OBJECTIVES

The following are the most commonly tested Pediatric Orthopedic topics
Key words are still key....

We will cover trauma, deformity, and developmental issues
FGFR-3?
ACHONDROPLASIA

The most common skeletal dysplasia

Mutation affects a single protein in fibroblast growth factor receptor-3 (FGFR-3) gene, changing glycine to arginine at position 380.

Result is growth retardation of the proliferative zone of the growth plate, resulting in short limbs.

The growth plates with the most growth (proximal humerus/distal femur) are most affected, resulting in rhizomelic (proximal more than distal) short stature.

Extremities

- trident hands (inability to approximate extended middle and ring finger)
- bowed legs
- radial head subluxation
- muscular hypotonia

Spine

- thoracolumbar kyphosis- often resolves by walking age
- short pedicles and decreased interpedicular distance from L1-S1
COMP?
PSEUDOACHONDROPLASIA

- Short-limbed rhizomelic dwarfism with normal facial features
- Autosomal dominant
- Mutation is in cartilage oligomeric matrix protein (COMP) on chromosome 19.
- Epiphyses are delayed and abnormal, metaphyseal flaring is present, and early onset osteoarthritis (OA) is common.
SULFATE TRANSPORT GENE???
DIASTROPHIC DYSPLASIA

- AUTOSOMAL RECESSIVE
- MUTATION IN SULFATE TRANSPORT PROTEIN THAT PRIMARILY AFFECTS CARTILAGE MATRIX.
DIASTROPHIC DYSPLASIA

- PHYSICAL EXAM AND SYNDROME FEATURES
  - SHORT STATURE ("TWISTED DWARF")
  - RHIZOMELIC SHORTENING
  - CLEFT PALATE (60%)
  - CAULIFLOWER EARS (80%)
  - HITCHHIKERS THUMB
  - POORLY DEVELOPED UE
  - THORACOLUMBAR SCOLIOSIS
  - SEVERE CERVICAL KYPHOSIS
CBFA-1 / RUNX2???
CLEIDOCRANIAL DYSPLASIA

- Skeletal dysplasia affecting bones formed by intramembranous ossification
- Disproportionate dwarfism
- Autosomal dominant
- Runx2/Cbfa1 mutation
- Associations
  - clavicle dysplasia/aplasia
  - Wormian bones
  - Frontal bossing
  - Delayed fontanelle ossification
  - Coxa vara
  - Shortened middle phalanges of 3-5 fingers
  - Delayed ossification of pubis
TYPE X COLLAGEN MUTATION IN COL10A1 GENE??
METAPHYSEAL DYSPLASIA: SCHMID TYPE

• AUTOSOMAL DOMINANT
• AFFECTS PROLIFERATIVE/HYPERTROPHIC ZONES
• MILD VERSION
• COXA VARA, GENU VARUM
MUTATION IN PARATHYROID HORMONE RECEPTOR?
METAPHYSEAL DYPLASIA: JANSSEN TYPE

- AUTOSOMAL DOMINANT
- AFFECTS PROLIFERATIVE/HYPERTROPHIC ZONES
- WIDE EYES
- SQUATTING STANCE
- HYPERCALCEMIA
- BULBOUS METAPHYSEAL EXPANSION OF LONG BONES
- EXTREMITY MALALIGNMENT
ALPHA-L-IDURONIDASE DEFICIENCY??
ACCUMULATION OF DERMATIN SULFATE??
HURLER SYNDROME

- PROPORTIONATE DWARFISM
- PROGRESSIVE MENTAL RETARDATION
- CLOUDY CORNEAS
- GENU VALGUM
- C1-C2 INSTABILITY (25%)
- CARPAL TUNNEL SYNDROME AND FINGER TRIGGERING
SULPHO-IDURONATE-SULPHATASE DEFICIENCY?
HUNTER SYNDROME

- Mental retardation
- Proportionate dwarfism
- Clear cornea
GALACTOSAMINE-6-SULFATE-SULPHATASE DEFICIENCY?
MORQUIO SYNDROME

- PROPORTIONATE DWARFISM
- NORMAL INTELLIGENCE
- WADDLING GAIT
- GENU VALGUM
- THORACIC KYPHOSIS
- CORNEAL CLOUDING
CHARCOT MARIE TOOTH DISEASE

► DIAGNOSIS
  • MOST RELIABLY MADE BY DNA TESTING
  • DUPLICATION OF PORTION OF CHROMOSOME 17

► PE
  • RIGID CAVOVARUS FOOT WITH HAMMER TOES
  • EDB, EHB ATROPHY
  • CALF ATROPHY
  • WEAK DORSIFLEXION, EVERSION
  • AREFLEXIA IN LOWER LIMB
  • COLEMAN BLOCK TEST TO EVALUATE HINDFOOT
  • CHECK FOR SCOLIOSIS
FRATAxin??
The most common form of spinocerebellar degenerative diseases

Characterized by lesions in the:

- dorsal root ganglia
- corticospinal tracts
- dentate nuclei in the cerebellum
- sensory peripheral nerves
The FA mutation is GAA repeats in 9q13, causing a lack of the frataxin protein.

