Pediatric Scoliosis and Kyphosis: An Overview of Diagnosis, Management, and Surgical Treatment

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ABSTRACT

Evaluation of pediatric spinal deformity requires knowledge of special orthopaedic testing and radiographic interpretation. The determination of recommendations for treatment of spinal abnormalities in children can be challenging and at times complex, as treatment options are dependent upon a variety of factors. The etiology of scoliosis or kyphosis, presence or absence of vertebral anomalies, symptoms, magnitude of the curve, physiologic/skeletal age, and evidence of and risk of progression all require consideration and play a role in the shared decision-making process. This article provides an overview of relevant information and includes research outcomes to support the care of pediatric patients with spinal deformities. [Pediatr Ann. 2017;46(12):e472-e480.]

Primary care providers (PCPs) often screen their pediatric patients for scoliosis and kyphosis when performing complete physical examinations during routine wellness visits. Identification of an abnormal spinal condition in infants, toddlers, children, and adolescents can generate a referral to an orthopaedic specialist. The specialist’s input may, at the very least, alleviate patient and family anxiety or, if necessary, provide for more treatment options and appropriate management with the potential to mitigate progression and long-term consequences. This article defines scoliosis and kyphosis in pediatric patients, reviews the differential diagnoses, categorizes the potential natural history and issues, examines treatment options, and examines shared patient/family-provider decision-making for treatment choice. It describes the complexity of the surgical decision (in the case of severe spinal abnormalities), explains the risks and benefits of surgery, considers postsurgical management, and reviews published historical complication rates of these procedures.

SPINAL MISALIGNMENT SYMPTOMS AND CLINICAL PRESENTATION

Most patients with scoliosis or kyphosis are asymptomatic, without complaints or conspicuous signs. Some patients or families may recognize a prominence of the back or uneven shoulders or waist, or report back pain. Scoliosis and kyphosis are typically not painful conditions. Back pain is primarily muscular or postural in nature, most often improving with core strengthening activities or physical therapy. It is unusual for significant back pain to interrupt daily activities or sleep, and rare to have unrelenting symptoms or associated neurologic signs or symptoms such as numbness and tingling in the extremities and bowel or bladder control issues. If any of these atypical symptoms are reported they may be associated with an
underlying pathology and further testing is likely warranted.

Some children, adolescents, or family members may notice an asymmetry with concern for scoliosis such as uneven shoulders, a prominence on one side of the back, a more pronounced scapula, amplified concave flank region, one hip appearing higher than the other, or an overall imbalance or leaning toward one side. Parents may notice a stooped posture or posterior prominence relating to a possible exaggerated kyphosis, or the family or patient may be bothered by their physical appearance.1-4 These family concerns and patient signs may prompt a visit to their PCP.

SCOLIOSIS AND KYPHOSIS: SCREENING AND EVALUATION

Scoliosis and kyphosis screening may be performed on all patients regardless of symptoms. Upon presentation to the PCP, spinal alignment and flexibility may be assessed by inspection, palpation, and an Adam’s forward bend test. This test is performed while the patient stands with their back to the provider, without shoes, feet spaced shoulder-width apart, legs and knees straight, bending to 90 degrees at the waist with arms dangling and palms together. The provider assesses for a significant rotational prominence of one side as measured using an inclinometer centered along the spine from the upper thoracic region to the sacrum, noting the associated spinal region and documenting the correlating angle. An asymmetry or angle of trunk rotation measurement of greater than 7 degrees may warrant a radiographic examination or referral to a spine specialist.

All patients should then be assessed from the side for posture while in an upright position, along with forward flexion and extension to demonstrate extent and flexibility of spinal kyphosis. Any significant increase in kyphosis of the spine should be noted. As sagittal alignment may prove rather difficult to judge, initial radiographic examination may include posteroanterior (PA) and lateral views.

