Adolescent idiopathic scoliosis

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Overview and Recommendations

Background

- Scoliosis is a lateral curvature of the spine ≥ 10 degrees in the coronal plane while standing.
- About 2% of the general population is reported to have adolescent idiopathic scoliosis and the cause is idiopathic in up to 80%.
- Factors associated with increased risk of curve progression in patients with scoliosis include a large curve (> 30 degrees) at diagnosis, skeletal immaturity at diagnosis, and female gender.
- Consider screening for scoliosis; twice in girls, at ages 10 and 12 years, and once in boys ages 13-14 years.

Evaluation

- Use the Adam's forward bend test and inclinometer to assess curve rotation (assess patient from behind while they bend forward).
  - Findings that are suggestive of scoliosis include:
    - rib prominence (particularly in thoracic spine area) and/or paraspinal muscle prominence in the lumbar spine
    - inclinometer reading is ≥ 7 degrees
  - If the inclinometer reading is < 7 degrees, have the patient follow-up in 6-12 months according to growth potential.
  - Curvature or rotation may indicate unequal leg lengths rather than scoliosis.
- The diagnosis is confirmed by posteroanterior (coronal) spinal x-ray with lateral curvature of spine (Cobb angle) ≥ 10 degrees in coronal plane while standing.

Management

- Referral to an orthopedist is generally recommended if the Cobb angle is > 20 degrees and the patient is skeletally immature.
- Treatment of adolescent idiopathic scoliosis (> 10 years old) is based on the Cobb angle.
  - Observation is recommended for curves ≤ 25 degrees regardless of the level of skeletal maturity with regular x-ray monitoring to assess for curve progression. The frequency of x-rays depends on the child's growth potential and Cobb angle in adolescents with no red flags.

- Consider bracing to prevent curve progression in patients with curves of 25-45 degrees and low skeletal maturity (Risser grade ≤ 2).
- Consider surgery (fusion of spine via instrumentation and bone grafting) to stop curve progression and improve spinal balance and alignment in patients with curves > 45 degrees with low skeletal maturity or curves > 50 degrees and high skeletal maturity (Risser grade ≥ 3).

Related Summaries

- Chronic low back pain

General Information

Description

- lateral curvature of spine (Cobb angle) ≥ 10 degrees in coronal plane while standing[1, 2]
- most common spinal deformity[2]

Types

- idiopathic scoliosis[1, 2]
  - most common type of scoliosis (reported in up to 80% of children with scoliosis)
  - classified based on age of onset
    - infantile (age of onset 0-3 years)
      - reported in 1% of idiopathic scoliosis cases
      - more common in boys (ratio 3:2)
      - 75%-90% reported to be convex left curves
    - juvenile (age of onset 3-10 years)
      - reported in 12%-21% of idiopathic scoliosis cases
      - slightly more common in girls
      - most are right thoracic curves
    - adolescent (age of onset 10-18 years)
      - most common type of idiopathic scoliosis
      - more common in girls
  - can also be classified as
    - early onset (typically defined as onset at < 5 years old, but may extend up to age 10 years)
    - late onset (onset at > 5 years old)
- congenital scoliosis [1, 2]
  - caused by spinal malformations present at birth but may not be apparent until later in childhood
  - classified as failure of formation or failure of segmentation

        - failure of formation - incomplete formation of one or more vertebral bodies (wedge vertebrae, hemivertebrae)
        - failure of segmentation - persistent fusion between ≥ 2 vertebrae (unilateral bar, block vertebra)
        - failure of formation and failure of segmentation may both be present
- neuromuscular scoliosis[1, 2]
    - caused by neurologic and/or muscular disorders resulting in lack of muscular support to spinal column
    - age of onset and natural history may vary by cause
- miscellaneous or syndromic scoliosis due to other known causes, including[1]
    - neurofibromatosis
    - connective tissue disorders
    - osteochondrodystrophies
    - metabolic conditions
    - tumors

Epidemiology

Incidence/Prevalence

- about 2% of general population reported to have adolescent idiopathic scoliosis[1, 2, 3]
    - **3.5% of adolescents in Hong Kong have adolescent idiopathic scoliosis**
        - based on cross-sectional analysis of retrospective cohort study
        - 306,144 children and adolescents attending school in Hong Kong had medical records evaluated
        - prevalence of Cobb angle ≥ 10 degrees
            - 3.5% overall
            - 4.8% of girls and 2.2% of boys
        - prevalence of Cobb angle ≥ 20 degrees
            - 1.8% overall
            - 2.8% of girls and 0.7% of boys
        - prevalence of Cobb angle ≥ 40 degrees
            - 0.2% overall
            - 0.4% of girls and 0.07% of boys
        - Reference - Spine J 2015 May 1;15(5):825

Likely risk factors

- family history (idiopathic scoliosis reported in about 10% of persons with affected first degree relative)[2]

Associated conditions

- Marfan syndrome
- Down syndrome (Curr Opin Pediatr 2008 Feb;20(1):30)
- Prader-Willi syndrome in children (Pediatrics 2008 Aug;122(2):e499 full-text)
- Ehlers-Danlos syndrome

Etiology and Pathogenesis

Causes

- cause of idiopathic scoliosis not known[1, 2]

Pathogenesis

- in children and adolescents, magnitude of curve increases as spine grows[1]

History and Physical

History

Chief concern (CC)

- typically presents as chest wall or back asymmetry[1, 2]
- adolescents may report asymmetry in shoulders or waists[1]
- adolescent girls may report asymmetry in breasts[1]
- severe pain not a major characteristic of scoliosis in adolescents[1, 2]
  - some patients may have localized pain in posterior chest wall around rib prominence
  - pain (usually benign and nonspecific) reported in about 25% with adolescent idiopathic scoliosis
  - mild pain reportedly common in children with significant curvature
- if severe pain (disrupting function or sleep) present, may indicate underlying or associated conditions, such as[1, 2]
  - infection
  - spinal tumors
  - Chiari type I malformation with a syrinx
  - tethered spinal cord
  - osteoid osteoma of the spine (worse at night and relieved with nonsteroidal anti-inflammatory drugs)
  - osteoblastoma (Neurosurg Clin N Am 2008 Jan;19(1):65)

Medication history

- ask about medication use (particularly with neuromuscular scoliosis), as it could affect surgical treatment for scoliosis[1]

Past medical history (PMH)

- history of heart disease may indicate other syndromic features (such as Marfan syndrome)[1]

Family history (FH)

- ask about family history of scoliosis[1]

Physical

Chest

- look for asymmetry along midline (including chest)[1, 2]
- some degree of chest and trunk asymmetry common in healthy adolescents[2]

Abdomen

- look for asymmetry along midline (including waist)[1, 2]

Back

- assess for lateral curvature of spine ≥ 10 degrees in coronal plane while standing[1, 2]
- asymmetry in shoulder/scapular area or flanks (waist asymmetry) while standing common in scoliosis[1, 2]
  - ensure level pelvis when assessing
  - if pelvis cannot remain level
    - assess for asymmetry in seated patient
    - spinal curvature due to unequal leg lengths resolves when seated
- use Adam's forward bend test and inclinometer to assess curve rotation (assess patient from behind while they bend forward)[1, 2]
  - findings suggestive of scoliosis include shoulder and torso asymmetry, rib prominence (particularly in thoracic spine area), and/or paraspinal muscle prominence in the lumbar spine
  - if inclinometer reading ≥ 7 degrees, suspect scoliosis and perform diagnostic evaluation
  - if inclinometer reading < 7 degrees but findings are suggestive of scoliosis, reassess in 6-12 months according to growth potential
  - curvature or rotation may indicate unequal leg lengths rather than scoliosis
- estimate likelihood of further spinal growth to inform treatment decisions and estimate possible progression of scoliosis[1, 2]
  - serial height measurements taken over time estimates growth velocity
  - peak growth velocity in girls occurs year before menarche

Extremities

- unequal leg lengths may
  - lead to compensatory postural changes and false positives during Adam's forward bend test or assessments for shoulder/scapular asymmetry[1, 2]

