage fractures

Posttraumatic calcifications, a stable union?

39 year old male, fall from height. Serial midchondral fractures on the left 6th and 7th rib cartilages (arrowheads).

Same patient. Dense calcifications (circled) are visible 13 months after the initial trauma.

16 year old male, anterior direct stroke to the shoulder in a bandy game. Right sternoclavicular posterior luxation.

CT angiography to exclude vascular injury
**Mechanism:** a “valve” that lets air into the pleural space during inhalation


http://brooksidepress.org/TCCC/wpcontent/uploads/2016/01/

Figure-3-11.-Tension-pneumothorax-resulting-from-a-closed-chest-injury.jpg
25 year old male with mental issues. Walks towards an ambulance in a desoriented state. Declares to have jumped 10 meters ending up on a lawn. No rib fractures. Deceleration?

Mediastinal shift
Increased intrathoracic volume
Diaphragm flattens
Tension pneumothorax resolved

Chest x-ray 42 minutes after the CT, chest tubes on both sides

- Right lung volume regained
- No mediastinal shift
- Domes of diaphragm are symmetrical

25 year old male with mental issues. Walks towards an ambulance in a desoriented state. Declares to have jumped 10 meters ending up on a lawn. No rib fractures.
25 year old male with mental issues, fall from height. **Day 5** chest tubes are out, still a small pneumothorax.
25 year old male with mental issues, fall from height. Patient was waiting for a transfer to psychiatric ward. 
**Day 5, ULD (ultra low dose) CT as a control study**

**Contusion/Laceration**

Radiation dose:
**TotalDLP 16**

Primary trauma WBCT
**TotalDLP 556 (scout DLP 6)**

Dose optimization determined by age and the clinical question
25 year old male with mental issues, fall from height. Patient was waiting for a transfer to psychiatric ward.

Day 5, ULD (ultra low dose) CT with MBIR (model based iterative reconstruction (GE))

- ULD CT fit for evaluation of Volume of pneumothorax
- Contusions
- Tube positioning
- Amount and location of fluid

CAVE!
- Suspicion of active bleeding or empyema requires i.v. contrast
- and assessment of mediastinal structures a higher dose!
46 year old female, fall from 4th floor window.

- Tension pneumothorax
- Large areas of contusion on the left
- Small pneumothorax
Contusion/Laceration/Tension pneumothorax

46 year old female, fall from 4th floor window.
22 male, MVA. Large contusions and lacerations on both sides. Pneumothx.

Laceration types
1 – intraparenchymal
2 – paravertebral
3 – lateral/near fx

22 male, MVA. Large contusions and lacerations on both sides.

Paravertebral shearing type of injury

Contusions do not respect the anatomic boundaries of lobes
Contusion/Laceration

22 male, MVA. Large contusions and lacerations on both sides.

Contusion vs. aspiration?

Aspiration:
- more central
- does not cross anatomic borders

- look for foreign bodies (teeth) in the bronchi!
Development of contusions in chest x-ray

22 year old female, MVA. Pulmonary contusions and serial rib fractures on the right.

4 hours later
Fracture detection

Conclusion:
“Using CPRs (curved planar reformats) for the detection of rib fractures accelerates the reading of trauma patient chest CTs, while offering an increased overall sensitivity compared to conventional standard MPRs.”

Screenshot of the unfolding software (A) showing the display configuration. Unfolded ribs (CPR) of a 48-year-old male patient with multiple rib fractures marked with white arrowheads.

23 year old female. Attempted suicide under influence of LSD, jumped from 7th floor balcony. Intraparenchymal liver laceration in the left lobe (arrow).

Cartilage fractures and an underlying liver injury.
23 year old female. Attempted suicide, jumped from the 7th floor. MRCP 6 weeks later.

Role of MRI in chest trauma
- chest wall
- lung injury volume?
Different modalities in chest trauma/ US

Role of ultrasound in chest trauma
- pneumothorax
- pleural effusions
- costal cartilage and rib fractures

52-year-old man, MVA. Midchondral fractures of the right 6th (B,D) and 7th (C,E) rib cartilage.

CT cor image (A)  
CT ax images (B,C)  
Ultrasound view of the same fractures (DE)
Thoracic injury vs. the time of surgery

Polytrauma - Bilateral Femur Fractures - Clearance for Nailing

Consider this patient as a patient at risk
Has the magnitude of chest injury been quantified?

Chest Injury present? Reach end points of resuscitation? High ISS >35

Yes No Yes No Yes No

Hemodynamically stable? ETC with ongoing evaluation DCO

Yes No No No

ETC with ongoing evaluation Prepare to change plan if deterioration

If the patient is hemodynamically unstable or has a substantial chest injury—i.e., if >25% of the lung is injured—damage control orthopaedics (DCO) should be performed.

DCO = damage control orthopedics
ETC = early total care

Mage of lung injury should be assessed in the radiology report

CT (or MRI) evaluation

Respiratory insufficiency/failure – A major cause for ICU bouncebacks

Bounceback = Unexpected readmission to intensive care unit (ICU)

Return transfer (RT) to the ICU negatively impacts
• patient outcomes
• length of stay (LOS)
• and hospital costs.

Respiratory insufficiency/failure (48%), cardiac (16%) and neurological (13%) events
Associated injuries: traumatic brain injuries (TBIs) (32%), rib fractures (30%), and pulmonary contusions (20%).

Trauma intensive care unit 'bouncebacks': identifying risk factors for unexpected return admission to the intensive care unit. Christmas, A et al. The American surgeon 2014; vol. 80 (8) p. 778-82
Key points/ chest trauma

- Respect the high trauma energy – maintain high level of suspicion

- Beware satisfaction of search – look for more lesions

- Rib cage = flexible ringlike structure

- Effect on respiratory function
  - flail chest segment
  - underlying lung injury
  - timeline of surgery in polytrauma

Check all views: AX / SAG / COR
CHEST WALL INJURIES  Literature