When findings on physical examination raise the suspicion of scoliosis or kyphosis, other key areas should be carefully assessed. The examiner should note the lower extremity range of motion at the hips, knees, and ankles; muscle strength including hip, knee, and toe flexion and extension, hip abductors, and hip adductors; evidence of joint hypermobility; and appraisal of any leg length discrepancy (if noted, measurement of each leg from the anterior superior iliac spine to the medial malleolus to determine difference). An examination for skin lesions (ie, café-au-lait spots) and midline cutaneous anomalies (ie, dimple, tuft of hair) should also be performed. The examination should also include testing the patient’s sensation, reflexes, and gait patterns.2,4

Assessment of children with neuromuscular conditions may be challenging for various reasons. In young children, cognitive and communicative skills may be limited. Posture, spinal alignment, and spine flexibility may need to be assessed in lying or sitting positions versus standing. The Adam’s forward bend test may not be feasible, warranted, or reliable; therefore, the test may need to be modified (eg, a family member supporting the child if there is evidence of weakness) or eliminated altogether if not reproducible. Clinicians should interview the child to assess for complaints of imbalance and pain, and include the caregiver’s perception of the child’s discomfort, difficulties with sitting, or issues maintaining positions. For a child whose primary mode of mobility is a wheelchair, the supportive seating system should be reviewed and documented. Other key physical examination considerations include typical positioning of upper and lower extremities while supine and upright, assessment of muscle atrophy, Galeazzi test to assess for hip dislocation, the presence of contractures, pelvic obliquity, excessive lordosis, and spasticity or increased tone.5

RADIOGRAPHIC EVALUATION FOR DIAGNOSIS AND TREATMENT OPTIONS

Radiographic studies are usually indicated when physical examination reveals 7 degrees or more of asymmetry on the Adam’s forward bend test, as this may be associated with a spinal curve of 20 degrees or more. Imaging of the entire spine should include PA and lateral views of the full spine, including the cervical, thoracic, and lumbar regions in the most upright position possible (standing preferred). If a leg-length discrepancy is identified on physical examination, a block may be placed beneath the foot of the shorter limb to level the pelvis (the size and position should be documented in the technique portion of the X-ray report). From the PA radiograph of the spine, overall alignment is assessed in addition to the Cobb angle (the angle between the most tilted cephalad and caudal vertebrae of the curve), along with the vertebral shape and development. The magnitude of this curve is used to classify scoliosis in terms of natural history, risk of progression, and treatment options4,6 (Figure 1).

The lateral radiograph includes assessment of the vertebral size, shape, or wedging, along with sagittal alignment. Hypokyphosis, or flattening of the thoracic spine, may occur with scoliosis (Figure 2).

The Cobb angle measurement on the lateral view may quantify the kyphosis or lordosis (Figure 3).
For patients with neurological issues, the clinician may obtain both supine and/or upright radiographs. For those who have difficulty standing, an upright view in sitting may give additional information to the supine view (Figure 4 and Figure 5). These additional views may provide useful information. In the supine position, they can show how minimal or improved the curve can be (how flexible is the curve), and in the sitting position they can show the maximum amount of the curve, with gravity a factor.

**RADIOGRAPHIC ASSESSMENT OF MATURITY**

The patient’s skeletal maturity, which is an important component regarding natural history and for treatment decisions, can be assessed on the spinal radiographs by evaluating the graduated ossification of the growth plate of the iliac crest during the adolescent years. The extent of calcification correlates with maturity level using the Risser grading scale (Table 1).

A bone-age X-ray (an AP view of the hand and wrist) is another way to determine skeletal age and, therefore, spinal growth remaining.

Thus, spinal radiographs confirming the diagnosis of scoliosis or kyphosis and the skeletal maturity along with the underlying etiology, are the basis for predicting natural history and potential issues, future treatment options, and management plans.

**DEFINITIONS OF SCOLIOSIS AND KYPHOSIS**

The Pediatric Orthopaedic Society of North America and the Scoliosis Research Society define scoliosis as a complex three-
dimensional rotational deformity of the spine characterized by a lateral curvature of the spine in the frontal plane with a Cobb angle of more than 10 degrees, with decreased thoracic spinal kyphosis in the sagittal plane and clinically characterized by a posterior rib prominence that is produced by rotation of the vertebrae in the transverse plane.