  - indicate tethered cord syndrome
- if tall and high arm span to height ratio, suspect Marfan syndrome[1]
- arachnodactyly or joint laxity may indicate heritable connective tissue disorders, such as Ehlers-Danlos syndrome[1, 2]

Neuro

- weakness or spasticity, abnormal sensation, and abnormal reflexes may indicate tethered cord syndrome, syringomyelia or other neurologic abnormality

Diagnosis

Making the diagnosis

- diagnosis suspected in patients with[1, 2]
  - chest wall, back, pelvis, shoulders, and/or waist asymmetry on physical exam
  - use Adam's forward bend test, inclinometer, and visual inspection to determine if pelvis, waist, and shoulders are symmetrical and horizontally level
    - findings suggestive of scoliosis may include rib prominence (particularly in thoracic spine area) and/or paraspinal muscle prominence in the lumbar spine
    - if inclinometer reading ≥ 7 degrees, suspect scoliosis
- diagnosis confirmed by posteroanterior (coronal) spinal x-ray with lateral curvature of spine (Cobb angle) ≥ 10 degrees in coronal plane while standing[1, 2]

Differential diagnosis

- unequal leg length[1, 2]
- other types of spinal injury or deformity
- hemihypertrophy (J R Soc Promot Health 2002 Mar;122(1):24)

Testing overview

- use Adam's forward bend test, inclinometer, and visual inspection to assess for asymmetrical chest, back, pelvis, waist, and/or shoulders[1, 2]
  - if inclinometer reading ≥ 7 degrees, perform posteroanterior (coronal) spinal x-ray from C7 to iliac crest (with patient in standing position) to confirm diagnosis and determine risk of progression
    - scoliosis confirmed by lateral curvature of spine (Cobb angle) ≥ 10 degrees in coronal plane while standing
    - risk of curve progression estimated with Risser grade for adolescent idiopathic scoliosis
    - skeletal maturity may also be estimated by x-ray of left hand for bone age
  - if inclinometer reading < 7 degrees but chest, back, pelvis, waist, and/or shoulders appear asymmetric, reassess in 6-12 months according to growth potential

- consider additional imaging to inform treatment

Imaging studies

X-ray

- perform posteroanterior (coronal) and lateral spinal x-ray from C7 to iliac crest with patient in standing position[1, 2]
  - imaging technique
    - use digital imaging enhancement
    - PA images viewed as if looking at patient from behind (with heart on left)
    - if unequal leg lengths, correct discrepancy with wooden block under shorter leg to level pelvis
    - on initial image, include lateral rib border to assess, but breast shield can be used for subsequent images
    - if child too young to stand independently, perform x-ray with patient in supine position
    - if patient cannot stand but can sit, perform x-ray while patient is in sitting position
  - scoliosis confirmed on posteroanterior (PA) view with Cobb angle ≥ 10 degrees
    - Cobb angle quantifies curve severity (0 degrees indicates no curvature)
    - to calculate Cobb angle (from PA view x-ray)
      - determine the 2 vertebrae that are at the superior and inferior ends of the curve (the "end vertebrae")
      - draw lines along the superior end of the superior vertebra and the inferior end of the inferior vertebra (the lines would be horizontal in a straight spine)
      - draw perpendicular lines to the 2 previous lines (these lines would be vertical in a straight spine)
      - Cobb angle is the angle between the 2 previous lines
      - Reference - Am Fam Physician 2014 Feb 1;89(3):193 full-text
  - considerations for lateral-view spinal x-ray include
    - assesses sagittal balance
    - lack of vertebral rotation or lack of hypokyphosis at apex might indicate specific cause of scoliosis such as osteoid osteoma orsyringomyelia
    - if lower back pain or most curvature in lumbar area, may assess for spondylolysis and spondylolisthesis
- structural findings on x-ray in adolescent idiopathic scoliosis[1, 2]
  - 90% of patients reported to have convex thoracic spine curvature to the right and/or convex lumbar spine curvature to the left
  - otherwise consider underlying conditions or nonidiopathic cause
- x-ray may help predict curvature progression and direct treatment decisions[1, 2]
  - for adolescent idiopathic scoliosis, use Risser grade to estimate skeletal maturity (lower score indicates less mature skeleton)

        - measures ossification of iliac apophysis
        - United States classification (total score range 0-5)
            - Grade 0 - 0% ossification
            - Grade 1 - 25% ossification
            - Grade 2 - 50% ossification
            - Grade 3 - 75% ossification
            - Grade 4 - 100% ossification
            - Grade 5 - fusion of ossified epiphysis to the iliac wing
        - French classification (total score range 0-4)
            - Grade 0 - 0% ossification
            - Grade 1 - 33.34% ossification
            - Grade 2 - 66.67% ossification
            - Grade 3 - 100% ossification
            - Grade 4 - fusion of ossified epiphysis to the iliac wing
        - Reference - Clin Orthop Relat Res 2012 Aug;470(8):2335 full-text
    - skeletal maturity may also be estimated by x-ray of left hand for bone age[2]
    - for assessment of spine flexibility (such as for surgery), consider x-ray of patient in lateral bending position[2]

Other imaging modalities

- additional imaging may help to inform treatment[1, 2]
- consider magnetic resonance imaging (MRI) for[1, 2]
    - atypical neurological exam or any suspected neural axis abnormalities
    - idiopathic scoliosis in patients with any of
        - clinically significant pain
        - atypical curve patterns, such as kyphotic apex
        - large or rapidly progressive curve
        - midline cutaneous abnormalities (may indicate neural tube defects)
        - neurofibromatosis
- consider computed tomography (CT) to[1]
    - further assess anatomy
    - assess flexibility with supine bending and stretching

Treatment

Treatment overview

- goal of treatment is to prevent curve progression by keeping scoliosis < 50 degrees at maturity[1]
- treatment options
    - observation recommended for most cases of adolescent idiopathic scoliosis without curve progression[2]

        - recommended for curves ≤ 25 degrees, regardless of level of skeletal maturity[1]
        - perform regular x-ray monitoring to assess for curve progression (5-6 degree change in Cobb angle)
    - scoliosis-specific exercises might help reduce progression of spine curvature
    - consider bracing to prevent curve progression in patients with curves 25-45 degrees and Risser grade ≤ 2 skeletal maturity
        - most common type of brace is thoracolumbosacral orthosis (TLSO)
            - TLSO braces are rigid with 3 points of support
            - appropriate for curves with apex at T7 or lower
            - include full-time (16-22 hours/day) use of Boston and Cheneau braces, and night-time (10-12 hours) use of Charleston and Providence braces
        - careful patient counseling recommended prior to bracing to ensure patient is aware and willing to accept that cosmetic deformity is unlikely to improve
    - consider surgery (fusion of spine via instrumentation and bone grafting) to stop curve progression and improve spinal balance and alignment in patients with
        - curves > 50 degrees
        - curves > 45 degrees and Risser grade ≤ 2

Surgery and procedures

Surgery for adolescent idiopathic scoliosis

- surgery for adolescent idiopathic scoliosis can help stop curve progression and improve spinal balance and alignment[1, 2]
    - Cobb angle > 50 degrees reported to be commonly used indicator for surgical treatment for adolescent idiopathic scoliosis due to increased risk of curve progression (Cochrane Database Syst Rev 2015 Apr 24;4:CD010663, N Engl J Med 2013 Oct 17;369(16):1512 full-text, Scoliosis 2012 Jan 20;7(1):3 full-text)
    - also consider surgery if Cobb angle > 45 degrees and skeletal immaturity (such as Risser grade ≤ 2)
    - surgical treatment is fusion of spine via instrumentation and bone grafting
        - involves placement hooks, wires, or pedicle screws anchored to vertebrae and connecting them to dual rod construction
        - can be performed anteriorly, posteriorly, or both depending on curve magnitude and type, skeletal maturity, and surgeon's experience
    - **Cotrel-Dubousset construct for posterior spinal fusion associated with better correction of coronal and sagittal plane defects compared to all-pedicle screw fixation in adolescents with idiopathic scoliosis (level 3 [lacking direct] evidence)**
        - based on nonclinical outcomes in systematic review
        - systematic review of 27 observational studies evaluating instrumented posterior spinal fusion techniques in 2,272 adolescents with idiopathic scoliosis

