Swedish Radiological Week, Norrköping, Sept 18, 2003

Trauma-CT
Part I
Why? How To?

Mats Beckman, Karolinska Sjukhuset, Bertil Leidner, Huddinge Universitetssjukhus
Bad organization
Random handling of patients
No ATLS
No trauma education
CT head, chest X-ray, US, plain films, angio?
Avoidable deaths
» TAI
Multiple Trauma

- Few trauma patients
- Limited personal experience
- Life threatening
- STRESS
- Systematic and structured approach clinically and radiologically

- Trauma CT
- Nordic Trauma Radiology Courses
Trauma

- Background facts
- Epidemiology
- Trauma Care – History
- Role of Trauma -CT
Trauma commonest cause of death for all young people

Young everyone age<45
Trauma causes

- Fall
- Traffic - MC, cycling
- Suicide
- Penetrating

11 September 2001

SAS Milano 011028
Trauma deaths equal

- Five (5) jumbojet crashes every year
- Traffic alone 2 jumbojets

- The number of severely injured amounts to many times the number of deaths.
Trauma cases admitted at KS 2000, n total 1184

- ISS>15: 209 (18%)
- 9<ISS<15: 328 (28%)
- Minor: 647
Causes of trauma KS 2000

- MVC: 41%
- Fall: 18%
- MC: 15%
- Ped: 12%
- Cycling: 5%
- Penetr: 3.1%
- Other: 6.9%
Statistics KS

- Ca. 90 % CT
- 76 % men
- 73% 15-54 YO
Axial tomography 1976
Helical Tomography 1992
In spiral with multi slice technique, MSCT 4-8-16 signals acquired simultaneously 1999

17 sek trunk examination
Multi-slice (detector)

- 4 channels = 8 x faster scanning compared to single detector spiral-CT

- 1990 non spiral – 5 images/minute
- 1992 spiral – 60 images/minute
- 4 channels – 500 images/minute
- 16 channels – 2400 images/minute
  – (x 0.75 mm + 0.42 sec rotation time)

- Speed ↑↑ + Accuracy ↑↑ improves trauma value
International acceptance

- Abdominal CT USA standard since late 1980’s; EAST Level 1 recommendation for blunt abdominal trauma
  - “physical examination inadequate”
- Trauma - CT concept implemented in
  - Denmark (Veile)
  - Finland (Tölöö, Helsinki)
  - Germany (München, Mainz)
Why CT?

Bleeding

- Pneumothorax
- Tamponade
- Haemothorax
- "Flail Chest"
- Aorta, TAI
- Trachea, bronchi
- Diaphragm
- Esofagus
- Lung contusion & laceration

Brain
Skull
Face
Ears

C-spine
T-L spine
Pelvis,
Shoulders
Hips
Spleen
Liver
Kidneys
Pancreas
Retroperitoneum
Bowel
Trauma CT

- Team work with many involved clinical specialties

- Trauma Radiology & Trauma CT
  - a vital link in chain of trauma care
Modern Trauma Management

- **ATLS - Advanced Trauma Life Support**
  - Systematic clinical examination/treatment
  - First survey - ABCDE – fast vital exam + treatment
  - Secondary survey from top-to-toe

- “Trauma – CT” becomes a systematic ATLS adjunct
  - (multislice)-CT used as a tertiary survey – from “top to toe”
  - Standardized procedure every time
    - Possible to train for techs
    - Fast
    - Minimizes possible omissions
What is a Trauma CT?