Kyphosis is defined as an exaggerated roundback deformity of the thoracic or thoracolumbar spine that measures greater than 40 degrees by Cobb technique.\textsuperscript{1,2,4}

**DIFFERENTIAL DIAGNOSIS OF SCOLIOSIS TYPES**

**Idiopathic**

Only 2% to 3% of the general population has significant scoliosis, and this can be further categorized according to the underlying cause. The most common type is idiopathic scoliosis, which is seen in otherwise healthy children with no associated disease nor identifiable source of the curvature. These patients typically present with thoracic curve (90% right), lumbar curve, or S-shaped curve (primary curve and a compensatory curve to maintain balance). These curves can progress during growth. Idiopathic scoliosis is further divided by age (adolescent, juvenile, and infantile). Early onset scoliosis (infantile and juvenile) has the greatest potential for curve progression.\textsuperscript{3,4}

**Congenital**

Congenital scoliosis occurs due to abnormal development of the vertebrae during embryogenesis, resulting in conjoined vertebra (failure of segmentation or a “bar”) or misshapen segments (failure of formation such as hemi-vertebrae, butterfly-shaped vertebrae, or tripedicular vertebrae). Scoliosis of this nature may be identified at any time throughout life with a variety of presentations, from mild to severe scoliosis and sometimes with complex curve patterns (Figure 6). Congenital scoliosis can be associated with other anomalies (ie, cardiac, and renal); therefore, the clinician needs to

<table>
<thead>
<tr>
<th>Risser Grade</th>
<th>Skeletal Findings and Maturity</th>
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<tbody>
<tr>
<td>0</td>
<td>No sign of calcification correlates with skeletal immaturity</td>
</tr>
<tr>
<td>1</td>
<td>Initial appearance of ossification of the iliac apophysis calcified 0%-25% correlates with prepuberty and maximal rate of spinal growth</td>
</tr>
<tr>
<td>2</td>
<td>Ossification 25%-50% across the superior ilium correlates with continuing spinal growth</td>
</tr>
<tr>
<td>3</td>
<td>Ossification 50%-75% across the superior ilium correlates with slowing of spinal growth</td>
</tr>
<tr>
<td>4</td>
<td>Ossification 75%-100% across the superior ilium without full fusion correlates with near complete spinal growth</td>
</tr>
<tr>
<td>5</td>
<td>Ossification fused to iliac crest relates to full maturity</td>
</tr>
</tbody>
</table>

Adapted from the Spinal Deformity Study Group.\textsuperscript{7}
perform a detailed history and complete physical examination with attention to associated systems.\textsuperscript{8}

\textbf{Neuromuscular}

Neuromuscular scoliosis affects patients with central neurologic dysfunction (ie, brain injury, cerebral palsy, spina bifida, stroke, spinal cord injury) and peripheral nerve or muscular conditions (ie, spinal muscular atrophy, muscular dystrophy). The muscular imbalance, hypotonia, spasticity, decreased mobility, lack of positional balance, and decreased ability to compensate for this can cause the spine to assume a long sweeping C-shaped curve that may extend to the sacrum with pelvic obliquity, negatively affecting functional sitting ability. Curves of this nature are more likely to be progressive, typically worsen during growth as the trunk elongates, but this may continue to increase into adulthood as well (regardless of the degree of the curve).\textsuperscript{9}

\textbf{Syndromic}

Syndromic scoliosis may be associated with a plethora of conditions not primarily congenital/structural or neuromuscular in etiology. Some fairly common genetic and syndromic diagnoses with increased risk of scoliosis include arthrogryposis, diastrophic dysplasia, Klippel–Feil syndrome, Marfan syndrome, or neurofibromatosis type 1; therefore, patients with these conditions should be screened on a consistent basis.\textsuperscript{10}

\textbf{DIFFERENTIAL DIAGNOSIS OF KYPHOSIS TYPES}

Thoracic or thoracolumbar spinal kyphosis should be evaluated for any structural abnormalities (eg, congenital or developmental kyphosis); if none are found then it is considered postural in nature. If vertebral body wedging (>5 degrees in at least three contiguous vertebrae) is noted, the patient may be diagnosed with Scheuermann’s deformity, which is often associated with irregularity of the vertebral endplates.\textsuperscript{4}

\textbf{FUNCTIONAL AND MEDICAL PROBLEMS OF SCOLIOSIS AND KYPHOSIS}

Scoliosis usually is not associated with functional difficulties. However, if the magnitude of the curve progresses significantly, altered spinal alignment, decreased spine flexibility, eventual degenerative changes, and symptoms of pain have the potential to occur during the patient’s lifetime. Restrictive lung disease (with measurable decrease in forced expiratory volumes or forced vital capacity) can occur in patients with thoracic curves greater than 70 degrees.\textsuperscript{4} Neurological disability is extremely rare. Kyphosis is associated with a modestly increased risk of back pain but otherwise no significant risk of functional issues, although it may have a negative impact on body image.\textsuperscript{1,3,10}

