DERLEME REVIEW

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Postoperative Complications in Patients Undergoing Scoliosis: Review

Skolyoz Cerrahisi Geçiren Hastalarda Görülen Postoperatif Komplikasyonlar

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ABSTRACT Scoliosis is the deformity of spinal vertebrae, most frequently seen in adolescence period when somatic growth rate and bone development is rapid. Etiology is mostly congenital in pediatric population while degenerative changes are more common reasons in adults. Postoperative complications commonly originate from respiratory system. Chronic obstructive pulmonary disease (COPD) is one of the most common factors that increase the risk of developing complications. Insulin dependent diabetes and chronic steroid usage and ASA score greater than 2 are the other risk factors inducing complications. Neurological deficit, another complication frequently seen after scoliosis surgery, may be caused by direct damage to spinal cord during surgery or spinal cord ischemia. Other rare complications of scoliosis surgery are visual problems, syndrome of inappropriate ADH (SIADH), pancreatitis, cholelithiasis, superior mesenteric artery syndrome, ileus and fat embolism. Some of these complications result from positioning during surgery. Particularly; inconvenience of ventilation in prone positioning, decrease in cardiac index, increase in epidural pressure, damage to large vessels like aorta and inferior vena cava and plexus/isolated nerve injuries may be seen.

Keywords: Scoliosis; postoperative complications; spine; adolescent

ÖZET Skolyoz; farklı nedenlerle her yaşta oluşabilen ancak somatik büyümenin ve kemik gelişiminin hızlı olduğu adölesan dönemde en fazla görülen omurga şekil bozukluğudur. Pediatrik popülasyonda konjenital sebeplerle olurken, erişkin hastalarda dejeneratif değişiklikler neden olarak ön plana çıkar. Postoperatif komplikasyonlar sıklıkla respiratuar orijinlidir. Komplikasyon gelişme riskini arttıran faktörlerin başında kronik obstrüktif akciğer hastalığı gelir. ASA sınıflaması 2 ve üzerinde, insülin bağımlı diyabet hastaları ve kronik streoid kullanımı da postoperatif komplikasyon riskini arttıran diğer faktörlerdir. Skolyoz cerrahisi sonrası sık görülebilen diğer komplikasyonlardan nörolojik defisit omuriliğe cerrahi sırasında direkt hasar sonucu ve omuriliğin iskemisine bağlı olabilir. Daha nadir görülen komplikayonlar ise görme problemleri, uygunsuz ADH sendromu, pankreatit, kolelitiazis, süperior mezenter arter sendromu, ileus, yağ embolisidir. Skolyoz cerrahisi sonrası görülen komplikasyonların bir kısmı da pozisyona bağlıdır. Özellikle pron pozisyonu ile ventilasyon güçlüğü, kardiyak indekste düşüş, epidural basınç artışı ve kanama aorta ve inferior vena kava gibi büyük damar yaralanmaları, pleksus veya izole sinir hasarları görülebilir.

Anahtar Kelimeler: Skolyoz; postoperatif komplikasyonlar; omurga; adölesan

Scoliosis is defined as spinal deformity that coexists with lateral angulation and rotation of vertebrae, causing thoracic cage abnormalities. For that reason, pulmonary, cardiovascular and neurological system problems mostly accompany scoliosis cases. Scoliosis is frequently idiopathic (75-90%) and seen 4 times more common in females.[1] Etiologic classification

of scoliosis as defined by ''Terminology Committee of The Scoliosis Research Society'' is collected in 6 main titles.

1. Idiopathic
   - Early onset
   - Late onset
2. Congenital
3. Neuromuscular scoliosis
   - Neuropathic; cerebral palsy, syringomyelia
   - Myopathic: muscular dystrophy, neurofibromatosis, Friedreich's ataxia
4. Neurofibromatosis
5. Mesenchymal diseases
   - Rheumatoid arthritis
   - Marfan syndrome
   - Osteogenesis imperfecta
6. Trauma (vertebral- extravertebral)
   - Fractures, radiotherapy, surgery

Scoliosis is seen more frequently and becomes clinically overt in adolescence period when somatic growth and bone development is rapid. However, it can be seen at any age. The degree of scoliosis can be determined with different methods but most commonly used method is "Cobb angle". Cobb angle is also defined by "Terminology Committee of The Scoliosis Research Society" and can be calculated within 3 steps. First of all, determine the vertebra at upper end of angulation and then, determine the vertebra at lower end of angulation and finally, draw two lines, one parallel to upper border of upper end vertebra and one parallel to lower border of lower end vertebra. Consequently, angle between the lines that are drawn in right angle to these lines is defined as "Cobb angle". Angle greater than 10 degrees is defined as scoliosis. Clinical significance of this angle is that postoperative pulmonary complication risk increases with the degree of angulation.