The age of onset of the disease is related to the number of GAA repeats.
FRIEDREICH’S ATAXIA

► EMG
  • REVEALS INCREASED POLYPHASIC POTENTIALS

► ATAXIA TYPICALLY FORCES PTS TO BE WHEELCHAIR BOUND BY AGE 15

► DEATH TYPICALLY OCCURS IN 40-50 DUE TO CARDIOMYOPATHY

► TREATMENT
  • CAVUS FOOT – PLANTAR RELEASE, POSSIBLE OSTEOTOMY
  • SCOLIOSIS – BRACING, PSF AND INSTRUMENTATION
    ▶ SIMILAR TO IDIOPATHIC SCOLIOSIS
FIBRILLIN-1?
MARFANS SYNDROME

• COMMON ORTHO MANIFESTATIONS
• ARACHNODACTYLY
• SCOLIOSIS (50%)
• PROTRUSIO ACETABULI (15-25%)
• LIGAMENTOUS LAXITY
• RECURRENT DISLOCATIONS (PATELLA, SHOULDER, FINGERS)
• PES PLANOVALGUS
FILAMIN B??
LARSEN’S SYNDROME

• DISORDER CHARACTERIZED BY MULTIPLE JOINT DISLOCATIONS, HYPERMOBILITY, CERVICAL KYPHOSIS, BRACHYCEPHALY, AND CLEFT PALATE
  • TYPICALLY HIP, KNEE, RADIAL HEAD
  • BILATERAL CONGENITAL KNEE DISLOCATIONS

• SIMILAR IN APPEARANCE TO ARTHROGRYPOSIS MULTIPLEX CONGENITA BUT THE JOINTS ARE LESS RIGID
Larsen’s Syndrome

Ligamentous laxity is so profound that it can be confused with Ehlers-Danlos Syndrome.
SMN(SURVIVAL MOTOR NEURON)??
SMA SYNDROME

**Symptoms**
- Symmetric progressive weakness that is
  - more profound in lower-extremity than upper extremity
  - more profound proximally than distally

**Physical exam**
- Absent deep tendon reflexes
  - distinguishes from Duchenne's muscular dystrophy where DTR are present
- Fasciculations present
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Age at Presentation</th>
<th>Prognosis</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Acute Werdnig-Hoffman Disease</td>
<td>&lt;6 months</td>
<td>Poor</td>
</tr>
<tr>
<td>II</td>
<td>Chronic Werdnig-Hoffman Disease</td>
<td>6-24 months</td>
<td>May live into 5th decade</td>
</tr>
<tr>
<td>III</td>
<td>Kugelberg-Welander Disease</td>
<td>2-10 years</td>
<td>Good – may need respiratory support</td>
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</tbody>
</table>

**SPINAL MUSCULAR ATROPHY**
DYSTROPHIN???
DUCHENNE’S MUSCULAR DYSTROPHY

▶ SEX LINKED RECESSIVE
▶ ABNORMALITY OF YOUNG BOYS CHARACTERIZED BY CLUMSY WALKING, DECREASED MOTOR SKILLS, LUMBAR LORDOSIS, CALF PSEUDOHYPERTROPHY
▶ ELEVATED CPK, ABSENT DYSTROPHIN PROTEIN
▶ HIP EXTENSORS ARE FIRST MUSCLES TO BE AFFECTED
▶ MONITOR FOR EARLY SCOLIOSIS
DUCHENNE’S MUSCULAR DYSTROPHY

Positive Gower’s Sign
- Walking hands up the legs due to weak glut max and quads

Goal is to keep pt ambulatory as long as possible

Age 10, typically lose independent ambulation ability
- KAFO and contracture releases can possibly delay time until loss of ambulation

Age 15, wheelchair bound
- Scoliosis progressive and relentless at this age due to loss of muscle support

Age 16+, bedridden, unable to sit upright for any period of time

Age 20, most die from cardiopulmonary issues
COL 1A1 AND COL 1A2??
• Orthopaedic Manifestations
  • Bone fragility and fractures
  • Fractures heal in normal fashion initially but the bone does not remodel
  • Can lead to progressive bowing
  • Ligamentous laxity
  • Short stature
  • Scoliosis
  • Codfish vertebrae (compression fx)
  • Basilar invagination
  • Olecranon apophyseal avulsion fx

Osteogenesis Imperfecta
SALTER HARRIS CLASSIFICATION

- Type 1: physeal separation
- Type 2: fracture traverses physis and exits metaphysis
- Type 3: fracture traverses physis and exits epiphysis
- Type 4: fracture passes through epiphysis, physis, metaphysis
  - Thurston Holland fragment
- Type 5: crush injury to physis
• TRAUMA IS THE MOST COMMON CAUSE OF DEATH IN CHILDREN OLDER THAN 1 YEAR.

• THE MOST COMMON CAUSES ARE FALLS AND MOTOR VEHICLE ACCIDENTS (MVAS).

• BECAUSE OF LARGE HEAD SIZE IN YOUNG CHILDREN, A SPECIAL TRANSPORT BOARD WITH AN OCCIPITAL CUTOUT IS NECESSARY WHEN TRANSPORTING CHILDREN YOUNGER THAN 6 YEARS TO THE HOSPITAL
  • PREVENTS CERVICAL SPINE FLEXION AND POTENTIAL IATROGENIC CERVICAL SPINAL CORD INJURY.
The two most important prognostic indicators of long-term neurologic recovery and function are:

- oxygen saturation at the time of presentation
- GCS score 72 hours after injury.

Heterotopic ossification (HO), especially around the elbow, is more common following traumatic brain injury.