        - mean follow-up 14.9 years (range 5-28 years)
        - Cotrel-Dubousset construct associated with significantly better correction of thoracic and lumbar curves, thoracic kyphosis, and lumbar lordosis compared to all-pedicle screw fixation
        - complications (pseudarthrosis, reoperation, infection) lowest with all-pedicle screw fixation (no p values reported)
        - Reference - Spine (Phila Pa 1976) 2013 Jan 15;38(2):E113
    - **surgical intervention reported to reduce rib hump in patients with scoliosis (level 3 [lacking direct] evidence)**
        - based on nonclinical outcomes from 3 case series
        - 2-stage vertebral column resection reported to reduce rib hump in 16 patients with severe and rigid scoliosis and low body weight in case series (Spine J 2013 May;13(5):481, editorial can be found in Spine J 2013 May;13(5):487)
        - posterior surgery with segmental pedicle screw fixation reported to reduce rib hump in 25 patients with adolescent idiopathic scoliosis in case series (Spine (Phila Pa 1976) 2008 Jun 15;33(14):1588)
        - surgical correction with anterior dual rod instrumentation reported to reduce rib hump by mean 66% in 93 patients with idiopathic scoliosis in case series (Orthopade 2007 Mar;36(3):273 [German])
    - **addition of bone graft augmentation to posterior spinal fusion may not affect spine curvature at 2 year follow-up in patients with adolescent idiopathic scoliosis with Risser grade ≥ 2 (level 3 [lacking direct] evidence)**
        - based on nonclinical outcomes from randomized trial with inadequate statistical power
        - 91 patients (≤ 21 years old) with adolescent idiopathic scoliosis with Cobb angle ≤ 80 degrees and Risser grade ≥ 2 were randomized to hook-screw and rod posterior spinal fusion with vs. without 180 mL bone corticocancellous allograft augmentation and followed for ≥ 2 years
        - 16% lost to follow-up
        - trial had 44% power to detect statistically significant differences in outcomes between groups
        - comparing allograft vs. no graft at last follow-up
            - Cobb angle 22.6 vs. 22.5 degrees (not significant)
            - Cobb angle correction from baseline 63% vs. 62% (not significant)
        - adverse events were similar between groups and included back pain in 4 patients (due to prominent instrumentation in 3 patients), pseudoarthrosis in 1 patient, and infection in 2 patients
        - Reference - Spine (Phila Pa 1976) 2006 Jan 15;31(2):121
    - Cochrane review found no randomized trials or prospective controlled studies found comparing surgical vs. nonsurgical interventions for adolescent idiopathic scoliosis (Cochrane Database Syst Rev 2015 Apr 24;(4):CD010663)
- complications of surgery for adolescent idiopathic scoliosis[1, 2]

- infection
  - within 3 months (reported in about 1% in patients with adolescent idiopathic scoliosis)
    - usually due to *Staphylococcus aureus* or *Streptococcus*
    - usual treatment is debridement with antibiotics IV for 4-6 weeks and subsequent antibiotics orally until well-established fusion bed
  - > 1 year after operation (reported in < 1% of patients with adolescent idiopathic scoliosis)
    - usually due to *Propionibacterium acnes* or *Staphylococcus epidermidis*
    - usual treatment is removal of spinal implants and administration of bacteria-specific antibiotics to treat vertebral osteomyelitis
- spinal cord injury
  - reported in 0.1%-0.5% in patients with adolescent idiopathic scoliosis
  - risk factors include spinal stenosis, Chiari malformation, tethered spinal cord, and syrinx
- in procedures using spinal fusion
  - decreased spinal motion
    - fusion in thorax results in no physical restrictions in most patients with adolescent idiopathic scoliosis
    - fusion in lumbar area associated with reduced activity and degenerative arthritis in patients with adolescent idiopathic scoliosis
  - if performed before in very young children, may lead to increased risk of pulmonary dysfunction due to interference with development of spine and lungs
- pain and loss of lumbar lordosis ("flat back" syndrome) possible but uncommon in patients with adolescent idiopathic scoliosis

Perioperative considerations

- to detect neurological deficits during surgery, consider multimodal intraoperative neurological monitoring with sensory- and motor-evoked potentials[2]
- blood loss
  - **antifibrinolytics may reduce perioperative blood loss and amount of blood transfused in children and adolescents having scoliosis surgery (level 3 [lacking direct] evidence)**
    - based on nonclinical outcomes from Cochrane review of small trials
    - systematic review of 6 randomized placebo-controlled trials evaluating effect of antifibrinolytics on perioperative blood loss in 254 children ≤ 18 years old having scoliosis surgery
    - antifibrinolytics evaluated were aprotinin (2 trials), tranexamic acid (2 trials), and aminocaproic acid (2 trials)
    - compared to placebo in analysis of 5 trials with 207 patients, antifibrinolytics associated with decreased

        - amount of blood loss (mean difference -427 mL, 95% CI -603 mL to -251 mL)
        - amount of blood transfused (mean difference -327 mL, 95% CI -469 mL to -186 mL)
    - no deaths or serious adverse events reported in any trial
    - no significant differences in number of patients requiring transfusion
    - Reference - Cochrane Database Syst Rev 2008 Jul 16;(3):CD006883
- **tranexamic acid may decrease need for blood transfusion and reduce blood loss in patients having spine surgery (level 2 [mid-level] evidence)**
    - based on systematic review without reporting of individual trial quality measures
    - systematic review of 11 randomized trials comparing tranexamic acid vs. placebo or no treatment in 644 patients having spine surgery
    - surgical procedures included spinal fixation surgery, decompressive laminectomy with fusion, cervical laminoplasty, surgery for adolescent scoliosis, spinal fusion, or surgery for degenerative lumbar instability with stenosis
    - comparing tranexamic acid to placebo, tranexamic acid associated with
        - decreased need for blood transfusion in analysis of 11 trials with 504 patients
            - risk ratio 0.67 (95% CI 0.54-0.83)
            - NNT 5-13 with blood transfusion in 46% of placebo group
        - reduced intraoperative blood loss (mean difference -219.03 mL, 95% CI -321.67 mL to -116.38 mL) in analysis of all trials, results limited by significant heterogeneity
        - reduced postoperative blood loss (mean difference -119.15 mL, 95% CI -140.76 mL to -97.54 mL) in analysis of 4 trials with 322 patients
        - reduced total blood loss (mean difference -202.07, 95% CI -229.25 mL to -104.88 mL) in analysis of 6 trials with 376 patients, results limited by significant heterogeneity
    - Reference - Spine J 2015 Apr 1;15(4):752
- **tranexamic acid and epsilon-aminocaproic acid appear similarly effective for reducing perioperative blood loss in adolescents having scoliosis surgery (level 3 [lacking direct] evidence)**
    - based on randomized trial without clinical outcomes
    - 125 patients (mean age 15 years, 78% female) having posterior spinal arthrodesis surgery for adolescent idiopathic scoliosis were randomized to 1 of 3 groups
        - intraoperative tranexamic acid 10 mg/kg IV for 15 minutes followed by 1 mg/kg/hour IV
        - intraoperative epsilon-aminocaproic acid 100 mg/kg IV for 15 minutes followed by 10 mg/kg/hour IV
        - intraoperative saline
    - patients in saline group had higher estimated blood volume at baseline