\textbf{ADVANCED IMAGING}

Testing with magnetic resonance imaging (MRI) may be warranted in infantile/juvenile scoliosis, congenital scoliosis or kyphosis, patients with atypical curves, significant persistent pain symptoms, neurologic abnormality or, rarely, other findings on examination (ie, midline cutaneous anomalies or sacral dimple) or history. MRI may identify anomalies of the vertebrae, discs, and spinal cord, including potential etiologies (eg, tethered cord). A computed tomography scan may be used to help further characterize the deformity.\textsuperscript{3,4} The results of these imaging tests may affect treatment decisions.

\textbf{NONSURGICAL ORTHOTIC (BRACE) TREATMENT}

Orthotic treatment continues to be recommended as a nonsurgical option for managing adolescent idiopathic scoliosis (AIS) patients who have curves of 25 to 45 degrees and are of appropriate skeletal age (immature.) Children with significant remaining growth potential (Risser grading scale 0-2) have the greatest propensity for curve progression, which may lead to long-term consequences and eventual surgical recommendation. Treatment with a customized brace (thoracolumbar sacral orthosis [TLSO]) to fit the patient provides external forces to the trunk’s specific curve patterns. The goal of bracing is to control or limit the progression of the curve during remaining growth and thus avoid long-term sequel and spinal fusion surgery. Multicenter studies have shown that bracing is effective for many children and adolescents if worn for more than 13 hours per day, with ef-
ficacy increasing with longer wear and peaking at 18 hours per day.\textsuperscript{11-13} Such brace wear may significantly reduce the risk of curve progression and subsequent surgery. Brace treatment for thoracic kyphosis typically requires a particularly high-based brace (a TLSO with high cervical or clavicle extension [ie, “Milwaukee” style]) that is worn for 1 to 2 years. Some correction of the kyphosis with bracing may occur during use; however, partial loss of this improvement may occur over time after discontinuation of the brace.

Brace compliance may be a challenge for some children and adolescents due to a variety of reasons (eg, discomfort, function, sensory, and peer issues). School accommodations can be made for removal of the brace in a private setting, if desired, for continued participation in physical education and/or sports. After-school and nighttime bracing may be an effective option to improve compliance. Monitoring devices (heat sensors) placed in the brace are being used by some providers with the expectation that compliance can be measured more accurately. Compliance has been shown to improve with such documentation and appropriate feedback\textsuperscript{11} (Table 2).

OTHER NONSURGICAL TREATMENT OPTIONS

Over the past century, many nonsurgical treatments have been attempted for scoliosis management, including spinal manipulation, chiropractic care, spine exercises, physical therapy, and yoga. Each of these have limited evidence of efficacy.

Physical therapists assess the postural deficits, pelvic imbalance, core and hip stability, weakness, and pain. They may focus treatment to include a variety of techniques such as thoracic and lumbar joint mobilization, lower extremity stretching and flexibility, postural stabilization and center of gravity training, spinal alignment training and feedback, neuromuscular re-education, core strengthening, soft tissue mobilization, and proprioception in the treatment sessions along with home exercise programs. Some therapists incorporate a methodical exercise approach to scoliosis, which is an individualized method adapted for idiopathic scoliosis based on self-correction techniques incorporated in functional exercises.\textsuperscript{14}

The “Schroth” method, developed in Germany nearly 100 years ago, has recently become popular in the United States as a conservative option for scoliosis patients.\textsuperscript{15} Schroth exercises promote a customized treatment directed toward spinal rotation, designed to help correct the imbalances of the scoliotic spine. Schroth treatment goals are to increase awareness of alignment, to slow or halt curve progression, and improve cardiopulmonary function. The availability of trained and certified Schroth therapists varies with locale. Although this specific program is promising, the evidence of any efficacy of this method is still limited.\textsuperscript{15}

Yoga maneuvers and poses to realign the spine through strengthening muscles on the convex side while stretching ligaments on the contralateral side requires daily practice for months to potentially benefit posture.\textsuperscript{16} General fitness, martial arts, sports participation, and overall physical education classes are not contraindicated, and thus should be continued and even encouraged after diagnosis of scoliosis. In the end, any and all of these methods do no harm and may improve core strength and posture, but none have been proven to affect the true structural nature or alter the natural history or risk of progression of idiopathic scoliosis.