- An increase in serum alkaline phosphatase may herald the onset of HO.
OPEN FRACTURES

• TETANUS STATUS SHOULD BE CONFIRMED AND UPDATED; CHILDREN WITH AN UNKNOWN VACCINATION HISTORY OR WHO HAVE NOT HAD A BOOSTER WITHIN 5 YEARS SHOULD RECEIVE A DOSE OF TETANUS TOXOID.

• RECENT STUDIES HAVE DEMONSTRATED THAT THE RISK OF INFECTION FOLLOWING OPEN FRACTURES IS NO HIGHER IF I & D IS PERFORMED 8 TO 24 HOURS POSTINJURY THAN IF IT IS PERFORMED WITHIN 8 HOURS OF INJURY.
Obstetric clavicle fractures are frequently associated with brachial plexus palsies.

The medial clavicular physis is the last physis in the body to close, at age 23 to 25 years.

Posteriorly displaced medial clavicle fractures can impinge on the mediastinal structures, including the great vessels and trachea.
Proximal humerus fractures have tremendous remodeling potential, so surgery is rarely needed.

The Neer and Horwitz classification is used to define the amount of fracture displacement.

- **grade I fractures** are displaced ≤5 mm
- **grade II fractures** ≤1/3 of the humeral diameter
- **grade III fractures** ≤2/3 of the humeral diameter
- **grade IV fractures** >2/3 of the humeral diameter

Reduction is generally obtained by shoulder abduction to 90° and external rotation to 90°.
HUMERAL SHAFT

- Radial nerve palsy occurs in <5% of humeral shaft fractures and is almost always a neurapraxia following middle or distal third fractures.

- Nonsurgical therapy is the mainstay of treatment.

- Significant displacement and angulation (up to 30°) are acceptable because range of shoulder motion is generally excellent.

- Typical immobilization is via sling and swathe, sugar-tong splint, or fracture brace; ROM exercises are started by 2 to 3 weeks post injury.

- If surgical, flexible nails retrograde
LATERAL CONDYLE FRACTURE

• MILCH CLASSIFICATION
  • TYPE I: FRACTURE LINE IS LATERAL TO TROCHLEAR GROOVE (CONSIDERED A SH IV FRACTURE)
  • TYPE II: FRACTURE LINE INTO TROCHLEAR GROOVE (CONSIDERED A SH II FRACTURE)

• RADIOGRAPHS
  • AP, LATERAL, AND OBLIQUE VIEWS OF ELBOW
  • INTERNAL OBLIQUE VIEW MOST ACCURATELY SHOWS MAXIMUM DISPLACEMENT AND FRACTURE PATTERN

• OPEN REDUCTION AND FIXATION
  • INDICATIONS
    • IF > 2MM OF DISPLACEMENT
    • ANY JOINT INCONGRUITY
    • FRACTURE NON-UNION
  • TECHNIQUE
    • DIRECT LATERAL APPROACH
    • AVOID DISSECTION OF POSTERIOR ASPECT OF LATERAL CONDYLE
SUPRACONDYLAR HUMERUS FRACTURE

Epidemiology

- consists of more than half of all pediatric elbow fractures
- extension type most common (95-98%) → AIN neuropraxia
- flexion type → Ulnar nerve neuropraxia

Associated injuries

- (AIN) anterior interosseous nerve neurapraxia (branch of median n.)
  - the most common nerve palsy seen with supracondylar humerus fractures
  - unable to flex the interphalangeal joint of his thumb and the distal interphalangeal joint of his index finger (can't make A-OK sign)

Complications

- Cubitus valgus
  - caused by fracture malunion
  - can lead to tardy ulnar nerve palsy
- Cubitus varus (gunstock deformity)
  - caused by fracture malunion
  - usually a cosmetic issue with little functional limitations
  - decreased carrying angle
• CLASSIFICATION (GARTLAND ‘59)
  • TYPE I – NONDISPLACED
  • TYPE II – DISPLACED WITH INTACT POSTERIOR PERIOSTEUM
  • TYPE III – DISPLACED WITHOUT CORTICAL CONTACT
TYPES I, II, III
• TREATMENT
  • TYPE I – LONG ARM CAST AT 90-DEGREES WITH FOREARM IN NEUTRAL FOR 3 WEEKS
  • TYPE II – CLOSED REDUCTION AND CASTING WITH HYPERFLEXION (120-DEGREES) FOR 3 WEEKS VS CLOSED REDUCTION PERCUTANEOUS PINNING
  • TYPE III
    • NONOPERATIVE TREATMENT (DIFFICULT, POOR RESULTS)
    • OPERATIVE TREATMENT
      • PERCUTANEOUS PINNING****
      • STRONGEST CONSTRUCT (ZIONTS '94) – MEDIAL AND LATERAL PINS
      • TWO OR THREE LATERAL PINS NEXT STRONGEST
      • REMOVE PINS AT 3 WEEKS
ELBOW FRACTURES COMMON Q’S

• DURING OPEN REDUCTION OF LATERAL CONDYLE FRACTURES, POSTERIOR SOFT-TISSUE DISSECTION MUST BE AVOIDED TO AVOID OSTEONECROSIS.

• THE ONLY ABSOLUTE INDICATION FOR SURGICAL TREATMENT OF MEDIAL EPICONDYLE FRACTURES IS ENTRAPMENT OF THE MEDIAL CONDYLE WITHIN THE JOINT.

