Pelvic Fractures in Children

Ng BKW
*Division of Paediatric Orthopaedics, Department of Orthopaedics & Traumatology, Prince of Wales Hospital, Chinese University of Hong Kong, Shatin, Hong Kong.
Epidemiology of Children Fractures

- 1 Distal radius fracture 20.2%
- 2 Supracondylar humeral 17.9%
- 3 Forearm shaft 14.9%
- 4 Tibial Shaft 11.9%
- 5 Fingers & hand 4.9%
- 6 Lateral condyle 4.8%
- 7 Femoral shaft 4.6%
- 8 Ankle 3.1%
- 9 Proximal radius (head & neck) 2.9%
- 10 Humeral shaft 2.8%
- 11 Medial Condyle humeral 2.5%
- 12 Olecranon 1.7%
- 13 Distal radius epiphyseal 1.7%
- 14 Elbow dislocation 0.8%
- 15 Rarities 5.4%

Pelvic Fractures in Children

• Very rare in children 0.5-7% level I trauma centres


• Risk factors are MVA, pedestrian or occupant, fall from height, severe crush

  Bucholz AR, Ezaki M, Ogden JA. JBJS A 1982;64:600-9

• High risks of severe haemorrhage and mortality rate - 42% of trauma related deaths in children

Outcome of severe paediatric pelvic fractures

- 30% of survived children have residual pain, limp or scoliosis
  
  Bucholz AR, Ezaki M, Ogden JA. JBJS A 1982;64:600-9

- Malunion may cause sexual disability particularly in female
  
  Bucholz AR, Ezaki M, Ogden JA. JBJS A 1982;64:600-9
Morbid complications

- Life threatening persistent arterial bleeding is usually associated with unstable Pelvic fractures
  
  *Lopez PP J of Trauma, Injury, Infection and Critical Care*

- Even clinically stable fracture has a bleeding risk

- Exercise Low threshold for angiography & embolisation
Special Anatomies

- Bones are less brittle, periosteum thick, ligaments strong, presence of growth centres, pelvic volume relatively shallow
- Leads to injuries of pelvic viscera without obvious fracture

Many Classifications

- **Quinby**: +/- Laparotomy +/- Vascular injury
- **Watts, Torode & Zieg**: Avulsion, Pelvic ring, and acetabular fractures
- **Key and Conwell’s** comprehensive
- **Young- Burgess** most important
- **Tile(AO)**: A >90% of cases, increasing unstable or acetabular fractures are associated with long term morbidity
- **Letournel** acetabular fractures should be separated from pelvis fractures
# Young & Burgess Classification

Based on 142 fractures, force application, 4 types of Force Patterns

<table>
<thead>
<tr>
<th>I AP Compression Fractures 15%</th>
<th>II Lateral Compression Fractures 57%</th>
<th>III Vertical shear Fractures 6%</th>
<th>IV Complex pattern Fractures (22%)</th>
</tr>
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<tbody>
<tr>
<td>APC 1 no posterior instability</td>
<td>LC1 posterior little/no instability</td>
<td>VS1 unilateral</td>
<td>LC + APC 19/21</td>
</tr>
<tr>
<td>APC 2 some posterior instability</td>
<td>LC 2 anterior some posterior instability</td>
<td>VS 2 bilateral</td>
<td>LC + VS 2/21</td>
</tr>
<tr>
<td>APC 3 Total disruption of SIJ</td>
<td>LC3 anterior disruption of ipsi- and contralateral SIJ SS ST Lig</td>
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AP Compression 15%

- AP compression (15%), external rotation force on hemipelvis
- Typically Symphsis diastasis, Open book or Sprung pelvis, vertical pubic fractures
  - APC 1- no posterior instability (5/22)
  - APC 2- symphysis diastasis + some posterior instability (10/22)
  - APC 3- Total disruption of SIJ (7/22)
• Don’t be misled by the subtlety of the fracture stability is determined by ligaments.
Lateral Compression (57%)

Type 1
Posterior

Type 2
Anterior
Stage I

Type 3
Anterior
Stage II
Type 1 LC

- Important features
- Intact posterior elements
- Horizontal & Coronal # lines
- No volume reduction
Vertical Shear - Unstable 6%
Vertical Shear
Complex Pattern(22%) - LC + VS
Key and Conwell’s