        - no significant differences in intraoperative estimated blood loss or postoperative total blood loss comparing tranexamic acid vs. epsilon-aminocaproic acid
        - compared to saline, antifibrinolytics (tranexamic acid and epsilon-aminocaproic acid) each associated with significantly reduced intraoperative estimated blood loss
        - no significant differences among groups in blood transfusion rate, surgery duration, levels fused, or number of pedicle screws placed
        - Reference - J Bone Joint Surg Am 2014 May 21;96(10):e80
- pain management
    - **dual continuous epidural analgesia may slightly reduce postoperative pain compared to either single continuous epidural analgesia or patient-controlled IV analgesia in adolescents having posterior spinal fusion and instrumentation for scoliosis (level 2 [mid-level] evidence)**
        - based on small randomized trial
        - 66 patients aged 10-21 years with adolescent idiopathic scoliosis having posterior spinal fusion and instrumentation were randomized to 1 of 3 groups
            - dual continuous epidural analgesia (2 catheters)
            - single continuous epidural analgesia (1 catheter)
            - patient-controlled IV analgesia
        - mean postoperative pain scores on visual analog scale (range 0-10, with higher score indicating greater pain severity)
            - 3.6 with dual continuous epidural analgesia ($p < 0.05$ vs. each other group)
            - 4.1 with single continuous epidural analgesia
            - 4.2 with patient-controlled IV analgesia
        - most common adverse events were pruritus, constipation, and nausea
        - Reference - Spine (Phila Pa 1976) 2013 Sep 1;38(19):1626
    - **double epidural analgesia appears more effective than IV morphine for postoperative analgesia**
        - based on small randomized trial
        - 30 adolescents having anterior correction for thoracic idiopathic scoliosis were randomized to epidural vs. morphine, epidural group has 2 epidural catheters placed after scoliosis correction
        - all patients given remifentanil until first postoperative morning then epidural group given continuous epidural ropivacaine 0.3% and morphine group given continuous IV morphine
        - epidural group had significantly less pain, less rescue morphine use, improved bowel activity, higher patient satisfaction, and fewer side effects
        - Reference - Spine 2006 Jul 1;31(15):1646
    - **addition of magnesium sulfate to ketamine may reduce postoperative morphine consumption in patients having surgery for idiopathic scoliosis (level 3 [lacking direct] evidence)**
        - based on nonclinical outcomes from small randomized trial

- 50 patients ≤ 18 years old having posterior spinal fusion and instrumentation surgery for adolescent idiopathic scoliosis were randomized to magnesium sulfate 50 mg/kg bolus IV after induction followed by continuous magnesium sulfate 8 mg/kg/hour vs. normal saline and followed for 48 hours postoperatively
- all patients had ketamine bolus 0.2 mg/kg IV after induction followed by continuous ketamine 0.15 mg/kg/hour until extubation
- postoperative care included morphine 20 mcg/kg bolus IV via patient control analgesia pump with lockout of 10 minutes and maximum dose of 20 mg in 4 hours
- comparing patients with ketamine plus magnesium sulfate vs. ketamine plus saline
  - cumulative morphine consumption over 48 hours 51.5 mg vs. 73.2 mg ($p < 0.001$)
  - nausea or vomiting in 0% vs. 16% ($p = 0.038$)
- no significant differences between groups in mean pain at rest, during movement, or while coughing
- Reference - Acta Anaesthesiol Scand 2014 May;58(5):572

Consultation and referral

- referral to orthopedist generally recommended if Cobb angle > 20 degrees and patient is skeletally immature[2]
- if connective-tissue disorder suspected, refer to genetic and cardiac specialists[2]

Other management

Bracing

- braces are usually custom made using plaster and fiberglass casting
  - computers may be used to scan patient and design brace
  - additional device shaping is done based on x-ray results to provide corrective forces for specific curve
  - pads are added for further comfort and fit
  - Reference - Eur J Phys Rehabil Med 2014 Feb;50(1):93 full-text
- in patients with adolescent idiopathic scoliosis[1, 2, 3]
  - bracing is primary treatment and appears effective, but based on low-quality evidence
    - effectiveness increases with increased hourly use per day
    - rigid braces may be more effective than elastic braces
  - consider bracing to prevent curve progression and keep it below surgical range at skeletal maturity
    - recommended for curves 25-45 degrees in patients with Risser grade ≤ 2
    - most common type of brace is thoracolumbosacral orthosis (TLSO), which are appropriate for curves with apex at T7 or lower

    - day-use braces are usually prescribed for 16-22 hours daily (full-time)
      - advise patients that benefit of brace wear increases with increasing hours of use
      - Boston brace is most commonly used and is a rigid, symmetric, posterior opening device
      - others rigid devices include Cheneau and progressive action short braces which are asymmetric, anterior opening devices
      - Spincor is a nonrigid, asymmetric device (infrequently used by orthopedic surgeons)
    - night-use braces are worn for 10-12 hours at night - include Charleston and Providence braces which are rigid, asymmetric, anterior opening devices
    - Reference - Eur J Phys Rehabil Med 2014 Feb;50(1):93
  - careful patient counseling recommended prior to bracing to ensure patient is aware and willing to accept that cosmetic deformity is unlikely to improve[1]
  - Canadian Spine Society recommends clinicians don't miss opportunity to brace patients with adolescent idiopathic scoliosis and skeletal immaturity, who have > 1 year of growth remaining and curve magnitude of > 20 degrees (Choosing Wisely Canada 2015 Jun 2)
  - **bracing may slow curve progression in adolescents with idiopathic scoliosis (level 2 [mid-level] evidence)**
    - based on Cochrane review of observational studies and trials with methodologic limitations
    - systematic review of 5 randomized trials and 2 prospective cohort studies evaluating bracing in 662 patients > 10 years old with idiopathic scoliosis
    - all trials had ≥ 1 limitation including
      - high or differential dropout rate
      - early termination
      - small sample size
    - treatment duration ranged from 1 to 5 years
    - no trials assessed pulmonary disorders, disability, back pain, psychological effects, or cosmetic issues
    - comparing bracing to observation
      - rigid thoracolumbosacral orthosis significantly increased treatment success (Cobb angle remaining below 50 degrees) at 2 years in 1 trial with 116 patients with mean Cobb angle 30.5 degrees (below)
      - Dynamic SpineCor brace orthosis significantly improved stabilization or correction (5 degrees or less curve progression) at 3 years, but no significant difference at 5 years in 1 trial with 47 patients with curves 15-30 degrees (below)
      - Boston brace significantly improved treatment success (progression < 6 degrees) at 3-4 years in 1 cohort study with 240 girls with curves 30-35 degrees
    - very rigid polycarbonate thoraco-lumbo-sacral orthosis (with Risser cast first in some patients) plus physical therapy significantly increased

treatment success (no progression > 5 degrees, no fusion, or no wait list for fusion) at 2-9 years vs. observation in 1 study with 57 patients with ≥ 1 curve ≥ 45 degrees

- polyethylene rigid orthosis brace significantly increased treatment success (no progression > 5 degrees) at 4 years vs. Dynamic SpineCor brace in 1 trial with 43 girls with curves 20-30 degrees
- Reference - Cochrane Database Syst Rev 2015 Jun 18;(6):CD006850
- **bracing may slow idiopathic scoliosis curve progression in adolescents with Cobb angle 20-40 degrees, and may increase likelihood of spinal curve remaining < 50 degrees (level 2 [mid-level] evidence)**
  - based on randomized trial with early termination
  - 155 children and adolescents aged 10-15 years with idiopathic scoliosis and no prior treatment for scoliosis were randomized to bracing with rigid thoracolumbosacral orthosis for ≥ 18 hours/day vs. observation and followed until skeletal maturity or Cobb angle ≥ 50 degrees
    - at baseline all patients had skeletal immaturity (Risser grade 0-2) and Cobb angle for largest curve 20-40 degrees
    - 39 children and adolescents not included in analysis due to efficacy-based early trial termination or trial withdrawal
    - trial terminated early, but results had not reached prespecified stopping criterion
  - treatment success defined as Cobb angle < 50 degrees at skeletal maturity
    - skeletal maturity - Risser grade 4 in females and 5 in males plus Sanders digital maturity stage 7
    - Cobb angle ≥ 50 degrees reported to be commonly used indicator for surgical intervention in adolescent idiopathic scoliosis
  - treatment success in 75% in bracing group vs. 42% in observation group ($p < 0.05$, NNT 3)
  - no significant differences in quality of life or adverse events
  - Reference - BRAIST trial (N Engl J Med 2013 Oct 17;369(16):1512 full-text), editorial can be found in N Engl J Med 2013 Oct 17;369(16):1558, commentary can be found in N Engl J Med 2014 Feb 13;370(7):680, J Pediatr 2014 Mar;164(3):673
- **SpineCor brace may prevent further curve progression or modestly correct spinal curve in adolescent idiopathic scoliosis (level 3 [lacking direct] evidence)**
  - based on randomized trial without clinical outcomes
  - 68 children and adolescents aged 9-14 years with idiopathic scoliosis and no prior treatment for scoliosis were randomized to brace (SpineCor) vs. no brace (control) and followed for 5 years
  - at baseline, all patients had Cobb angle 15-30 degrees, Risser grade ≤ 2, and suspected high risk of progression (based on family history and physical maturity) or demonstrated progression of ≥ 5 degrees in past 6 months