• ELBOW DISLOCATIONS IN YOUNG CHILDREN ARE EXCEEDINGLY RARE, SO TRANSPHYSEAL FRACTURES SHOULD BE SUSPECTED IN PATIENTS WITH DISPLACEMENT OF THE PROXIMAL RADIUS AND ULNA RELATIVE TO THE HUMERUS.

• TO DIAGNOSE NURSEMAID’S ELBOW, THE CLASSIC POSITION OF ELBOW EXTENSION AND FOREARM PRONATION SHOULD BE NOTED
  • WITH ONE THUMB HELD OVER THE AFFECTED RADIAL HEAD, THE FOREARM IS SUPINATED AND THE ELBOW IS FLEXED PAST 90°.
Unlike in adults, intramedullary fixation in children results in rapid healing, and nonunion is rare.

Advantages of intramedullary fixation are a smaller dissection, use of a load-sharing device, and fewer stress risers.

Unacceptable alignment includes:

- Angulation >15° in children younger than 10 years
- >10° in children 10 years of age or older
- bayonet apposition in children older than 10 years

Unlike in adults, intramedullary fixation in children results in rapid healing, and nonunion is rare.
MONTEGGIA FRACTURE

- ISOLED RADIAL HEAD DISLOCATIONS ALMOST NEVER OCCUR IN CHILDREN.

- THESE PRESUMED “ISOLATED” INJURIES ARE ALMOST ALWAYS THE RESULT OF PLASTIC DEFORMATION OF THE ULNA WITH CONCOMITANT RADIAL HEAD DISLOCATION (MONTEGGIA FRACTURE).

- CLOSED TREATMENT IS OFTEN SUCCESSFUL IN PEDIATRIC MONTEGGIA FRACTURES EARLY

- IF NO REDUCTION, REDUCE THE RADIAL HEAD AND PLACE A FLEXIBLE NAIL INTO THE ULNA.
# BADO CLASSIFICATION

<table>
<thead>
<tr>
<th>Bado Type</th>
<th>Apex of Ulnar Fracture</th>
<th>Radial Head Pathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Anterior</td>
<td>Anterior dislocation</td>
</tr>
<tr>
<td>II</td>
<td>Posterior</td>
<td>Posterior dislocation</td>
</tr>
<tr>
<td>III</td>
<td>Lateral</td>
<td>Lateral dislocation</td>
</tr>
<tr>
<td>IV</td>
<td>Any direction (typically anterior)</td>
<td>Proximal radius dislocation and fracture</td>
</tr>
</tbody>
</table>
DISTAL RADIUS FRACTURE

Unacceptable alignment for complete metaphyseal fractures is

| >20° of angulation in any age child | bayonet apposition in children older than 10 years | residual displacement >50% |

For physeal fractures, no more than one or two reduction attempts should be attempted in the emergency department.

Physeal fractures should not be manipulated more than 5 to 7 days postinjury.
Plain AP pelvis radiographs fail to identify about half of all pediatric pelvic fractures found on CT scan. Most pediatric pelvic fractures can be treated nonsurgically with good results.
AVULSION FRACTURES OF THE PELVIS

The most common avulsion sites (and the causative muscles) are the:

- Ischium (because of the hamstring/adductor muscles)
- Anterior superior iliac spine (sartorius)
- Anterior inferior iliac spine (rectus femoris)
- Iliac crest (abdominals)
- Lesser trochanter (iliopsoas)

These fractures typically occur in adolescent athletes involved in explosive-type activities (such as sprinting, jumping, and/or kicking).
DELBET CLASSIFICATION FEMORAL HEAD AND NECK

1. Type I—transphyseal
2. Type II—transcervical
3. Type III—cervicotrochanteric
4. Type IV—intertrochanteric
FEMORAL HEAD FX

• THE RATE OF AVN OF THE HIP IS INVERSELY RELATED TO THE DELBET FRACTURE CATEGORY
  • 90% TO 100% FOR TYPE I FRACTURES
  • 50% FOR TYPE II FRACTURES
  • 25% FOR TYPE III FRACTURES
  • 10% FOR TYPE IV FRACTURES

• SURGICAL FIXATION OF HIP FRACTURES (PARTICULARLY DELBET II AND III FRACTURES)
  • SIGNIFICANTLY DECREASES THE RISKS OF COXA VARA AND NONUNION.
SCFE

- SLIPPED CAPITAL FEMORAL EPIPHYSIS (SCFE) IS A DISORDER OF THE HIP IN WHICH THE FEMORAL NECK DISPLACES ANTERIORLY AND SUPERIORLY RELATIVE TO THE FEMORAL EPIPHYSIS.

- DISPLACEMENT OCCURS THROUGH THE PROXIMAL FEMORAL PHYSIS.

- SCFE IS THE MOST COMMON DISORDER OF THE HIP IN ADOLESCENTS. MALES ARE MORE COMMONLY AFFECTED THAN FEMALES (2:1).

- THE LEFT HIP IS MORE COMMONLY INVOLVED.

- UNILATERAL INVOLVEMENT AT TIME OF PRESENTATION IS MORE COMMON (80%).
Common physical findings include an abnormal gait (antalgic and/or Trendelenburg) and decreased ROM (in particular, decreased hip flexion and decreased internal rotation).