Indication for surgery in scoliosis is determined by Cobb angle greater than 50 degrees in thoracic vertebrae and Cobb angle greater than 40 degrees in lumbar vertebrae. The rationale is that angulations greater than 50 degrees proceed even after maturation of skeletal system; respiratory functions deteriorate and chance of recovery with surgery gets difficult proportional to the degree of angulation.[2]

CARDIOVASCULAR SYSTEM COMPLICATIONS

In scoliosis cases, cardiovascular system changes are related to mediastinal structural defects and chronic respiratory problems. Cardiac compression caused by thoracic deformity results in decreased exercise capacity and decreased cardiac output marked even in resting state. Cardiac filling pressures have been limited resulting in decreased cardiac output and hypotension during exercise. Therefore, hypotension may be more pronounced under anesthesia in patients with limited preload. Pulmonary hypertension precipitated by chronic hypoxia also contributes to cardiac performance decline. Both decreased preload and increased pulmonary artery pressure result in intense hemodynamic comprise during the whole procedure. Therefore, the evaluation of the preoperative cardiac reserve may play an important role to predict the hemodynamic course of the case. Accompanying congenital heart disease prevalence is increased in scoliosis patients. According to the mitral valve prolapsus incidence is increased by 25% in idiopathic scoliosis cases.[1]

Surgical intervention in scoliosis surgery can be anterior, posterior or combined depending on reason and extension of angulation. In anterior approach, wide thoracoabdominal incision and one-lung ventilation is needed.[3] Posterior approach is related with more blood loss during surgery. Haemorrhagia is more common in long surgery cases with bad positioning and in whom bone grefting is performed. Controlled hypotension, hemodilution and perioperative autotransfusion cell saver can be used to save blood and decrease transfusion requirements. In cardiomyopathy cases, maintainance of total blood volume becomes challenging in case of hemorrhagia. Hypothermia must be prevented by use of bed heaters, humidifiers and infusers with heater.[4] It's shown that use of an-

tifibrinolytic agents diminishes blood loss intraoperatively. The most potent antifibrinolytic agent is aprotinin, a serin protease inhibitor. Aprotinin is associated with hypersensitivity reactions which may reoccur in postoperative 6 months.[5]

RESPIRATORY SYSTEM COMPLICATIONS

Scoliosis is a restrictive pulmonary disease characterised by decreased vital capacity, decreased functional residual capacity and decreased total lung volume. Scoliosis does not directly affect intercostal muscles but may disrupt their functions. Besides restrictive pulmonary disease caused by spinal deformity; in neuromuscular scoliosis, insufficient cough as a result of muscle weakness, increased risk of aspiration and decreased ventilation capacity is also present as the reason of pulmonary dysfunction. Surgical treatment does not restore restrictive pulmonary disease but ceases progression.[6]

The most common perioperative complications after scoliosis surgery are respiratory complications. Main respiratory complications are acute respiratory distress syndrome (ARDS), pneumonia, atelectasis, pulmonary embolism and pneumothorax. Respiratory complications necessitate close follow-up in intensive care unit. Relation between preoperative pulmonary function tests and postoperative complication risk development is still controversial. Studies show no association between preoperative pulmonary function tests and respiratory complication development in idiopathic scoliosis cases.[7] Efficiency of pulmonary function tests has not been shown also in pulmonary complication risk assessment in neuromuscular scoliosis patients. Requirement for postoperative mechanical ventilation is determined by duration of surgery, type of surgery and other intraoperative variables such as blood transfusion.[6]