    - dropouts 19% with brace vs. 42% with observation only (no p value reported)
    - comparing brace vs. control at 5 year follow-up in 47 patients who completed study
      - correction ≥ 5 degrees from baseline in 50% vs. 9.5% (p = 0.003, NNT 3)
      - correction or stabilization (change < 5 degrees from baseline) in 73.1% vs. 57.2% (no p value reported)
      - progression > 5 degrees from baseline in 26.9% vs. 42.8% (no p value reported)
      - Cobb angle ≤ 45 degrees in 88.5% vs. 85.7% (no p value reported)
    - Reference - Eur J Phys Rehabil Med 2014 Oct;50(5):479 full-text
    - *DynaMed commentary* -- Spincor is a nonrigid, asymmetric device infrequently used by orthopedic surgeons
  - **electronic monitoring may improve brace compliance in patients with adolescent idiopathic scoliosis (level 3 [lacking direct] evidence)**
    - based on small randomized trial without clinical outcomes
    - 21 patients (mean age 12 years) with adolescent idiopathic scoliosis and thoraco-lumbo-sacral-orthosis spinal brace randomized to notification of compliance monitoring vs. no notification for 14 weeks
    - compliance assessed with temperature probe inside brace
    - brace compliance was 85.7% with notification vs. 56.5% with no notification (p = 0.029, corresponding to mean difference of 5.24 hours/day)
    - Reference - Spine (Phila Pa 1976) 2012 Apr 20;37(9):717

Scoliosis-specific exercises

- scoliosis-specific exercises may be considered as adjuvant treatment to other conservative treatments, but evidence for effectiveness is weak and inconsistent[3]
  - usually involves attempts at auto-correction
  - has been reported to reduce progression of spine curvature in patients with adolescent idiopathic scoliosis, but evidence is of limited quality
    - **scoliosis-specific exercises might help reduce spine curvature in patients with adolescent idiopathic scoliosis (level 3 [lacking direct] evidence)**
      - based on nonclinical outcome from Cochrane review with limited evidence
      - systematic review of 1 randomized trial and 1 prospective cohort study evaluating scoliosis-specific exercises in 154 patients with adolescent idiopathic scoliosis
      - compared to conservative treatments alone in 1 trial with 80 adolescents, addition of scoliosis-specific exercises to other conservative treatments decreased spine curvature, including

        - thoracic curve (mean difference 9 degrees, 95% CI 5.47-12.53 degrees)
        - lumbar curve (mean difference 8 degrees, 95% CI 5.08-10.92 degrees)
    - scoliosis-specific exercises associated with nonsignificant reduction in brace prescriptions (risk ratio 0.24, 95% CI 0.06-1.04) in 1 prospective cohort study with 74 patients
    - Reference - Cochrane Database Syst Rev 2012 Aug 15;(8):CD007837
- **self-correction spinal exercises and education may decrease or slow progression of spinal curve more effectively than traditional spinal exercises in patients with adolescent idiopathic scoliosis (level 3 [lacking direct] evidence)**
    - based on nonclinical outcome from randomized trial without attention control
    - 110 patients > 10 years old with adolescent idiopathic scoliosis with Cobb angle 10-25 degrees and Risser grade < 2 were randomized to active self-correction vs. traditional spinal exercises in outpatient sessions with therapist for 60 minutes once weekly until skeletal maturity (Risser grade 5) (mean 42.5 months)
        - active self-correction spinal exercises included
            - spinal strengthening and stretching exercises tailored to specific type of curve
            - self-correction during task-oriented exercises such as sit-to-stand activities and with light weights
            - cognitive behavioral strategies and ergonomic education
        - traditional spinal exercises included range of motion, spinal strengthening, and stretching exercises, but no educational component
        - all patients asked to complete additional at-home self-regulated exercise sessions for 30 minutes twice weekly during treatment
    - patients evaluated 12 months after treatment
    - comparing mean Cobb angle with active self-correction vs. traditional spinal exercises
        - at baseline 19.3 vs. 19.2 (not significant)
        - at end of treatment 14 vs. 20.9 ($p < 0.001$)
        - at 12-month follow-up 14.3 vs. 22 ($p < 0.001$)
    - minor temporary pain reported in 20% with active self-correction vs. 25.5% with control and managed by symptomatic drugs and brief rest periods
    - Reference - Eur Spine J 2014 Jun;23(6):1204, commentary can be found in Eur Spine J 2014 Oct;23(10):2218, Eur Spine J 2014 Oct;23(10):2221
- **addition of forward head correction to traditional stretching and strengthening exercises may improve function at 3 months in adolescents with idiopathic scoliosis (level 2 [mid-level] evidence)**
    - based on randomized trial without blinding

    - 76 adolescents (mean age about 13.8 years) in Egypt with adolescent idiopathic scoliosis were randomized to forward head posture corrective exercise program 4 times weekly vs. no head posture correction for 10 weeks and followed for 3 months
      - forward head posture corrective exercise program consisted of strengthening of deep cervical flexors, cervical flexors through chin drop in sitting, shoulder retractors, and unilateral and bilateral pectoralis stretches
      - all patients had traditional stretching and strengthening exercises 3 times weekly for 10 weeks
    - at baseline, all patients had Cobb angle 10-30 degrees, craniovertebral angle < 50 degrees, and skeletal immaturity (Risser grade ≤ 2)
    - comparing patients with vs. without forward head posture correction exercise
      - self-reported Functional Rating Index (total score range 0-100 with higher score indicating increased disability)
        - at end of treatment 10.7 vs. 11.9 (not significant)
        - at 3-month posttreatment follow-up 10 vs. 13.8 (p = 0.001)
      - craniovertebral angle (based on lateral photograph of patient in sitting position)
        - at end of treatment 41.2 vs. 38.4 degrees (p = 0.006)
        - at 3-month posttreatment follow-up 41.2 vs. 37.5 degrees (p = 0.002)
    - Reference - Clin Rehabil 2012 Dec;26(12):1123
    - review of exercise therapy for treatment of adolescent idiopathic scoliosis can be found in Eur Spine J 2012 Mar;21(3):382 full-text, commentary can be found in Eur Spine J 2013 Jun;22(6):1438 full-text
- may be effective for pain associated with scoliosis
  - **aerobic-centered physiotherapy might improve quality of life in patients with adolescent idiopathic scoliosis requiring surgical treatment (level 2 [mid-level] evidence)**
    - based on small randomized trial
    - 40 patients (aged 10-18 years) requiring surgery for adolescent idiopathic scoliosis and thoracic curve Cobb angle ≥ 45 degrees were randomized to aerobic-centered (with treadmill or stationary bike) physiotherapy for 60 minutes 3 times weekly vs. no physiotherapy (control) for 4 months before surgery
    - Short Form-36 quality-of-life scores increased from baseline for physiotherapy but not control group for each component
    - comparing Short Form-36 quality-of-life scores after 4 months in physiotherapy vs. control groups (for each component, total score range 0-100 with higher score indicated better outcomes)
      - functional capacity 91.3 vs. 49.5 (p < 0.001)
      - physical health 96.3 vs. 58.8 (p < 0.001)
      - pain 97.1 vs. 76.7 (p < 0.001)