ROM testing may also reveal obligate external rotation, i.e., external rotation of the hip as the hip is brought into flexion.

The foot and knee progression angles are usually externally rotated.
LODER CLASSIFICATION

• THE SCFE IS STABLE IF THE PATIENT IS ABLE TO WEIGHT BEAR ON THE INVOLVED EXTREMITY (WITH OR WITHOUT CRUTCHES).

• THE SCFE IS UNSTABLE IF THE PATIENT IS UNABLE TO WEIGHT BEAR ON THE INVOLVED EXTREMITY.

• THE VALUE OF THE LODER CLASSIFICATION IS ITS SUPERIOR ABILITY TO PREDICT OSTEONECROSIS.
AP VS. FROG LEG LATERAL

COMMON QS

• THE FROG-LEG LATERAL RADIOGRAPH IS THE MOST SENSITIVE FOR DETECTING SCFE.

• DURING IN SITU SCREW FIXATION, THE STARTING POINT SHOULD BE POSITIONED ANTERIORLY BECAUSE THE FEMORAL EPhipYSIS IS POSTERIOR RELATIVE TO THE FEMORAL NECK.

• BECAUSE OF AN INCREASED RISK OF FRACTURE, A LATERAL ENTRY POINT SHOULD BE AVOIDED, ESPECIALLY WHEN AT OR DISTAL TO THE LESSER TROCHANTER.

• BECAUSE OF THE “BLIND SPOT,” SCREWS IN THE CENTER-CENTER POSITION MUST BE AT LEAST 5 MM FROM SUBCHONDRAI BONE ON ALL VIEWS—AT LEAST 10 MM WHEN THE SCREW IS NOT IN THE CENTER-CENTER POSITION.
Child abuse is by far the most common reason for a femoral shaft fracture in a child younger than 1 year. Child abuse can also be causative in children up to 5 years of age.

Spica casting for femoral shaft fractures is appropriate for most children younger than 5 years.

Surgical treatment of femoral shaft fractures is indicated for most children older than 5 years.

Femoral overgrowth of 7 to 10 mm is typical in children who sustain a femoral shaft fracture between the ages of 2 and 10 years.
Most displaced distal femoral metaphyseal fractures are treated surgically to prevent malunion.

Distal femoral physeal fractures have a worse prognosis than other physeal fractures because of the high rate of growth arrest (up to 50%) and the rapid growth of the distal femur.

Fixation should be used for all displaced fractures of the distal femoral physis to minimize the risk of redisplacement.
TIBIAL SPINE FRACTURES

Meyers and McKeever classification

- Type I → minimally displaced
- Type II → hinged with displacement of the anterior portion
- Type III → completely displaced

Type II fractures that do not reduce with casting and type III fractures are treated surgically.
PROXIMAL TIBIA FRACTURES

• BECAUSE OF THE FACT THAT LIGAMENTS IN CHILDREN ARE GENERALLY STRONGER THAN BONE, TIBIAL SPINE FRACTURES, RATHER THAN ACL INJURIES, OFTEN OCCUR IN CHILDREN.

• AN ENTRAPPED MENISCUS OFTEN PREVENTS TYPE II TIBIAL SPINE FRACTURES FROM REDUCING CLOSED.

• VASCULAR INJURY AND/OR COMPARTMENT SYNDROME OCCURS IN NEARLY 10% OF PATIENTS WITH FRACTURES OF THE PROXIMAL TibIAL PHYSIS; THE RISK IS HIGHEST WITH HYPEREXTENSION INJURY.

• PROXIMAL TibIAL METAPHYSEAL FRACTURES IN CHILDREN YOUNGER THAN 10 YEARS TYPICALLY GROW INTO VALGUS IN THE FIRST 6 TO 12 MONTHS AFTER INJURY.
  • OBSERVATION IS INDICATED IN THESE CASES BECAUSE THE GENU VALGUM USUALLY RESOLVES SPONTANEOUSLY.

• Tibial tubercle fractures may be treated closed only if there is minimal displacement and no extensor lag.
TILLAUX FRACTURES

- **SALTER-HARRIS III FRACTURES** OF THE ANTEROLATERAL PORTION OF THE DISTAL TIBIA
- **EPIPHYSEAL AVULSION AT THE SITE OF ATTACHMENT OF THE ANTERIOR INFERIOR TIBIOFIBULAR LIGAMENT**
TILLAUX FRACTURES

• 3-5% OF PEDIATRIC ANKLE FRACTURES
• CHILDREN NEARING SKELETAL MATURITY DURING TIBIAL PHYSIS CLOSURE
• BIPLANAR SALTER-HARRIS III FX
• TYPICALLY SUPINATION-EXTERNAL ROTATION
# TREATMENT OF TILLAUX FRACTURE

<table>
<thead>
<tr>
<th>Maintaining the reduction of the intra-articular surface of the distal tibia</th>
<th>Non-displaced fractures</th>
<th>Displaced Fractures</th>
</tr>
</thead>
</table>
| | • Cast immobilization 6 weeks | • Closed reduction under sedation  
• Mechanism of injury (supination-external rotation) is reversed with applied pressure to the anterolateral fragment  
• Post-reduction films and/or CT scan to assess adequacy of reduction/joint surface |
TREATMENT OF TILLAUX FRACTURES

Nearing skeletal maturity:
Fixation may cross the physis

Non-anatomic reduction
Open reduction with direct visualization articular surface
Anterolateral approach