Development of postoperative pulmonary complication is found to be associated with preoperative Cobb angle greater than 69 degrees.[6] Indeed, Cobb angle equal or greater than 65 degrees is related with significant decrease in lung volumes and ventilation perfusion mismatch. Most cases with Cobb angle greater than 100 degrees develop chronic respiratory disease, pulmonary hypertension and right ventricular hypertrophy, and these situations contribute to increase in morbidity and mortality.[1-7] Risk for development of chronic respiratory disease and pulmonary hypertension is increased in patients with Cobb angle greater than 100 degrees.[1]

Factors determining postoperative mechanical ventilation need after scoliosis surgery are; presence of neuromuscular disease, restrictive pulmonary dysfunction with vital capacity lower than 35%, congenital heart disease, right ventricular dysfunction, obesity, surgery with anterior thoracic approach and blood loss greater than 30 ml/kg during surgery.[1] Besides these factors, postoperative mechanical ventilation need may be due to operation room environment not allowing extubation. Hypothermia is the first thing come to mind that some studies report most scoliosis cases develop hypothermia delaying emergence, even they are poikilothermic postoperatively.[8]

In a study by Gurajala et al., 102 scoliosis patients underwent surgery were followed up and postoperative mechanical ventilation need found to be high in patients with more than 8 vertebrae fused and in patients who are hypothermic intraoperatively.[8] The excess number of vertebrae fused with surgery is associated with increased duration of surgery and increased blood loss, thereby blood transfusion. Therefore risk of developing lung injury related to transfusion is increased. Blood transfusion also increases the risk of hypothermia, hemodynamic instability and pulmonary complication risk. In the same study, it's found that tranexamic acid use had an effect on decreasing blood loss but no effect on early extubation. Likewise, hypothermia causes coagulation defect and increases blood loss. In addition, thoracic scoliosis, anterior approach surgery and thoracoplasty contribute to postoperative respiratory complication develpoment. It's found that thoracic scoliosis, anterior approach surgery and thoracoplasty have no effect on early extubation.[8]

Postoperative pulmonary embolism is a rare consequence of idiopathic scoliosis surgery. Only 1 patient has developed symptomatic postoperative deep vein thrombosis (DVT), none developed pul-

monary embolism, of 313 patients who have spinal surgery.[9] Pulmonary embolism is more common after anterior approach spinal surgery compared with posterior approach. This difference is a result of manipulation of major vascular structures in anterior approach.[9] Pateder et al. studied 361 patients who have undergone 407 scoliosis, kyphosis or kyphoscoliosis surgery retrospectively and reported 10 pulmonary embolism cases despite pharmachologic thromboprophylaxis. In the same study, age, gender, amount of blood loss, duration of surgery and number of fused vertebrae were not risk factors for development of pulmonary embolism.[10] Dearborn et al. investigated 116 adults with spinal surgery, used ultrasonography to diagnose DVT incidence. As a result, they found that 73 patients had asymptomatic pulmonary embolism, one patient had asyptomatic iliac vein thrombosis and 7 patients developed symptomatic pulmonary embolism (2.2%).[11] Of the 7 patients developed symptomatic pulmonary embolism, 6 were combined anterio-posterior spinal fusion surgery patients and onewas posterior approach spinal fusion surgery patient.[11]

NEUROLOGICAL COMPLICATIONS

Neurologic injury risk is always present during surgical instrumentation in scoliosis surgery. Neuromonitorisation is mandatory to minimize the risk of neurologic damage. Particularly in patients who are neurologically intact before surgery, neuromonitorisation has extra importance. It enables detection, prevention and management of a probable injury. However, neurological tests require special equipment and trained personnel, thus they are expensive. Wake up test is the first method for intraoperative neurologic monitorisation in history. Other monitorisation techniques are SSEP (somatosensory evoked potentials) and MEP (Motor Evoked Potentials) monitorisation. Electromyography can also be used for the same purpose.