        - general health status 68.2 vs. 29.9 ($p < 0.001$)
        - vitality 81.3 vs. 41.3 ($p < 0.001$)
        - social aspects 84.4 vs. 52.5 ($p < 0.001$)
        - emotional aspects 93.3 vs. 38.3 ($p < 0.001$)
        - mental health 86.4 vs. 49 ($p < 0.001$)
    - Reference - Am J Orthop (Belle Mead NJ) 2014 Jun;43(6):E112

Follow-up

- in patients being observed for adolescent idiopathic scoliosis, perform regular x-ray monitoring to assess for curve progression (≥ 5 degree change in Cobb angle)[2]
    - suggested follow-up schedule varies by growth potential and Cobb angle in adolescents with no red flags
    - red flags requiring earlier follow-up include clinically significant pain, neurofibromatosis, connective-tissue disorders, left thoracic curvature, neurologic abnormalities, foot deformity, or excessive lordosis or kyphosis
    - for prepubertal girls and boys aged < 10 years
        - Cobb angle 10-14 degrees, follow-up diagnostic assessment in 1 year
        - Cobb angle 15-19 degrees
            - follow-up diagnostic assessment in 3-6 months
            - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
        - Cobb angle 20-24 degrees
            - follow-up diagnostic assessment or refer to orthopedist in 3 months
            - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
        - Cobb angle ≥ 25 degrees, refer to orthopedist and see patient in 1 month
    - for pubertal but premenarchal girls and pubertal boys aged 12-14 years
        - Cobb angle 10-14 degrees, follow-up diagnostic assessment in 1 year
        - Cobb angle 15-19 degrees
            - follow-up diagnostic assessment in 3-6 months
            - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
        - Cobb angle 20-24 degrees
            - follow-up diagnostic assessment in 3 months
            - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
        - Cobb angle ≥ 25 degrees, refer to orthopedist and see patient in 1 month
    - for postmenarchal girls and boys aged 14-16 years
        - Cobb angle 10-14 degrees, follow-up diagnostic assessment in 1 year
        - Cobb angle 15-29 degrees
            - follow-up diagnostic assessment in 6 months
            - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
        - Cobb angle 30-45 degrees, refer to orthopedist
        - Cobb angle ≥ 45 degrees, refer to orthopedist and see patient in 1 month

    - for girls ≥ 2 years after menarche or boys aged 16-18 years
      - Cobb angle 10-19 degrees, no treatment necessary
      - Cobb angle 20-29 degrees
        - follow-up diagnostic assessment in 5 years
        - if Cobb angle increased ≥ 5 degrees, refer to orthopedist
      - Cobb angle 30-45 degrees, refer to orthopedist
      - Cobb angle ≥ 45 degrees, refer to orthopedist and see patient in 1 month
- **postoperative x-ray appears to have limited utility for guiding postoperative management of scoliosis (level 2 [mid-level] evidence)**
    - based on diagnostic cohort study without blinding and without independent validation
    - 451 patients (mean age 15 years) with scoliosis who had surgical correction at 1 institution were assessed
      - analysis included 1,969 clinical exams and corresponding x-rays
      - 72.5% had adolescent idiopathic scoliosis, 23.3% had neuromuscular scoliosis, and 4.2% had scoliosis due to other causes
    - 42 patients (9.3%) had change in treatment course overall
      - all patients with change in treatment were symptomatic
      - 15 of these patients had abnormal postoperative x-ray
    - no patients had change in treatment course for abnormal x-ray finding alone
    - performance of abnormal x-ray finding for predicting change in treatment
      - sensitivity 35.7%
      - specificity 98.1%
      - positive predictive value 28.8%
      - negative predictive value 98.6%
    - Reference - J Bone Joint Surg Am 2014 Jul 2;96(13):1127

Complications and Prognosis

Complications

- primary complication of idiopathic scoliosis is disfigurement of torso with shoulder or waist asymmetry, rib rotation, or trunk imbalance[2]
- pulmonary insufficiency syndromes due to altered posture impairing development[1, 2]
    - less common with adolescent onset scoliosis
    - thoracic scoliosis > 50 degrees in adolescent patients increases risk for shortness of breath later in life
    - lung volumes are diminished if thoracic idiopathic scoliosis is ≥ 70 degrees
    - symptomatic restrictive pulmonary disease common in patients with curve magnitude > 100 degrees

Prognosis

- 3%-10% of patients having surgery for idiopathic scoliosis reported to require revision surgery within 10 years[2]
- in adolescents with idiopathic scoliosis[1, 2]
  - scoliosis is not progressive after skeletal maturity in most cases
  - curve progression rare if Cobb angle ≤ 30 degrees and patient has reached skeletal maturity (bone age 15 years in girls or 17 years in boys, or fusion of physis on phalanges and metacarpals)
  - factors associated with increased risk for curve progression
    - Cobb angle ≥ 50 degrees in female adolescents associated with highest risk for curve progression into adulthood
    - initial large curve (> 30 degrees)
    - skeletally immaturity at diagnosis
    - female sex
    - for mild scoliosis (Cobb angle < 25 degrees)
      - curve progression reported in 10%-15%
      - severe curve progression (Cobb angle > 45 degrees) reported in 2%-4%
      - Reference - Spine (Phila Pa 1976) 2010 Dec 1;35(25):E1455
    - **skeletal immaturity, initial Cobb angle ≥ 30 degrees, and osteopenia at time of diagnosis each associated with increased risk of spinal curve progression within 3 years in patients with adolescent idiopathic scoliosis**
      - based on cohort study
      - 324 girls (aged 11-16) in Hong Kong diagnosed with adolescent idiopathic scoliosis who had no treatment or who had no demonstrated halt of curve progression due to bracing were assessed every 6 months for 3 years
      - 50% had curve progression (increase in Cobb angle by ≥ 6 degrees between consecutive assessments)
      - factors at time of diagnosis associated with increased risk of progression in multivariate analysis
        - skeletal immaturity as evidenced by
          - lower Risser grade (odds ratio [OR] 4.7, 95% CI 2.2-9.9)
          - younger age (OR 2.1, 95% CI 1.1-4)
          - premenarchal status (OR 2.5, 95% CI 1-6)
        - initial Cobb angle 30-39 degrees (compared to < 20 degrees) (OR 4.8, 95% CI 1.9-11.9)
        - initial Cobb angle ≥ 40 degrees (relative to < 20 degrees) (OR 4.6, 95% CI 1.3-15.9)
        - osteopenia of the concave femoral neck (OR 2.3, 95% CI 1.1-4.5)
      - initial Cobb angle 20-29 degrees not associated with increased risk of progression
      - Reference - J Bone Joint Surg Am 2005 Dec;87(12):2709
    - curve > 50 degrees reported to progress 0.75-1 degrees annually