Closed reduction/percutaneous fixation with cannulated screws

>2mm of residual displacement mandates reduction and internal fixation
TRIPLANE FRACTURES

• ACCOUNT FOR 5-7% OF PEDIATRIC ANKLE FRACTURES
• SALTER-HARRIS TYPE II + III
• COMPONENTS IN THE SAGITAL, CORONAL AND TRANSVERSE PLANES
• MAY BE TWO, THREE, OR FOUR-PART FRACTURES
TRIPLANE FRACTURES

• RESULT OF CLOSING OF PARTICULAR ASPECT OF DISTAL TIBIAL PHYSIS AT DIFFERING TIMES
  • MIDDLE, MEDIAL, LATERAL

• AVERAGE AGE 13 YRS
  • MAY BE AS YOUNG AS 10

• TYPICALLY YOUNGER THAN THOSE WITH TILLAUX FRACTURES
TRIPLANE FRACTURE

• SH II ON LATERAL VIEW
• SH III ON AP VIEW
CT SCAN

- MERCEDES BENZ SIGN ON AXIAL CUT
- 3 D RECONS HELPFUL
TREATMENT
TRIPLANE FRACTURES

Non-displaced- same treatment as Tillaux and Salter-Harris Type IV

Displaced initial closed reduction

Post-reduction CT Scan is imperative to assess the reduction
TREATMENT
TRIPLANE
FRACTURES

- ORIF FOR INTRA-ARTICULAR DISPLACEMENT >2MM OR PHYSEAL DISPLACEMENT OF >2MM
- ANTEROLATERAL OR ANTEROMEDIAL APPROACH
TREATMENT
TRIPLANE
FRACTURES

• CANNULATED SCREW SYSTEMS FOR ACCURATE PLACEMENT
  • MINIMIZE INCIDENTAL INJURY TO THE PHYSIS

• FIBULAR FRACTURES PROXIMAL TO THE PHYSIS IN INDIVIDUALS NEARING SKELETAL MATURITY
  • OFTEN SPIRAL AND UNSTABLE EVEN AFTER REDUCTION OF THE TIBIA
  • ORIF IS NECESSARY
CEREBRAL PALSY

The CNS lesion in cerebral palsy is static, but the peripheral manifestations of CP often change over time.

Botulinum toxin blocks the presynaptic release of acetylcholine and generally relaxes the muscle(s) into which it is injected for 3 to 6 months.

Scoliosis occurs in >50% of patients with quadriplegia and ~1% of patients with hemiplegia.
CEREBRAL PALSY

- THE MOST COMMON CAUSES OF INTOEING IN CHILDREN WITH CP ARE FEMORAL ANTEVERSION AND INTERNAL TIBIAL TORSION.
- VARUS FOOT DEFORMITIES COMMONLY CAUSE INTOEING IN PATIENTS WITH HEMIPLEGIA BUT NOT IN PATIENTS WITH DIPLEGIA OR QUADRIPLEGIA.
- VARUS FOOT DEFORMITIES ARE DUE TO OVERACTIVITY OF THE ANTERIOR TIBIALIS, POSTERIOR TIBIALIS, OR BOTH.
- DYNAMIC ELECTROMYOGRAPHY (EMG) IS HELPFUL IN DISTINGUISHING THE ETIOLOGY.
- SOFT-TISSUE TRANSFERS ALONE WILL NOT SUFFICE TO CORRECT A RIGID FOOT DEFORMITY. BONE SURGERY WILL BE NEEDED IN SUCH CASES AS WELL.
Supplementation with folic acid decreases the risk of myelodysplasia, but only if taken in the first weeks following conception.

Serial neurologic examinations are critical. Changes in strength and/or spasticity are early signs of a tethered cord.

Prior to any spinal surgery, ventriculoperitoneal (VP) shunt function must be checked. If the VP shunt is not working, tying off the spinal cord at the time of surgery can cause death due to acute hydrocephalus.
• HIP DISLOCATIONS IN CHILDREN WITH MYELODYSPLASIA RARELY REQUIRE TREATMENT.
• FUSIONS SHOULD BE AVOIDED DURING FOOT SURGERY TO DECREASE THE RISK OF PRESSURE SORES.
• A CHILD WITH MYELODYSPLASIA WHO PRESENTS WITH A RED, HOT, SWOLLEN LEG SHOULD BE ASSUMED TO HAVE A FRACTURE UNTIL PROVEN OTHERWISE.
NF1 is the most common single gene disorder (1 in 3,000 births).

The mutation in NF is in the neurofibromin gene.

Neurofibromin regulates cell growth by modulating Ras signaling

**Anterolateral bowing of the tibia**

50% of patients with anterolateral bowing have NF, but only 10% of children with NF have anterolateral bowing.
• MANY PATIENTS HAVE CAFÉ-AU-LAIT SPOTS. SIX OR MORE (OF THE NOTED SIZE) ARE REQUIRED AS A CRITERION FOR NF.

• SCOLIOSIS IN PATIENTS WITH NF IS OFTEN DYSTROPHIC (SHORT AND SHARPLY ANGULAR CURVE). SURGICAL SUCCESS IS MUCH HIGHER WITH COMBINED ANTERIOR AND POSTERIOR FUSIONS.

• 87% OF CURVES RAPIDLY PROGRESS WHEN THREE OR MORE RIBS ARE PENCILED.