In wake-up test, patient is informed before anesthesia induction and asked to recognise the voice of testing personnel and follow the instructions. At the time of procedure, patient's wakefullness is provided through the cessation of anesthesia and asked to move hands and feet. During the test, full analgesia must be provided. After getting the response, anesthesia induction is ensured again. Wake-up test is easy to perform in patients who don't have any hearing problem or cognitive dysfunction. The worst complication during wake-up test is a sudden awakening and uncontrolled movement of patient, causing falling of equipment to floor and local injury of incision site. Another complication of wake-up test is pain during awakening period and patient's recalling this pain after the surgery consciously or unconsciously. Unconscious recalling is associated with various neuropsychiatric disorders and difficult to diagnose. It's observed that patient's that wake-up test were performed had sleeping disorders in postoperative period.[12]

SSEP provides continous monitorisation of spinal sensory integrity. It gives opportunity to compare the variables before and after instrumentation and realize the changes. It's known that abnormal SSEP values turn to normal basal values after immediate correction of surgical intervention. SSEP values can be disrupted by trauma at surgical site, compression, hypothermia, hypotension, hypoxia and deep anesthesia. MEP provides motor function monitorisation. MEP results are supressed by spinal cord ischemia, hypotension, blood loss, anemia, neural compression, neuromuscular blocking agents and inhalation anesthetics. According to the latest literature, total intravenous anesthesia does not supress MEP signals.[13]

The neurological damage may complicate as partial or total paraplegia, quadriplagia or peripheral nerve injury postoperatively. Neurologic deficit may be as a result of direct damage to spinal cord or spinal cord ischemia. Migration of bone grefts to spinal canal, fraction of implants, penetration of instrumentations to spinal canal are also reported as reasons of neurologic injury. Neurological deficit related to spinal cord contusion may recover in time. Neurological deficit related to spinal cord ischemia is more likely to be permenant. Ischemia may result from stretching of the spinal vessels during performing maneuvers to correct de-

formity and disturbance of spinal perfusion. In case of occurance of electrophysiologic changes due to ischemia during the maneuvers, stretching of vessels may decrease blood flow and spinal perfusion can be maintained again by decreasing the fixing angle. Prolonged hypotension during surgery may result in disturbance of spinal perfusion. In addition to this, anterior segmental artery ligation in anterior approach surgeries may contribute to spinal cord ischemia. Rarely, neurological injury may be caused by epidural or subdural spinal hemorrhagia in postoperative period.[14]

Scoliosis Research Society reported postoperative neurologic complication in 31 of 6,334 idiopathic adolescent scoliosis cases during 2001-2003 years period, in a report published in 2006.[14] None of them were total neurological deficits and total recovery occured in 61% of cases. Of 1164 patients who have undergone anterior fusion surgery, 5.2% of patients developed neurological complications; and of 4369 patients had underwent posterior fusion surgery, 5.1% of patients developed neurological complication. Risk factors for development of neurological deficits are congenital scoliosis deformities, sharp angled rigid deformities, hyperkyphosis and combined anterior-posterior approach surgery.[14]

OTHER COMPLICATIONS

Visual problems are the leading of rare complications seen after scoliosis surgery. Visual loss results from ischemic optic neuropathy, retinal artery occlusion and cerebral ischemia. Optic neural and retinal perfusion is maintained by the balance between arterial pressure and intraocular pressure or central venous pressure. Postoperative visual loss is asociated with accompanying vascular disease, intraoperative hypotension, anemia, blood loss, prolonged surgery and male gender. Prone positioning is known to cause external compression to the eye resulting in central retinal artery occlusion. Intraocular perfusion significantly diminishes by the contribution of systemic blood pressure fall to intraocular pressure rise in prone position. Eyes should be periodically controlled during surgery in terms of external compression.[15]

In a review, 37 cases with visual loss after spinal surgery were included, mean operation duration was 410 minutes, mean blood loss during surgery was 3500 ml and most patients developed intraoperative hypotension. No significant difference was detected between patients with visual loss and normal visual acuity in terms of hematocrit or blood pressure changes.[15]

Vascular complications are not frequent after spinal surgery and considered as a serious complication. Lumbar arterial injury is reported after posterior spinal instrumentation. In a case report, Sandri et al. reported a 39 years old female who developed hypotensive crisis and abdominal distension 5 hours after the surgery for T8-L5 midline posterior approach stabilization and CT scan revealed wide retroperitoneal hematoma.[16] Angiography showed rupture of lumbar artery. Anterior approach is more likely to cause visceral and vascular complications compared to posterior approach. Major vascular damage is the most tragic complication. In anterior approach spinal surgery, bifurcation of iliac artery and vein is located in front of the surgical site. Iliac vein is prone to trauma and easy to rupture. In addition to this, aorta and vena cava inferior injuries are frequently fatal.