- adolescent idiopathic scoliosis associated with increased risk for chronic back pain in adulthood, regardless of treatment modality
  - **untreated adolescent-onset idiopathic scoliosis associated with increased risk of long-term chronic back pain**
    - based on cohort study
    - 179 patients had physical exam and completed questionnaires
      - 117 patients (aged 54-80 years, 89% women) with untreated, late-onset (usually at puberty) idiopathic scoliosis diagnosed between 1932 and 1944 and followed 50 years
      - 62 age- and sex-matched controls without evidence of non-age-related spinal deformity
    - comparing patients with scoliosis vs. controls at 50-year follow-up
      - chronic back pain in 61% vs. 35% ($p = 0.003$)
      - overall body satisfaction 3.6 vs. 4.2 ($p = 0.001$) (score range 1-6 with higher score indicating increased satisfaction)
      - no significant differences in pulmonary function, number of study-defined daily activities able to be performed, or depression
    - Reference - JAMA 2003 Feb 5;289(5):559, editorial can be found in JAMA 2003 Feb 5;289(5):608, commentary can be found in JAMA 2003 May 28;289(20):2644, J Fam Pract 2003 Jun;52(6):451, Am Fam Physician 2003 Jun 1;67(11):2391
  - **adolescent idiopathic scoliosis treated with bracing associated with increased risk of mild lumbar and thoracic pain and increased functional disability in adulthood**
    - based on cohort study
    - 209 adults evaluated for back pain and function
      - 109 adults (mean age 39.3 years) who had brace treatment for adolescent idiopathic scoliosis before age 21 (between 1968 and 1977) and were followed ≥ 20 years
      - 100 age- and sex-matched controls
    - 7.9 degrees mean curve progression from end of treatment in patients with scoliosis
    - comparing patients vs. controls at follow-up
      - lumbar pain (mostly mild) in 75% vs. 47% ($p = 0.005$)
      - thoracic pain (mostly mild) in 36% vs. 22% ($p = 0.033$)
      - Oswestry Disability Index for back function 9.2 vs. 4.8 ($p = 0.001$) (higher score indicating increased dysfunction)
      - Oswestry Disability Index for general function 7.7 vs. 4.2 ($p < 0.001$) (higher score indicating increased dysfunction)
      - occurrence of sick leave due to back problems in 38% vs. 19% ($p < 0.004$)
    - no significant differences in other sociodemographic factors or general health-related quality of life
    - Reference - Spine (Phila Pa 1976) 2003 Sep 15;28(18):2078

- **adolescent idiopathic scoliosis treated with spinal fusion surgery associated with increased risk of mild lumbar pain in adulthood**
  - based on cohort study
  - 239 adults evaluated for back pain and function
    - 139 adults who had spinal fusion surgery for adolescent idiopathic scoliosis before age 21 (between 1968 and 1977) and were followed ≥ 20 years
    - 100 age- and sex-matched controls
  - in patients with scoliosis
    - mean curve progression 3.5 degrees from end of treatment
    - revision surgery in 5.1%
  - comparing patients vs. controls
    - lumbar pain (mostly mild) in 65% vs. 47% ($p < 0.008$)
    - occurrence of sick leave due to back problems in 45% vs. 19% ($p = 0.004$)
  - no significant differences in Oswestry Disability Index for back function or general health-related quality of life
  - Reference - Spine (Phila Pa 1976) 2003 Sep 15;28(18):E373

Prevention and Screening

Screening

- Scoliosis Research Society, Pediatric Orthopedic Society of North America, American Academy of Orthopedic Surgeons, and the American Academy of Pediatrics all recommend screening for scoliosis
  - twice in girls, at ages 10 and 12 years
  - once in boys, at age 13 or 14 years
  - Reference - Scoliosis Research Society 2016 full-text

- United States Preventive Services Task Force (USPSTF) recommends against the routine screening of asymptomatic adolescents for idiopathic scoliosis (USPSTF Grade D) (USPSTF 2004 Jun)
  - *DynaMed commentary* -- USPSTF recommendations have not been updated since newer evidence published indicating benefit from bracing

- American Academy of Family Physicians recommends against screening adolescents for scoliosis
  - there is no good evidence that screening asymptomatic adolescents detects idiopathic scoliosis at an earlier stage than detection without screening
  - potential harms of screening and treating adolescents include unnecessary follow-up visits and evaluations due to false positive test results and psychological adverse effects
  - Reference - Choosing Wisely 2013 Sep 24

- **school-based scoliosis screening may help detect adolescent idiopathic scoliosis (level 2 [mid-level] evidence)**
  - based on diagnostic cohort study
  - 306,144 children and adolescents attending school in Hong Kong had school-based screening for scoliosis (annual screening from grades 5 to 9 beginning in 1995-1996)
  - follow-up 10 years
  - screen used forward bending test with scoliometer
    - if scoliometer reading 5-15 degrees, referred to further screen with moiré topography (if positive, referred for medical evaluation)
    - if scoliometer reading ≥ 15 degrees, referred for medical evaluation
  - diagnosis of scoliosis (Cobb angle > 10 degrees) confirmed by medical records
  - prevalence of scoliosis
    - 3.5% with Cobb angle ≥ 10 degrees
    - 1.8% with Cobb angle ≥ 20 degrees
    - 0.2% with Cobb angle ≥ 40 degrees
  - diagnostic performance of school-based screening for detection of adolescent idiopathic scoliosis
    - with Cobb angle ≥ 10 degrees
      - sensitivity 93.8%
      - specificity 99.2%
      - positive predictive value (PPV) 81%
      - negative predictive value (NPV) 99.8%
    - with Cobb angle ≥ 20 degrees
      - sensitivity 91%
      - specificity 97.5%
      - PPV 39.8%
      - NPV 99.8%
    - with Cobb angle ≥ 40 degrees
      - sensitivity 77.6%
      - specificity 96.1%
      - PPV 4.6%
      - NPV 99.9%
  - Reference - Spine J 2015 May 1;15(5):825

Quality Improvement

Choosing Wisely

- American Academy of Family Physicians recommends against screening adolescents for scoliosis

- there is no good evidence that screening asymptomatic adolescents detects idiopathic scoliosis at an earlier stage than detection without screening
- potential harms of screening and treating adolescents include unnecessary follow-up visits and evaluations due to false positive test results and psychological adverse effects
- Reference - Choosing Wisely 2013 Sep 24

Choosing Wisely Canada

- Canadian Spine Society recommends clinicians don't miss opportunity to brace patients with adolescent idiopathic scoliosis and skeletal immaturity, who have > 1 year of growth remaining and curve magnitude of > 20 degrees (Choosing Wisely Canada 2015 Jun 2)

Guidelines and Resources

Guidelines

International guidelines

- Society on Scoliosis Orthopaedic and Rehabilitation Treatment (SOSORT)
  - SOSORT guideline on orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth can be found in Scoliosis 2012 Jan 20;7(1):3 full-text
  - SOSORT consensus paper on reducing x-ray exposure in pediatric patients with scoliosis can be found in Scoliosis 2014 Apr 25;9:4 full-text
  - SOSORT guideline on standards of management of idiopathic scoliosis with corrective braces in everyday clinics and in clinical research can be found in Scoliosis 2009 Jan 16;4:2 full-text

United States guidelines

- American College of Radiology/Society for Pediatric Radiology/Society of Skeletal Radiology (ACR/SPR/SSR) practice parameter on performance of radiography for scoliosis in children can be found at ACR 2014 PDF
- United States Preventive Services Task Force (USPSTF) recommendation on screening idiopathic scoliosis in adolescents can be found atUSPSTF 2004 Jun
- American Association of Neuroscience Nurses (AANN) guideline on thoracolumbar spine surgery preoperative and postoperative patient care can be found at National Guideline Clearinghouse 2012 Jun 11:35210

European guidelines

- Haute Autorité de Santé conseils pour scoliose structurale évolutive (dont l'angle est égal ou supérieur à 25 degré) jusqu'à maturation rachidienne se trouvent sur le site Haute Autorité de Santé 2008 Feb [French]

Review articles

- reviews of adolescent idiopathic scoliosis can be found in

- BMJ 2013 Apr 30;346:f2508, commentary can be found in BMJ 2013 May 28;346:f3392
- Pediatr Ann 2013 Nov;42(11):224
- Adolesc Health Med Ther 2013;4:59 full-text
- Lancet 2008 May 3;371(9623):1527
- Scoliosis 2006 Mar 31;1(1):2 full-text

- reviews of treatments
  - review of bracing for idiopathic scoliosis in adolescents can be found in Eur J Phys Rehabil Med. 2014 Feb;50(1):93 full-text
  - review of exercise-oriented management of scoliosis can be found in Scoliosis 2015;10:3 full-text
  - review of surgical treatment of scoliosis in growing spine can be found in Curr Opin Pediatr 2014 Feb;26(1):57
  - review of new methods for treatment of scoliosis in growing spine can be found in Neurosurg Clin N Am 2007 Oct;18(4):697
- review of early-onset scoliosis can be found in Pediatrics 2016 Jan;137(1):1
- review of back pain in children can be found in J Musculoskel Med 2007 Feb;24(2):73
- review of exercise for managing adolescent scoliosis can be found in J Musculoskel Med 2007 Mar;24(3):107

