Spinal Cord Injury: Pathophysiology and Acute Management

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Historical Perspective

• 2500BC   Egypt
  - Traumatic tetraplegia
  “an ailment not to be treated”

• WW1   90% dead < 1 yr post ASCI

• 1944 Sir Ludwig Guttmann
Epidemiology

- Incidence: Worldwide
  11 - 112 per 1,000,000
  Blummer Neuroepidemiology 1995

- Age: Mean 33yrs
  72% < 40yrs

- Sex: M - F 3 - 1
  Karamehmetoglu Paraplegia 1995
Injury Level

- Cervical 49%
- Thoracic 27.5%
- Lumbar 23.5%

Silberstein *Paraplegia* 1995
Epidemiology

- 5% ASCI in Children / Youth
  - 29% 0 - 12 yrs
  - 71% 13 - 15 yrs

- Mode level of bony injury
  - C2 0 - 12 yrs
  - C4 13 - 15 yrs
  - C4 - C5 > 15 yrs

Apple *Clinical Paediatrics* 1995
Aetiology

• Trauma
  - Non-Penetrating
  - Penetrating

• High Energy
  except with:
  - Osteoporosis
  - Tumour
  - Infection

• Vascular
  - Artery of Adamkiewicz

• Iatrogenic
Aetiology

- Salisbury 1993 - 95

- RTA 36%
- Falls 37%
- Sport 20.5%
- Criminal/Self Harm 6.5%
Geography

- Michigan

RTA   40%
Falls 20%
Bullets 13.6%

Burney *Archives of Surgery* 1993
Geography

- Amman
  - RTA: 46%
  - Bullets: 25%
  - Falls: 21%

Otom *Spinal Cord* 1997
Aetiology in Atlanta

- Violent:

  - 0 - 12 yrs: 19%
  - African - American: 28%
  - Adults: 12%
  - Caucasians: 7%

Apple  *Clinical Paediatrics*  1995
Cord Injury

- Primary
  - Initial - Mechanical Force
    - Axonal injury
    - Vascular injury
    - Biochemical injury

- Secondary

  Tator 1979
Vascular mechanisms

Tator  *Journal of Neurosurgery*  1997

- Histology in 9 ASCI autopsy cases
- Death 20 mins - 9 months post ASCI

- Centrifugal sulcal arterial system
- Pial arteries
- Anterior and Post. Spinal arteries
Histology: Acute

• Severe haemorrhages
  Grey matter
  > white matter

• White matter
  - decreased staining
  - disrupted myelin
  - axonal and periaxonal swelling
Histology: Acute

- Lesions extend far from injury
  - Proximally + distally

- No complete large vessel occlusion

- Occluded intramedullary veins in posterior white matter
Histology: Chronic

• Injured segment
  - major tissue loss with cavitation
  - origin syringomyelia

• Remote from injury site
  - necrotic areas
  - ? infarction of posterior columns
Conclusions

- Small artery / vein occlusion by primary or secondary insult
  - white matter lesions

- Ant. sulcal artery damage
  - haemorrhagic necrosis and central myelomalacia
Biochemistry

- Raised intracellular Ca++
- Activation PLA2
- Release AA
- Formation - PGE2 / PGE2 alpha
  - TXA2
  - TXB2
  - LTC4
  - 6 keto PGF1
Biochemistry

- Secondary processes
  - Ischaemia
  - Hypoxia
  - Oedema
  - Influx PMNL / Microglia

Hall *J Neurotrauma* 1995
Nishosko *Neurosurgery* 1996

- Lipid peroxidation / hydrolysis
Neurology

- Complete or Incomplete
- Frankel classification
- Level of injury

- Spinal shock - hrs / wks
- Neurogenic shock
- Autonomic dysreflexia
Incomplete

- Sacral sparing
- Anal reflex
- Bulbocavernosus reflex

- Not always reliable indicators
- Conus / Cauda lesions - no return
Central Cord

- Older pts - spondylosis
- Hyperextension
- Disc / lig. flavum
- LMN arms > UMN legs
Anterior Cord

- Flex / rotation
- Ant. Spinal artery
- Power loss legs > arms
- Decreased pain + temp.
Posterior Cord

- Hyperextension
- Posterior Columns
- Loss proprioception
- Pain / temp. sparing
- Ataxia
Brown - Sequard

- Stab injuries
- Ipsilateral power loss + proprioception
- Contralateral pain + temp.
- Crossed spinothalamic tracts
Priorities

• Life - threatening injuries
• Minimise secondary damage
  - cannot reverse primary insult
• Stabilise
• Transfer to spinal centre
Management