- “Whole body” examination
- head & c-spine
  - non-contrast
  - arms by body side
- thorax & abdomen/pelvis
  - arms above head
  - always intravenous contrast
- total time in practice
  - 5 min + 5 min pre-post exam patient handling table
  - 12 min exam
Huddinge Trauma CT Protocol

- **Head**
  - topogram head/c-spine 5 s
  - 4x2.5 mm scan 50 s

- **C-spine**
  - 4x1 mm scan 30 s

- **Thorax-abd**
  - topogram 10 s
  - 4x1mm, pitch 2 CM delay 50 s 40 s
  - renal topogram wait 70 s 10 s
## CT- Scanning Parameters

<table>
<thead>
<tr>
<th>Area</th>
<th>kVp</th>
<th>Eff mAs</th>
<th>Rot time</th>
<th>Pitch</th>
<th>Detector width</th>
<th>Slice width/incr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>120</td>
<td>300</td>
<td>1</td>
<td>0.65</td>
<td>4 x 2.5</td>
<td>5/5 mm</td>
</tr>
<tr>
<td>C-spine</td>
<td>140/120</td>
<td>120</td>
<td>0.75</td>
<td>1.5</td>
<td>4 x 1</td>
<td>1 /0.8</td>
</tr>
<tr>
<td>Thorax-abdomen</td>
<td>120</td>
<td>90</td>
<td>0.5</td>
<td>2</td>
<td>4 x 1</td>
<td>5/5</td>
</tr>
</tbody>
</table>
Why "Whole Body" CT?

- Choice:
  - Single area CT guided by clinical findings
  - Whole body CT
Head - normal clinical status

- **Brain**
  - Normal neuro status
  - GCS 15

- **Face**
  - 116 unconscious multitrauma patients without clinical fracture suspicion
  - routine CT
  - 27 fractures
  - 13 operated
Thorax - normal clinical status

- Thorax
  - small pneumothorax/
    hemothorax/
aortic injury
  » MVA
  » normal breath
    sounds (??!)
Abdomen - normal clinical status

- 15 year old MC driver
  - CGS 15
  - Skin bruise of thorax
  - Normal abdominal palpation

- 35 year old drug addict
  - Fall
  - Normal abdominal palpation
Pelvis - normal clinical status

- 35 year old drug addict
  - clinically stable pelvis

- Karolinska Hospital
  - 7/10 unstable pelvic fx
    - undiagnosed clinically
Why “Whole Body” CT?
Clinical status cannot rule out injury!

- C-spine – clinical injury exclusion needs
  » Alert patient, no drugs
  » No distracting painful injury in any other body part
- i.e. excludes injured multitrauma patients

- In high energy trauma not possible to clear spine, thorax, abdomen, aorta with only clinical examination
  » Multiple references
Whole Body CT - advantage

- Fast - the Golden Hour
- Whole body evaluation in one setting
- Evaluation of circulation
  - hypovolemia
  - active bleeding, pseudoaneurysms
  - multislice - angiographic evaluation
- High quality skeletal evaluation
- Intestinal injuries – 75-90% sensitivity
Whole Body CT - advantage

- Superior skeletal evaluation
  - Spine & pelvis
  - JTrauma aug 2003; Griffen/Hauser
    - Sensitivity fx
      - C-spine 2946 pat´s 60% 98%
      - T&L-spine 215 pat´s 58% 97%
  - Multi-slice excellent
  - Little role for plain films
Multiplanar evaluation
MIP - 4x1 mm - duodenal hematoma
Hypovolemic Shock

- Male 28 years old
- Steering wheel towards abdomen
- Hypovolemic Shock
  - Significant bleeding
  - Constriction of aorta
  - Low volume IVC
Save the mother – save the fetus
### Swedish Trauma Scene

<table>
<thead>
<tr>
<th>Hospital size</th>
<th>Trauma patients</th>
<th>Radiologist</th>
<th>Pat/rad.</th>
<th>25% severe injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>30</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Medium/Large</td>
<td>250</td>
<td>30</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Trauma center</td>
<td>1000</td>
<td>30</td>
<td>33</td>
<td>8</td>
</tr>
</tbody>
</table>

- Few severe cases per radiologist
- Clinical standardization – ATLS
- Radiological standard – Trauma CT
Problems in Trauma Radiology

- Untrained staff
- Untrained radiologist
- Unfamiliar diagnostics
- Need for standardization and joint training