Serial casting of the trunk is an option typically reserved for infantile scoliosis patients with significant otherwise uncontrollable curves, often in conjunction with eventual bracing.

SURGICAL TREATMENT OPTIONS FOR SPINAL DEFORMITY

Surgery is generally reserved for children who have scoliotic curves greater than 45 to 50 degrees or, more rarely, those with significant imbalance or symptoms. Kyphosis correction surgery is less commonly required, yet offered for patients who have curves of significant magnitude or, rarely, sharp deformities of a lesser degree (with the potential of neurologic compromise). Surgical technique depends on numerous factors including etiology, curve magnitude, spinal balance, and remaining growth. Surgical advances have been made in procedural safeguards, surgical techniques, and instrumentation to improve patient safety and outcomes. Although technological advances have evolved over the decades, the goals of the surgery remain largely unchanged. The overall goal of surgical intervention is to prevent further progression of the primary and compensatory curvatures while improving alignment and overall balance. Spinal fusion intervention includes instrumentation (combination of rods, with hooks, cables, wires, and screw fixation) and bone graft (autograft, allograft, and bone substitutes) to create bone fusion of the vertebrae to achieve long-term stability and alignment. Surgical alternatives such as in situ fusion constructs that allow for or encourage growth, or address accompanying chest wall deformity may be indicated for specific pathology (such as congenital or juvenile scoliosis, or rib anomalies). Developing technologies include vertebral stapling or tethering to manipulate spinal growth. Although the risks of spine surgery include infection, blood loss with need for transfusion, failure of
instrumentation or fusion, and rarely respiratory or neurologic compromise, these are relatively uncommon in the pediatric population.17

The decision to undertake surgical intervention in AIS, congenital, and syndromic scoliosis, and in kyphosis is based on the patient and family’s determination of the potential long-term benefits to alter the natural history, including prevention of later dysfunction, disfigurement, and pain, weighed against the extensive effort and potential complications related to surgery (Figure 7 and Figure 8).

NEUROMUSCULAR SCOLIOSIS

For children, adolescents, and young adults with neuromuscular scoliosis or kyphosis, the treatment decisions, including surgical options, are complex, as both the natural history and response to treatment are quite varied. The underlying neurological etiology and disease course without such intervention are highly variable; thus, long-term outcomes are less predictable. The risk of curve progression is influenced by the disease itself, the magnitude and rigidity of the curve, and balance of the spine. Furthermore, due to muscular imbalance, scoliosis can progress after the child has reached skeletal maturity. Brace treatment has limited scientific evidence for prevention of curve progression in this population; however, orthotics are used to help function (ie, improved posture during activities) and for their possible impact on delaying or halting progression. In children who are primarily wheelchair bound, increased supportive seating components may be incorporated (chest strap, lateral supports, molded back or specialized seating system) to sustain upright posture, alleviate discomfort, and to reduce family concerns of positioning. Due to concern that pulmonary function may be affected by the spinal deformity with diaphragmatic displacement elevated within the thoracic cage, monitoring respiratory status may be warranted. Surgical intervention most often entails instrumentation to the lower lumbar spine or to the pelvis to positively affect balance and sitting tolerance (Figure 9 and Figure 10).

Collaboration with the patient and family when making the decision to undergo this surgery is important so they can understand the potential benefits and possible risks. In certain cases, surgical intervention is determined more by the parent’s perspective on the child’s behalf, with quality-of-life considerations and goals of treatment including the patient’s expression of discomfort or parent’s belief regarding amount of pain and expectations of comfort achieved, assessment of the child’s current level of function and predicted improvements, alleviation of the burden of care, and facility of patient care needs. These benefits may offset the more complex surgery risks (eg, prolonged anesthesia, increased blood loss, higher risk of infection).18

POSTSURGICAL CONSIDERATIONS

Postsurgical management in the hospitalized patient requires a team of professionals. The medical and nursing teams closely monitor the patient’s vital signs, neurological examination, gastrointestinal/genitourinary function, respiratory function, pain, and surgical site for signs of infection, along with other issues. In our hospital, pain management is typically guided by the anesthesia pain team through protocols (initially with epidural catheter and/or intravenous pain medications, then transitioned to oral medications) with the entire team’s around-the-clock assessments, including the patient’s family’s input of pain control, with alterations made to optimize comfort. Physical therapists educate the patient and family regarding spinal precautions (limited trunk forward flexion, avoidance of twisting