• A PREOPERATIVE MRI SCAN SHOULD BE OBTAINED TO RULE OUT DURAL ECTASIA AND INTRASPINAL NEUROFIBROMAS.
GROWTH AND DEVELOPMENT

• SEVERAL SIGNALING CENTERS ARE CRITICAL FOR UPPER LIMB DEVELOPMENT
  • THE APICAL ECTODERMAL RIDGE GUIDES PROXIMAL-TO-DISTAL DEVELOPMENT
  • THE ZONE OF POLARIZING ACTIVITY GUIDES RADIOULNAR DEVELOPMENT.
  • THE WNT SIGNALING CENTER GUIDES DORSOVENTRAL DEVELOPMENT.
• STAPH AUREUS IS STILL THE MC CAUSATIVE ORGANISM
• KINGELLA KINGAE IS BEING RECOGNIZED NOW AS RESPONSIBLE FOR A GREATER PERCENTAGE OF MUSCULOSKELETAL INFECTIONS
SEPTIC ARTHRITIS

• OSTEOMYELITIS AND SEPTIC ARTHRITIS CAN OCCUR SIMULTANEOUSLY
  • PTS UNDER 18 MONTHS HAVE BLOOD SUPPLY TO THE CHONDROEPIPHYSIS WHICH PREDISPOSES THEM TO DEVELOP OSTEOMYELITIS AND SEPTIC ARTHRITIS

• CAN OCCUR IN 4 LOCATIONS DUE TO THE METAPHYSIS BEING INTRA-ARTICULAR IN THESE LOCATIONS
  • PROXIMAL FEMUR
  • PROXIMAL HUMERUS
  • DISTAL LATERAL TIBIA
  • PROXIMAL RADIUS
JOINT ASPIRATION

A lot of emphasis has been given to cell counts greater than 50,000/mL

- **MC cause of cell count greater than 50K is bacterial infection BUT it's not 100% sensitive or specific**
- Fink and Nelson found in a series of 126 proven cases of septic arthritis
  - 55% had counts of 55K or less
  - 34% had counts of 25K or less
  - Diseases like RA, can have cell counts of 80,000/mL

Percentage of PMN cells greater than 75% is highly suggestive of joint sepsis

Atypical infectious organisms are less likely to cause a cell count of 50,000/mL

- Brucellar arthritis
DIFFERENTIAL DIAGNOSIS

4 independent multivariate clinical predictors

<table>
<thead>
<tr>
<th>Fever</th>
<th>Non-weight bearing</th>
<th>ESR 40+</th>
<th>Serum WBC &gt; 12,000/mL</th>
</tr>
</thead>
</table>

Kocher et al reviewed cases of kids treated at Boston Children’s b/t 1979-1996
DIFFERENTIAL DIAGNOSIS

Kocher’s Criteria
- If had 1, 3% chance of septic arthritis
- If had 2, 40%
- If had 3, 93.1%
- If had 4, 99.6%

Kocher prospectively put these criteria to use and later found
- If had 1, 9.5%
- If had 2, 35%
- If had 3, 72.8%
- If had 4, 93%
PREAXIAL POLYDACTYLY

• ALSO REFERRED TO AS THUMB DUPLICATION, THUMB POLYDACTYLY, OR “SPLIT THUMB”

• INCIDENCE REPORTED TO BE APPROXIMATELY 1 PER 1,000 TO 10,000 LIVE BIRTHS

• MALES MORE COMMONLY AFFECTED THAN FEMALES; WHITES MORE COMMONLY AFFECTED THAN BLACKS

• TYPICALLY SPORADIC
WASSEL CLASSIFICATION

• BOTH THE RADIAL AND ULNAR COMPONENTS HAVE STRUCTURES THAT MUST BE PRESERVED AND RECONSTRUCTED TO PROVIDE A STABLE, MOBILE, AND FUNCTIONAL THUMB.

• IN WASSEL TYPE II, THE RADIAL DIGIT HAS THE RADIAL COLLATERAL LIGAMENT INSERTION AND THE ULNAR DIGIT HAS THE ULNAR COLLATERAL LIGAMENT INSERTION OF THE INTERPHALANGEAL (IP) JOINT.

• IN WASSEL TYPE IV (MOST COMMON), THE THENAR MUSCLES INSERT ON THE MORE RADIAL DIGIT AND THE ADDUCTOR POLLICIS INSERTS ON THE MORE ULNAR DIGIT
80% to 90% of patients demonstrate spontaneous recovery.

If antigravity biceps function recovers by 2 months, full recovery is anticipated.

If biceps function recovers at or after 5 months, incomplete recovery is likely.

Presence of Horner syndrome portends worse prognosis.
<table>
<thead>
<tr>
<th>Age</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-6 months</td>
<td>Bimanual reach in midline</td>
</tr>
<tr>
<td>6 months</td>
<td>Grasp</td>
</tr>
<tr>
<td>6-8 months</td>
<td>Independent sitting</td>
</tr>
<tr>
<td>9-12 months</td>
<td>Thumb-index pinch</td>
</tr>
<tr>
<td>18 months</td>
<td>Voluntary digital release</td>
</tr>
<tr>
<td>2-3 years</td>
<td>Fine motor patterns established</td>
</tr>
<tr>
<td>3-4 years</td>
<td>Hand dominance established</td>
</tr>
</tbody>
</table>
• DDH IS THE MOST COMMON DISORDER OF THE HIP IN CHILDREN. ONE IN 1,000 CHILDREN (0.1%) IS BORN WITH A DISLOCATED HIP; 10 IN 1,000 CHILDREN (1%) ARE BORN WITH HIP SUBLUXATION OR DYSPLASIA.