- First aid
  - Suspect / recognise ASCI
- Evacuation
  - Spinal immobilisation
  - Temp. control
- Initial management at receiving hospital
  - ATLS protocol
Diagnosis ASCI

- RTA / Fall - 5 - 10% risk C-spine #
- Head injury
- Alcohol
- Drugs
- Concious / unconscious
Suspect ASCI

- Flaccid arreflexia
- Diaphragmatic breathing
- Flex elbows but not extend
- Grimaces to pain only above clavicle
- Hypotension with bradycardia
- Priapism
- Spinal deformity / increased gap
Associated injuries

- 80% Multiple injuries
  - 52% c-spine
  - 19.8% mortality
- 20% Isolated
  - 65% c-spine
  - 6.9% mortality

Burney *Archives of Surg.* 1993
Missed injuries

- Loss of sensation
- Abdo - T7 or higher
Chest

- Intercostal paralysis
- Phrenic n. palsy
- Unable to expectorate
- VQ mismatch
- Assoc. chest injuries
<table>
<thead>
<tr>
<th>Level</th>
<th>No.</th>
<th>Complications</th>
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<tbody>
<tr>
<td>C1 - C4</td>
<td>22%</td>
<td>84%</td>
</tr>
<tr>
<td>C5 - C8</td>
<td>47%</td>
<td>60%</td>
</tr>
<tr>
<td>T1 - T12</td>
<td>31%</td>
<td>65%</td>
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</tbody>
</table>

CVS

- Neurogenic shock
- Hypovolaemic shock
- Invasive CVS monitoring
  - minimise secondary insult
  - consider early surgery

Levi Neurosurgery 1993
Documentation

• Neurological deficit
  - Paramedics
  - On pt. arrival
  - Subsequent course
Imaging

- Trauma series
- Thoraco - lumbar spine
- complete C - spine
- Multi level injuries 10 - 20%
- CT
- MR
Vertebral column

- Stable / Undisplaced
- Unstable / Undisplaced
- Displaced

- Hard collar + Sand bags + Tape
- Skeletal Traction
  - Halo
  - Gardner-Wells tongs
Steroids

- Reverse intracellular Ca++ flow
- Inhibit PLA2
- Retard secondary neuronal degeneration
- Suppress lipid peroxidation and hydrolysis

Hall *Cellular and molecular Neurology* 1993
Steroids

- 1st used 1960’s
- NASCIS 1975
- NASCIS 2 1990
- 1992
- 1994 Japan
- NASCIS 3 1997
NASCIS 3

Bracken  JAMA  1997

- MP  24 hr protocol
  bolus 30mg/kg
  infusion  5.4 mg/kg/hr
- MP  48 hr protocol
- Tirilizad Mesylate
Results

- MP 24hrs = Tirilazad
- MP 48hr protocol
  - improved motor recovery
  - 6/52 and 6/12 if started 3 - 8 hrs post injury

but increased severe sepsis and pneumonia
Conclusions

• < 3hrs post injury
  24hr MP protocol

• 3 - 8 hrs
  48hr MP protocol
Penetrating ASCI

- MP
- No significant benefit
- No increase in complications

Levy  Neurosurgery  1996
Early Surgery

- Communication with Spinal Unit
- Reduction
- Decompression
- Stabilisation
- Associated injuries
- Penetrating injuries
Early Surgery

- 175 / 255 pts
- 51.4% < 24hrs
- 10.5% > 2/52
- 45.2% reoperations
- Neurologic improvement in 50% - all initially incomplete lesions

Botel *Spinal Cord* 1997
Missile Injuries

- Conservative - 55% improvement
- Surgery - No better
- Complications
  - CSF fistula  76%
  - Meningitis   87%
  - Local sepsis 67%

Aarabi  Neurosurgery  1996
Thromboprophylaxis

- DVT 49 - 100%
  - Stasis
  - Hypercoagulability
- PE major cause death
- LMWH 8 - 12/52

GI Tract

- Paralytic ileus
- Distended abdo.
- PU
  - IV fluids
  - NG tube
  - IV H2 antag.
Early care

- Skin
  - pressure sores

- Bladder
  - Avoid distension
The Future?

- MP decreases BDNF + NT3 mRNA
- alpha MSH
- TGF beta antagonists

- Spinal cord repair
  - Swedish
  - Miami
Conclusion

“Numerous drug treatments are proposed which will never take the place of immediate resusitation care and cord decompression.”

Pointillart  Cahier’s  d’Anaesthesiologie  1994