- I Fractures without a break in the continuity of pelvic ring
  - A Avulsion fractures
    - 1 ASIS
    - 2 AIIS
    - 3 Ischial tuberosity
  - B Fractures of the pubis or ischium
  - C Fractures of the wing of the ilium
  - D Fractures of the sacrum or coccyx
- II Single break in the pelvic ring
  - A Fractures of two ipsilateral rami
  - B Fracture near or subluxation of symphysis pubis
  - C Fracture near or subluxation of sacro-iliac joint
- III Double break in the pelvic ring
  - A Double vertical fractures or dislocation of pubis (Straddle fractures)
  - B Double vertical fractures or dislocation (Malgaigne)
  - C Severe multiple fractures
- IV Fractures of acetabulum
  - A Small fragment associated with dislocation of the hip
  - B Linear fracture associated with non-displaced pelvic fracture
  - C Linear fracture associated with hip joint instability
  - D Fracture secondary to central dislocation of the acetabulum
Avulsion Fractures

- ASIS Sartorius, AIIS Rectus femoris, Ischial tuberosity - Hamstrings ST/SM/BF
- Mostly athletic injuries
  - Football, jumping, great exertional activities
- Diagnosis: not difficult, local swelling, X-rays shows avulsion fragments
- Treatment conservative
  - Rest and weight relief with crutches
- Complications
  - Excessive callus formation in Ischial tuberosity fracture may require excision
Fractures of Pubis or Ischium

- Constitute 33-69% of pelvic fractures
- In contrast to adult (Low energy osteoporotic), pubic ramus fractures in children are caused by high energy-MVA fall from height
- Associated injuries, HI, Long bone fractures, visceral injuries
- Should be undisplaced if not look for other fractures with special views or CT
- Treatment of uncomplicated fracture is straightforward
Stress fractures

- Can occur in adolescent and young adult
- Repetitive stress to bone from riding
- X-rays may show faint callus formation
- Fusion of ischiopublic synchondrosis can be mistaken as fracture
- Assessment with bone scan if necessary
- Treatment is reduction of the causative activities
Wing fractures (Duverney 1751)

- 12% of pelvic fractures
- Direct trauma
- Can be associated with other injuries HI, fractures pelvis elsewhere, long bone, spine, ruptured spleen small bowel
- Management hinges on excluding major associated injuries as above
- Treatment simple for uncomplicated fractures
Sacrum & Coccyx

- 5-10% of pelvic fractures
- Can be overlooked due to poor visualisation
- May cause sacral roots injury and sphincter function impairment - has not been reported in literature
- PR is important assessment
- CT scan is important for assessment
- Coccygeal fractures are self limiting
Single Breaks in Pelvic Ring

- Ipsilateral double pubic rami fractures
- Fracture near or Symphysis pubis subluxation
- Fracture Near or Sacroiliac subluxation
- By definition stable
- Importance to rule out associated fractures and visceral injuries- abdominal and chest
- Treatment is conservative and result good
Symphysis Pubis fracture

- Isolated injury is rare often associated with disruption of posterior structures SIJ
- Exquisite pain anterioly, Fabere sign positive
- X-rays- Widening symphysis, Open book
- Treatment is conservative – bed rest, pelvic sling, spica cast
Sacro-iliac joint fractures

- Isolated injury extremely rare
- Must exclude associated fractures
- Should be suspected in high velocity injuries
- Fabere sign is positive on ipsilateral side
- CT scan remained most useful investigation
- Treatment: Skeletal traction three weeks, single hip spica cast
Double Breaks in Pelvic Ring

- Straddle – bilateral pubic rami fractures floating anterior arch
- Associated with bladder or urethral disruption (7-20%)
- Peltier “Most dangerous of all pelvic fracture”
- Displacement proximal from rectus pull
- Treatment is bed rest with flexed hip to relax abdominals 4-6 weeks
Malgaigne Fractures 1859