- Cooperation & training with trauma team, OP & anestesiology.
- “Train the Trauma Chain”

→ Trauma CT
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Trauma-CT
Part II
Who to scan? - Indications

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Trauma alarm - Traumadefinition

- Physiological parameters
  - Breathing difficulties
  - BP fall
  - Lowered consciousness or spinal cord symptoms
Trauma alarm - Traumadefinition

- Physiological parameters
- Injury mechanisms
  - Car crash 50 / 70 km/
  - MC
  - Pedestrian/bicyclist
  - Fall from >3m
  - Compression of trunk
Trauma alarm - Traumadefinition

- **Physiological parameters**
- **Injury mechanisms**
- **Injury types**
  - Penetrating neck & torso
  - Pelvic fractures
  - Paralyses
  - Amputations
  - Trauma and
    - Burn
    - Cooling
    - Drowning
  - Flail Chest
Who to scan?

- Selection difficult because of limited value of clinical examination
- Selection hampered by
  - costs in money and radiation dose
  - limited number of observation beds.
Case A

- Male age ca 35
- Fall 3 meter
- Subjective pain upper thoracic spine
- No pain on examination

- Next step?
Case A
Case B

- Male age 43
- Fall 6 meters
- Admitted on spineboard
- toe pain
- On examination foot pain, no back pain
Case C

- Male age 75
- Fall on staircase unclear length
- Back pain
- Admitted as trauma 3- apparently uninjured
- 1st examination CR TH-L- spine is normal
Case C

- CT head normal
- CT C-spine normal but incidental finding
Case C

- CT head normal
- CT C-spine normal but incidental finding
Case D

- 12 year old girl
  - Fall from 1.5 m tree
  - Back pain
Case D

- 12 year old girl
  - Fall from 1.5 m tree
  - Back pain
Trauma CT in practice - Uppsala WBCT-results

- Siemens Somatom Plus/Plus 4
- 304 patients (mid-1990)
- Pos CT = significant injury =
  - 118 patients - 39%
  - 195 injuries
Trauma CT in practice - Uppsala WBCT-results

- Siemens Somatom Plus/Plus 4
- 304 patients (mid-1990)
- Pos CT = significant injury =
  - 118 patients - 39%
  - 195 injuries
- 47% not suspected clinically
- 10% in patients with clinically NO injury
How do we select patients to Trauma CT?

- Huddinge University Hospital
  - Active participation in trauma room
  - Trauma surgeon in CT suite
  - Stepdown
  - Trauma team training

- Karolinska Sjukhuset
  - Central Trauma Room
  - Level 1,2,3
The Trauma Team

- Anesthesiologist
- Anesthetic nurse
- Radiologist
- Radiology Nurse
- General Surgeon
- ER Nurse
- Trauma leader
- Orthopedic Surgeon
- Operation Nurse
- OR Nurse Assistants

Trauma Bay area

Prehospital Staff
Trauma care education

- multidisciplinary involvement
- all staff involved in trauma trained
- mortality/problem conferences
Inclusion criteria - discussion

- Cirkulatory stable
- By trauma mechanism
- By vital & clinical signs
Trauma mechanism analysis

- Major trauma mechanism
  - Focal or general trauma
    - Hit by bat once vs fall from height
    - Body parts at risk? – no head/c-spine? No thorax-abd??
    - Unknown
  - How great was the violence?
    - 90 or 50 km/hour?
    - Vehicle intrusion? – crash pictures
  - Body protection
    - Vehicle? Seatbelt? Airbag?
    - Beware of the Unprotected body!
Clinical signs ➔ CT

- Decreased level of consciousness
- Non-reliable patient
  » Alcohol, drugs, language, culture
- Respiratory distress
- Circulatory distress
- Overt signs of injury
Step-down → clinical observation

- Limited violence by analysis
- Reliable patient
- No clinical signs of injury?
- When in doubt – take the patient to the CT
- Remember – the patient’s life could be in immediate danger
The price:
Dose & Cancer Induction