Rare medical complications seen after scoliosis surgery are syndrome of inappropriate ADH (SIADH), pancreatitis, cholelithiasis, superior mesenteric artery syndrome, ileus and fat embolism. SIADH incidence after scoliosis surgery is 6.9%, but it's 2-4 times more frequent in revision surgeries. Patients must be followed carefully in terms of sodium balance and osmolarity in postoperative period.[17] SIADH is thought to be associated with hypotonic salin infusions given preoperatively or intraoperatively. Brazel and Mcphee . Randomized 12 patients who were planned to undergo surgery for idiopathic scoliosis and infused hypotonic salin solution to study group and isotonic salin solution to control group.[18] At the end of the trial, study group showed significant decrease in serum sodium levels and serum osmolarity and developed SIADH.

Superior mesenteric artery syndrome (SMAS); is a rare but potentially fatal complication of scol-

iosis surgery. Clinical manifestations are postoperative nausea and intermittant vomiting. However, these symptoms can be seen non-specifically in postoperative period of scoliosis surgery or ileus. In the presence of any suspect of SMAS, abdominal radiography and barium contrasted graphies should be performed. Early abdominal surgeon consultation should be done especially in high risk patients. (BMI<5% percentile and sagittal kyphosis). Zhu and Oiu reported 7 postoperative SMAS cases in a prospective study including 640 adolescent scoliosis surgery patients.[19] All these 7 patients manifest nausea and intermittent vomiting in 5th day postoperatively. Upper gastrointestinal barium contrast graphies revealed linear cut off in 3rd segment of duodenum from the SMA side. 7 patients that developed SMAS were found to have lower body weight and were higher than normal population. All patients were treated with antiemetic medication and intravenous fluid infusion, none necessitated laparotomy and all recovered without sequela. In the same study study; height percentile< 50%, weight percentile< 25%, sagittal kyphosis, rapid and harsh halofemoral traction in anterior approach are defined as potential risk factors for SMAS.

Korovessis et al. reported pancreatitis in a 28 years old polioscoliosis patient who had undergone combined anterior Zielke procedure and Luque-TSRH (Texas Scottish Rite Hospital) operation in the same session.[20] Diagnosis of this female patient with increased amilase levels was confirmed with ultrasound. Symptoms were relieved in a couple of weeks with conservative treatment (diet, antibiotics and fluid infusion). Amilase level rise and symptoms had recurred in 6th, 16th, 32th months postoperatively. Atypical abdominal pain and elevated serum amilase levels after spinal surgery should be accepted as warning for pancreatitis and rapid diagnosis and early supportive treatment should be performed to decrease morbidity and mortality.

One group of complications that occur after spinal surgery is embolic complications. This may be seen as air, fat or bone marrow embolism. Rodriguez et al. detected high intensity transient signal (HITs) in transcranial doppler USG evaluation of 92% of pediatric scoliosis surgery patients consistent with microemboli in cerebral artery.[21] However, no postoperative neurological change was found in any of patients.[21] One study reported early postoperative ARDS following Harrington instrumentation and spinal fusion in an idiopathic scoliotic adolescent. Postmortem findings revealed massive pulmonary fat embolism.[22]

In conclusion, scoliosis surgery is associated with a lot of potential complications for both surgery and anesthesia teams in the postoperative period. The scoliosis operations are considered as one of the most jeopardous surgical interventions although there's a significant decrease in postoperative complication rates due to recent developments in anesthetic and surgical techniques. The optimization of the respiratory and cardiovascular systems is imperative to minimize these challenging complications. In addition to this, advanced monitorisation techniques including cardiovascular or neurological systems monitorisation should be used. Postoperative intensive care and respiratory therapy may be required in high risk patients.

Conflict of Interest

Authors declared no conflict of interest or financial support.

Authorship Contributions

Collecting and analyzing the data, drafting, final approval: *Menekşe Özçelik;* ***Drafting,collecting the data:*** *Şeyda Özalp;* ***Collecting the data:*** *Mahmut Kalem;* ***Collecting and analyzing the data, revision of the manuscript:*** *Onat Bermede;* ***Revision of the manuscript:*** *Tarık Yazar;* ***Designing and conducting the study, drafting, analyzing the data, revision of the manuscript:*** *Feyhan Ökten.*

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