• 80% OF AFFECTED CHILDREN ARE FEMALE.

• THE LEFT HIP IS MORE COMMONLY INVOLVED (60%)

• DDH OCCURS MORE COMMONLY IN FEMALES AND FIRSTBORNS, AND WITH BREECH PRESENTATION (30% TO 50%).

• DDH IS COMMONLY ASSOCIATED WITH INTRAUTERINE “PACKAGING” PROBLEMS, SUCH AS
  • PREMATURITY
  • OLIGOHYDRAMNIOS
  • CONGENITAL DISLOCATION OF THE KNEE
  • CONGENITAL MUSCULAR TORTICOLLIS (8% TO 17% COEXISTENCE)
  • METATARSUS ADDUCTUS (0% TO 10% COEXISTENCE)
DDH

The Barlow test is performed by applying a posterolateral force to the extremity with the hip in a flexed and adducted position → Dislocates

The Ortolani test is performed by abducting and lifting the proximal femur anteriorly → Reducable
DDH

- BECAUSE THE OSSIFIC NUCLEUS OF THE FEMORAL HEAD DOES NOT APPEAR UNTIL 4 TO 6 MONTHS OF AGE, ULTRASOUND IS A BETTER TEST THAN PLAIN RADIOGRAPHS IN THE FIRST 4 TO 6 MONTHS OF LIFE.

- ROUTINE ULTRASOUND SCREENING SHOULD BE PERFORMED FOR INFANTS WITH RISK FACTORS FOR THE CONDITION.

- BECAUSE OF THE POOR SPECIFICITY OF ULTRASONOGRAPHY IN CHILDREN YOUNGER THAN 1 MONTH, HIP ULTRASONOGRAPHY SHOULD BE DEFERRED UNTIL AFTER 1 MONTH OF LIFE.
DDH

• EXCESSIVE HIP FLEXION IN THE PAVLIK HARNESS RESULTS IN AN INCREASED RISK OF FEMORAL NERVE PALSY.

• EXCESSIVE HIP ABDUCTION IN THE PAVLIK HARNESS RESULTS IN AN INCREASED RISK OF OSTEONECROSIS OF THE FEMORAL HEAD.

• HIP ABDUCTION DOES NOT BECOME LIMITED IN DDH UNTIL APPROXIMATELY 6 MONTHS OF AGE.
Legg-Calvé-Perthes disease (LCPD) is an idiopathic osteonecrosis of the capital femoral epiphysis in children. LCPD affects 1 in 1,200 children.

The disease more commonly affects boys than girls (4:1 to 5:1).

The hips are involved bilaterally in 10% to 12% of cases.

LCPD is more commonly diagnosed in urban than rural communities.
LCP

• DEFICIENT VASCULARITY MAY BE DUE TO INTERRUPTION OF THE BLOOD SUPPLY TO THE FEMORAL HEAD.

• THE VASCULARITY OF THE CAPITAL FEMORAL EPiphysis MAY ALSO BE THREATENED BY THROMBOPHILIA AND/OR VARIOUS COAGULOPATHIES (PROTEIN C AND S DEFICIENCY, ACTIVATED PROTEIN C RESISTANCE).

• LCPD OCCURS MOST COMMONLY IN CHILDREN FROM AGE 4 TO 8 YEARS (RANGE, 2 YEARS TO LATE TEENS).

• USUALLY SMALL, HYPER KIDS. EXACT OPPOSITE OF SCFE KIDS

• ONSET IS INSIDIOUS, AND CHILDREN WITH LCPD WILL COMMONLY HAVE A LIMP AND PAIN IN THE GROIN, HIP, THIGH, OR KNEE REGIONS.
LCPD typically proceeds through four radiographic stages.

(A) Initial stage—Early radiographic findings are a sclerotic, smaller proximal femoral ossific nucleus (due to failure of the epiphysis to increase in size) and widened medial clear space (distance between teardrop and femoral head).

(B) Fragmentation stage—Segmental collapse (resorption) of the capital femoral epiphysis follows, with increased density of the epiphysis.

(C) Reossification or reparative stage—Necrotic bone is resorbed with subsequent reossification of the capital femoral epiphysis.

(D) Remodeling stage—Remodeling begins when the capital femoral epiphysis is completely reossified.
TREATMENT OPTIONS

• NONSURGICAL
  • CONTAINMENT MAY BE ACHIEVED BY NONSURGICAL MEANS, SPECIFICALLY BY CASTING OR BRACING IN AN ABDUCTED AND INTERNALLY ROTATED POSITION.
  • PETRIE CASTS AND A VARIETY OF ABDUCTION ORTHOSES HAVE BEEN USED.

• SURGICAL
  • (A) ON THE FEMORAL SIDE, A PROXIMAL FEMORAL VARUS OSTEOTOMY IS AN OPTION.
  • (B) ON THE ACETABULAR SIDE, A PELVIC OSTEOTOMY (SALTER, TRIPLE INNOMINATE, DEGA, OR PEMBERTON) MAY BE PERFORMED.
QUESTIONS

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