- **Dose (HS)**
  - Head: 2.0 mSv
  - C-spine: 3.5 mSv
  - Body: 9.0 mSv
- **Total dose**: ~14.5 mSv
- **KS**: 13 mSv
- **5 cancers/100 Sv → 0.00075 cancers/15 mSv**
  - 1 lifetime deadly cancer per 1333 patients
  - 266 spontaneous cancers per 1333 patients

- **HS 250 / KS 1000 Trauma CT/year**
Dose

- **CT Dose**
  - head: 2.0 mSv
  - c-spine: 3.5 mSv
  - body: 9.0 mSv
  - Total dose: ~14.5 mSv

- **4-6 years Swedish background radiation**

- **CT + US + Convent. X-rays**
  - Head (CT): 2.0 mSv
  - C-spine: 0.5 mSv
  - Chest: 0.02 mSv
  - T+L-spine: 2.0 mSv
  - Pelvis: 0.7 mSv
  - US: 0.0 mSv
  - Angio 10% x 5: 0.5 mSv
  - Total dose: ~5.7 mSv

- Incomplete abdominal exam – US << CT
- Substandard spine evaluation
Additional benefits:
Incidental findings at trauma CT

- Tumors 2-6/1000
  - kidney
  - lung
  - liver
  - skeletal metastases
  - lymphoma

- Non-cancers
  - Aneurysm (cerebral, abdominal)
  - Fatty liver, Teeth infections
  - Calculi - gallstones, kidneystones
  - Myoma, lung granulomas
Conclusions

- High energy impact causes injuries
- Clinical evaluation is not enough
- CT is the radiological method of choice
- Need to limit unnecessary examinations
  - Cost
  - Radiation
Conclusions - recommendations

- **Trauma patients – high risk**
- **Intimate cooperation**
  - The radiologist in the trauma room
  - The surgeon in the CT-suite
- **Recognize the risk patient**
  - Trauma mechanism
  - How great was the force?
  - Beware: *unprotected body*
  - Deranged physiology (i.e., tachycardia)
- **Clinical step-down**
- **Whole Body Trauma CT should be used for general trauma patients.**
- **With ”focal trauma mechanism”**
  - Scanning alternatives
    - Whole body
    - Head + c-spine
    - Thorax + abdomen
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Trauma-CT
Part III
Discussion

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What about ultrasound?

- Ultrasound not for diagnosing organ injury
- Helpful to select patients for immediate intervention - splenectomy, Būlau.
- Only use if CT is scheduled soon
- Trust result ca 10 min
The role of US

- For the circulatory unstable patient, fast.
- Fluid detection – where does the patient bleed?
  » Abdomen, pelvis, pleural cavities, pericardium

- NO place in acute organ injury diagnosis
- Misses 30% of known injuries even with contrast enhancement
- Cannot exclude serious abdominal injuries
  » which exists without hemoperitoneum in 30%
- Mobile (CT is “not”
Save the mother – save the fetus
Pelvimetry &cancer

- 25344 pelvimetries
- identical controls
- foetal marrow dose ca 1 mSv
- 42 cancers in study group, 41 in control group
  - Beckman et al unp.
The Trauma Care Chain
"Missed patients"

- No trauma alarm
  - By "own" car
- Bypassed trauma room
  - Fall from ladder – back pain – to orthopedics
  - Fall – ear bleed - ENT
  - Pregnant patients – Gynecology
- Incomplete trauma mechanism analysis
  - Fall from low height to hard pointed objects
Trauma CT- limitation

» Motion and metal artifacts
» A snapshot in time!!!!
  – the information is true for the time of scanning
  – Do rescan on clinical deterioration
» Timing of scanning – iv.-contrast, oral contrast
» Difficult diagnosis - GI-injuries, pancreas
» 1500 images –
  – SOS – Satisfaction Of Search
» Reader knowledge
» Patient transfer problems

● Need for standardization