### TABLE 2. Treatment Options for Adolescent Idiopathic Scoliosis

<table>
<thead>
<tr>
<th>Observation</th>
<th>Observation or Brace</th>
<th>Brace Treatment</th>
<th>Observation or Surgery</th>
<th>Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25 degrees</td>
<td>Regardless of maturity</td>
<td>25-45 degrees</td>
<td>25-45 degrees</td>
<td>45-49 degrees</td>
</tr>
<tr>
<td>Risser grade 0-5</td>
<td>Moderate/near complete skeletal maturity</td>
<td>Skeletally immature</td>
<td>Skeletally mature</td>
<td>Risser grade 0-2</td>
</tr>
<tr>
<td>20-45 degrees</td>
<td>Skeletally mature</td>
<td>Risser grade 5</td>
<td>–</td>
<td>45-49 degrees</td>
</tr>
<tr>
<td>&lt;25 degrees</td>
<td>Moderate/near complete skeletal maturity</td>
<td></td>
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<td>–</td>
</tr>
</tbody>
</table>
and prone positions, limited upper extremity weight lifting, limited shoulder flexion past 90 degrees, and limited lower extremity hip flexion past 90 degrees), and the treatment team reinforces these with functional activities. The first 2 days after surgery, ambulatory patients are typically walking in the room or hallway, and patients with neuromuscular disorders are sitting in an appropriate wheelchair. A postoperative brace is occasionally fabricated to maintain postural alignment and follow through with precautions.

After discharge home, effective communication, including key information provided regarding postoperative plans for individualized care, may help to facilitate coordination of care for such things as pain control at home and guidance for weaning medications, strategies for constipation relief, and assessment for wound/incision infection through the family and primary care provider. We recommend that the spinal precautions be used for 3 months; however, limitation of activities (such as no physical education and sports participation) may be recommended for at least 6 months while the bone fusion matures. Specific activity restrictions may be individualized based on the patient’s underlying diagnosis, medical history, age, and healing outlook.

**SURGICAL OUTCOMES REPORTED**

The Scoliosis Research Society (SRS) studies complication rates for all deformity operations and tracks statistics such as neurological deficit and wound infection rates. In the reported study of operative treatment in pediatric scoliosis by Reames et al., the overall reported complication rates varied by type: idiopathic with the lowest rate (6.3%), neuromuscular population with the highest rate (17.9%), and congenital (10.6%). Other differences in the incidence of complication rates occurred based on scoliosis etiology (Table 3).

**CONCLUSION**

For children and adolescents with significant scoliosis or kyphosis, patients and families are encouraged to...
consider the long-term issues involved in the complex decision-making about intervention with bracing or surgery. The use of a brace has the most proven efficacy to prevent the progression of adolescent idiopathic scoliosis compared to other nonsurgical options, but it may be less effective for kyphosis management. Long-term outcome data support spine fusion treatment in children and adolescents who are surgical candidates, with excellent healing rates (bone fusion) and minimal complication rates. For patients with neuromuscular scoliosis, families have a more challenging decision regarding the options, as this group often has more limited goals and higher complication rates.

REFERENCES


### TABLE 3.

<table>
<thead>
<tr>
<th>Complications Rates of Pediatric Scoliosis Surgery</th>
<th>(n = 19,360)</th>
<th>(n = 11,227)</th>
<th>(n = 4,657)</th>
<th>(n = 2,012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic deficit, %</td>
<td>0.8 (86)</td>
<td>1.1 (49)</td>
<td>2 (41)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary issues, %</td>
<td>0.6 (63)</td>
<td>1.9 (90)</td>
<td>1.1 (23)</td>
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</tr>
<tr>
<td>Superficial wound infection, %</td>
<td>0.5 (61)</td>
<td>1.7 (79)</td>
<td>1.3 (27)</td>
<td></td>
</tr>
<tr>
<td>Deep wound infection, %</td>
<td>0.8 (95)</td>
<td>3.8 (177)</td>
<td>0.9 (18)</td>
<td></td>
</tr>
<tr>
<td>Death, %</td>
<td>0.02 (2/10,000)</td>
<td>0.3 (3/1,000)</td>
<td>0.3 (3/1,000)</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Reames et al. 13