MEDLINE search

- to search MEDLINE for (Scoliosis) with targeted search (Clinical Queries), click therapy, diagnosis, or prognosis

Patient Information

- handout from National Institute of Arthritis and Musculoskeletal and Skin Diseases PDF or in Spanish PDF
- handout from American Academy of Orthopaedic Surgeons
- handout from American Association of Neurological Surgeons
- handout from Patient UK PDF
- handout from KidsHealth or in Spanish
- handout from TeensHealth or in Spanish
- handout from Mayo Clinic
- handout from Johns Hopkins Medicine

ICD-9/ICD-10 Codes

ICD-9 codes

- 737.30 scoliosis (and kyphoscoliosis), idiopathic
- 737.31 resolving infantile idiopathic scoliosis
- 737.32 progressive infantile idiopathic scoliosis

- 737.33 scoliosis due to radiation
- 737.34 thoracogenic scoliosis
- 737.39 other kyphoscoliosis and scoliosis
- 737.43 scoliosis associated with other conditions
- 754.2 congenital musculoskeletal deformities of spine

ICD-10 codes

- M41 scoliosis
  - M41.0 infantile idiopathic scoliosis
  - M41.1 juvenile or adolescent idiopathic scoliosis
  - M41.2 other idiopathic scoliosis
  - M41.3 thoracogenic scoliosis
  - M41.4 neuromuscular scoliosis
  - M41.5 other secondary scoliosis
  - M41.8 other forms of scoliosis
  - M41.9 scoliosis, unspecified
  - optional fourth digit site codes
    - 0 multiple sites in spine
    - 1 occipito-atlanto-axial region
    - 2 cervical region
    - 3 cervicothoracic region
    - 4 thoracic region
    - 5 thoracolumbar region
    - 6 lumbar region
    - 7 lumbosacral region
    - 8 sacral and sacrococcygeal region
    - 9 site unspecified
- M96.5 postradiation scoliosis
- Q67.5 congenital deformity of spine
- Q76.3 congenital scoliosis due to congenital bony malformation

References

General references used

- 1. El-Hawary R, Chukwunyerenwa C. Update on evaluation and treatment of scoliosis. Pediatr Clin North Am. 2014 Dec;61(6):1223-41
- 2. Hresko MT. Clinical practice. Idiopathic scoliosis in adolescents. N Engl J Med. 2013 Feb 28;368(9):834-41
- 3. Negrini S, De Mauroy JC, Grivas TB. Actual evidence in the medical approach to adolescents with idiopathic scoliosis. Eur J Phys Rehabil Med. 2014 Feb;50(1):87-92 full-text

Recommendation grading systems used

- United States Preventive Services Task Force (USPSTF) grades of recommendation (after July 2012)
  - Grade A - USPSTF recommends the service with high certainty of substantial net benefit
  - Grade B - USPSTF recommends the service with high certainty of moderate net benefit or moderate certainty of moderate-to-substantial net benefit
  - Grade C - USPSTF recommends selectively offering or providing the service (based on professional judgment and patient preference) with at least moderate certainty of small net benefit
  - Grade D - USPSTF recommends against providing the service with moderate-to-high certainty of no net benefit or harms outweighing benefits
  - Grade I - insufficient evidence to assess balance of benefits and harms
  - Reference - USPSTF Grade Definitions

Synthesized Recommendation Grading System for DynaMed Plus

- *DynaMed* systematically monitors clinical evidence to continuously provide a synthesis of the most valid relevant evidence to support clinical decision-making (See 7-Step Evidence-Based Methodology).
- Guideline recommendations summarized in the body of a *DynaMed* topic are provided with the recommendation grading system used in the original guideline(s), and allow *DynaMed* users to quickly see where guidelines agree and where guidelines differ from each other and from the current evidence.
- In *DynaMed Plus* (DMP), we synthesize the current evidence, current guidelines from leading authorities, and clinical expertise to provide recommendations to support clinical decision-making in the Overview & Recommendations section.
- We use the Grading of Recommendations Assessment, Development and Evaluation (GRADE) to classify synthesized recommendations as Strong or Weak.
  - **Strong recommendations** are used when, based on the available evidence, clinicians (without conflicts of interest) consistently have a high degree of confidence that the desirable consequences (health benefits, decreased costs and burdens) outweigh the undesirable consequences (harms, costs, burdens).
  - **Weak recommendations** are used when, based on the available evidence, clinicians believe that desirable and undesirable consequences are finely balanced, or appreciable uncertainty exists about the magnitude of expected consequences (benefits and harms). Weak recommendations are used when clinicians disagree in judgments of relative benefit and harm, or have limited confidence in their judgments. Weak recommendations are also used when the range of patient values and preferences suggests that informed patients are likely to make different choices.
- *DynaMed Plus* (DMP) synthesized recommendations (in the Overview & Recommendations section) are determined with a systematic methodology:

- Recommendations are initially drafted by clinical editors (including ≥ 1 with methodological expertise and ≥ 1 with content domain expertise) aware of the best current evidence for benefits and harms, and the recommendations from guidelines.
- Recommendations are phrased to match the strength of recommendation. **Strong recommendations** use "should do" phrasing, or phrasing implying an expectation to perform the recommended action for most patients. **Weak recommendations** use "consider" or "suggested" phrasing.
- Recommendations are explicitly labeled as **Strong recommendations** or **Weak recommendations** when a qualified group has explicitly deliberated on making such a recommendation. Group deliberation may occur during guideline development. When group deliberation occurs through DynaMed-initiated groups:
  - Clinical questions will be formulated using the PICO (Population, Intervention, Comparison, Outcome) framework for all outcomes of interest specific to the recommendation to be developed.
  - Systematic searches will be conducted for any clinical questions where systematic searches were not already completed through DynaMed content development.
  - Evidence will be summarized for recommendation panel review including for each outcome the relative importance of the outcome, the estimated effects comparing intervention and comparison, the sample size, and overall quality rating for the body of evidence.
  - Recommendation panel members will be selected to include at least three members that together have sufficient clinical expertise for the subject(s) pertinent to the recommendation, methodological expertise for the evidence being considered, and experience with guideline development.
  - All recommendation panel members must disclose any potential conflicts of interest (professional, intellectual, and financial), and will not be included for the specific panel if a significant conflict exists for the recommendation in question.
  - Panel members will make **Strong recommendations** if and only if there is consistent agreement in a high confidence in the likelihood that desirable consequences outweigh undesirable consequences across the majority of expected patient values and preferences. Panel members will make **Weak recommendations** if there is limited confidence (or inconsistent assessment or dissenting opinions) that desirable consequences outweigh undesirable consequences across the majority of expected patient values and preferences. No recommendation will be made if there is insufficient confidence to make a recommendation.
  - All steps in this process (including evidence summaries which were shared with the panel, and identification of panel members) will be transparent and accessible in support of the recommendation.
- Recommendations are verified by ≥ 1 editor with methodological expertise, not involved in recommendation drafting or development, with explicit confirmation that Strong recommendations are adequately supported.

- Recommendations are published only after consensus is established with agreement in phrasing and strength of recommendation by all editors.
- If consensus cannot be reached then the recommendation can be published with a notation of "dissenting commentary" and the dissenting commentary is included in the topic details.
- If recommendations are questioned during peer review or post publication by a qualified individual, or reevaluation is warranted based on new information detected through systematic literature surveillance, the recommendation is subject to additional internal review.

DynaMed editorial process

- DynaMed topics are created and maintained by the DynaMed Editorial Team and Process.
- All editorial team members and reviewers have declared that they have no financial or other competing interests related to this topic, unless otherwise indicated.
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