- Double vertical breaks in anterior and posterior ring
- Vertical hemipelvis instability
- 8-30% of pelvic fractures
- **3 Mechanisms: AP, Lateral and Axial compression forces**
- Associated injuries common
- LLD and pelvic asymmetry
- CT scan is best assessment
Malgaigne Fracture Treatment

- Bed rest - three months
- Skeletal or skin traction
- Pelvic sling +/- skeletal traction
- Turnbuckle cast
- Close manipulation and spica cast
- Close reduction and external fixation
- ORIF
Treatment Principles

• Children are different from adult, good or excellent results reported in 20 unstable fractures treated conservatively despite radiological deformity

• Ex fix or ORIF if conservative treatment fails

• Surgical complications are catastrophic, pelvic fractures in children should not be undertaken casually by inexperienced surgeons
Modern Perspectives

- Severely displaced and unstable fractures occurs in children older than 8-10 or adolescents, adult treatment methods should be followed

- Indications for ORIF and CREF
  - Failure to obtain acceptable reduction with traction
  - markly displaced and unstable fractures
Severe Multiple Fractures

• Rare
• Difficult to classify
• Associated with insult incompatible with survival – e.g. crushed by vehicle
• Massive haemorrhage and vascular injury are common
Acetabular Fractures

- 5-10% of pelvic fractures
  
  Hall BB, Klassen RA, Ilstrup DM. Unpublished  

- Fracture Classification
  
  - 1 small fragments associated with dislocation
  - 2 Linear undisplaced
  - 3 Linear with hip instability
  - 4 Central dislocation

Treatment of acetabular Fractures

- Principle same as in adults – obtain congruity
- Rim fragments (usually posterior) with dislocation should be fixed after OR
- Little information on treatment for Complex fractures and central dislocation Axial or Lateral Traction recommended
- Open reduction reports poor results- AVN, heterotopic ossification
Initial Assessment

• ATLS – ABCDE
• ABC for vitals, vascular access, resuscitations
• D concerns with neurological or vascular deficits
• E Exposure examination extremities - most important - pelvic stability assessment
• Radiological assessments: trauma series of C-spine, CXR, AXR & suspected long bones fractures & Dislocation
Fracture analysis

Plain X-rays

Pelvic fractures:
  AP, Inlet and Outlet

Acetabular fractures:
  AP, Iliac and Obturator obliques

CT with Pacs system probable replaces all of the above examinations for proven pelvic ring fractures
Local experience

• Simple avulsion fractures are frequently seen and are not problematic
• Major pelvic fractures are seen only once very few years
• We had 5 haemodynamically unstable pelvic fractures over 15 years- 4 MVA 1 fall from height
Outcome of HUPF

- One transferred from another hospital after laparotomy and died at A&E from uncontrolled bleeding
- One treated conservatively after resuscitation
- One associated with vascular injuries required multiple operations and iliac vessel repair
- One required multiple embolisation for uncontrolled haemorrhage
- One require Ext fix and other limp fracture fixations
M/12 Fell from roof top

- Loss of consciousness 1-2 minutes, abdominal, back and wrist pain
- AED BP 118/62, Pulse 134, RR18, GCS15/15
- ISS 36 PS 0.947(0.003 mortality)
- Blood test at AED showed:
  - Hb10.9g/dl, Platelet 294 x10⁹/l, WC 20.7 x10⁹/l.
CXR extensive opacification of both lung fields more on the right

# right base Inferior pubis and at junction of ischium Diastasis

CXR extensive opacification of both lung fields more on the right
CT Chest showing right lung contusion

# distal left radius
Standard pelvic views excluded major pelvic acetabular disruption
CT sacral fracture retroperitoneal haematoma pushing bladder flattening it on the right
Treatment & Progress

• Admission to ICU due to lung contusion and potential haemorrhage
• BP remained stable with persistent tachycardia
• Return to ward 18 hours after injury
• Developed nausea, coffee ground vomiting and abdominal discomfort
• BP remained stable, tachycardia 110-120
• Haemoglobin dropped to 6.4g/dl Platelet to 123 x10^9/l, coagulation profiles normal
• Abdominal distension and difficulty with breathing
Abdomen Workup and transfusion

- Abdomen distended and tender all round
- Per rectum examination no malaena
- 2 units of pack cells and 4 units each of platelets and FFP to optimise coagulation
- Pelvic arterial Haemorrhage (PAH) was therefore suspected
- Angiography arranged for unexplained haemorrhage
Abdominal distension & Swollen right leg twice size of left
Right internal iliac canulation 4 vascular blushes posterior division

Aortogram after selective embolisation, No vascular blushes

selectively embolised with gel foam slurry injections
2\textsuperscript{nd} Aortogram proximal injection showing new bleeding sites

After 2\textsuperscript{nd} selective embolisation still one distal site blush could not be controlled after few attempts flow slowed down

4 hours after 1\textsuperscript{st} angiography and embolisation repeated blood tests showed haemoglobin at 7g/dl and platelet 110, INR 1.11.
Progress

- Further blood and platelets transfusions were given but the haemoglobin level remained same. He started to desaturate SaO2 93% on 6 litres of O2 and dyspnoea and was readmitted to ICU.
- He was intubated and ventilated
- 3rd Angiography arranged
3rd angiogram bleeding from all sites of the posterior division again

After Non selective embolisation all sites stopped blushing
After Non-selective Embolisation

- Heart rate had for first time reduced below 100 after 2 hours
- Blood pressure rose to above 130 mmHg
- Ventilated four more days for ARDS.
- Extubated when CXR showed lungs clear
- Rapid recovery and no treatment required for pelvis fracture
• Persistent Tachycardia

Embolisation

BP maintained

HR 110

140mmhg

70mmhg
Clotting profile and angiography

First angiogram
second angiogram
Third angiogram

Day since admission
Time (sec)
PT, INR APTT
Platelet change and angiography
Haemoglobin change vs angiography vs Transfusion

HB changes during admission

First angiogram
second angiogram
Third angiogram

Multiple transfusions 6 packed cells, 12 Platelets 4 FFP
Serial CXR demonstrating ARDS & Clearing of the chest post angiographic embolisation and extubation at 5.5D
X-rays showing healing of pelvic fracture
Pelvic haemorrhage associated with pelvic fracture has a mortality rate of up to 20%.\textsuperscript{1}

The rarer source of arterial bleeding of 10% as compare to venous 90% is more frequently associated with haemodynamic instability.\textsuperscript{2}

More often the arterial disruption occurs in the hypogastric branches and surgical control often fails due to its deep inaccessibility.\textsuperscript{3,4}

Pelvic angiography has become a gold standard in the diagnosis and treatment of pelvic arterial haemorrhage.\textsuperscript{4,5}
Potential sites of avulsion and bleeding from both anterior and posterior divisions of Internal Iliac
Discussion 2

- Recurrent pelvic arterial haemorrhage after initial successful control is rare (7.5%) but a well recognised entity.\(^6\)
- External fixation for bleeding control were not used in this case as there was no unstable fracture.
- The symphysis pubis diastasis was not expected to cause large area of cancellous bone surface for bleeding.
• The placement of external fixation pins may lead to troublesome pin site bleeding if there were uncontrollable pelvic bleeding.

• The diastasis had been listed as one of the risk factors associated with pelvic arterial haemorrhage due to its close relationship with the umbilical artery and the hypogastric system. This may possibly allow postulation of traction injury.
Discussion 4

• The recurrent bleeding from new or previous embolised sites as reported by Gourlay etal were well illustrated in this case.
• Proximal non-selective embolisation seemed to be the treatment of choice to reduce repeat angiography.
• The coagulation profile had never been dearranged indicating pelvic bleeding could not be controlled with pharmacological agents alone.
Conclusion

- Life threatening Pelvic Arterial Haemorrhage (PAH) can occur in stable pelvic fracture in children
- The presentation can be erroneous and deceptive
- Unexplained persistent tachycardia is an important indicator of persistent bleeding
- Regular haemoglobin Q6 hours in the first 24 hours is useful to allow early detection of PAH and intervention
- Early angiogram and embolisation remains the Gold Standard in the management of this life threatening condition
- Recurrent bleeding either from new or embolised sites can occur.
- There is merit in non-selective slurry embolisation which may reduce the need for repeated procedures
Best external fixation is Slatis and Karaharju Trapezoidal frame 5mm pins
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