

# Spina Bifida: An Overview

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## ABSTRACT

Spina bifida (SB) is a congenital malformation in which the spinal column is split (bifid) as a result of failed closure of the embryonic neural tube, during the fourth week post-fertilization. The prevalence of spina bifida is 1-10 per 1000 births. Diagnosis of SB is usually made prenatally by measurement of alpha fetal protein in the maternal serum at 16 weeks of gestation or by ultrasound of the fetus at 18-20 weeks of gestation. Depending on the lesion, interruption of the spinal cord at the site of the defect causes paralysis of the legs, incontinence of urine and feces, anesthesia of the skin, and deformation of the hips, knees, and feet. Clinical presentation depends both on the level and type of the spinal lesion at the vertebral column. Early surgical repair of the spinal lesion is essential in preventing further deficits and neurological damage. Conventional approach dictates the surgical repair in 48 hours of birth. With the application of this principle, the rate of protection of the infant's spinal cord and nerve roots has increased. Prenatal surgery which is a relatively new approach is proven to be more effective than postnatal surgery in lowering the occurrence of future complications. A child with the SB diagnosis is a life-long rehabilitation patient. Detailed clinical examination and setting age-appropriate goals is the first step for achieving the best possible outcome.

## INTRODUCTION

Spina bifida (SB) is a congenital malformation in which the spinal column is split (bifid) as a result of failed closure of the embryonic neural tube, during the fourth week post-fertilization. It is a general term which encompasses different types of myelodysplasia which ranges from mild types, such as spina bifida occulta, to severe and clinically significant types as spina bifida aperta.<sup>[1]</sup>

### Clinical And Research Consequences

#### Types of SB

**Spina Bifida Aperta:** When a meningocele and a meningocele (MMC) are diagnosed, both are defined as spina bifida aperta. Myelomeningocele is the most common and most severe type with nerve roots and cord structures herniated in the sac. This lesion usually has congenital paralysis. The spinal cord is open dorsally, forming a placode on the back of the fetus or new-born baby with or without a meningeal sac. If a meningeal sac is present, the lesion is then called as spina bifida cystica.<sup>[2]</sup>

**Spina Bifida Occulta:** In spina bifida occulta, there is no

visible sac. Discoloration, nevus and hair growth in the midline are the only signs that can be observed. It is mostly asymptomatic at birth and carries the risk of developing neurological deficit over time, the main reason for this risk is tethering of the cord. Lesions like lipomeningocele, lipomyelomeningocele, dermoid cyst and dermoid sinus lead to spina bifida occulta.<sup>[3]</sup>

The prevalence of spina bifida is 1-10 per 1000 births.<sup>[4-6]</sup> MMC is the most common form of spina bifida aperta. The estimated incidence of the diagnosis is 1.8 per 10,000 live births in the United States according to the Centers for Disease Control and Prevention (CDC). The figure appears to be higher in Caucasians and Hispanics than in African Americans and Asians. It is critical to keep in mind that 90-95% of affected infants are born without a family history.<sup>[7]</sup>

#### Risk Factors

The etiology of myelomeningocele is often does not depend on a single factor. Environmental, maternal, genetic factors combined lead to the diagnosis. Pesticides, teratogenic factors, radiation exposure, pollution of different

types, organic solvents may be included in environmental factors. Maternal risk factors may vary. Diminished folate level is undoubtedly the best-known risk factor and maternal obesity is particularly notable. In addition, diabetes, hyperthermia, anxiety, caffeine/alcohol consumption, smoking and use of anticonvulsants are also considered as maternal risk factors.<sup>[8-12]</sup> Although there is some genetic predisposition is noted, most of the cases of myelomeningocele are sporadic. However, it is notable that chromosomal anomalies of trisomy 18 or 13 and an affected twin or first-degree relative might increase the risk ratio. Although spina bifida appears to have a familial pattern, it has been previously noted that reported familial relapse patterns cannot be attributed to the effects of a single genetic locus. Despite the decades long endeavor to unravel the affect of genetic factors on the NTD etiology, yet no conclusive evidence is defined.<sup>[13]</sup>

## Diagnosis

Prenatal scanning is the first step. Alpha fetal protein measurement in the maternal serum at 16 weeks of gestation or by screening of the fetus by ultrasound at 18-20 weeks of gestation are the two highly accurate methods (85-90%) used in diagnosis. Positive findings from either of these two screenings should be followed by amniocentesis or detailed sonography, or both.<sup>[14]</sup>

The detection rate of spina bifida aperta using ultrasound goes as high as 100%. Detection of the indirect cranial signs as the “lemon” and the “banana” sign leads the way. The shape of the skull is described by the “lemon” sign whereas the “banana” sign refers to the cerebellum. The sign is based on the downward traction of the cerebellum, most likely caused by the spinal fluid leakage from the defect site.<sup>[15]</sup>

When spina bifida diagnosis is confirmed, ultrasound is used to assess spontaneous leg and foot motion, leg and spine deformities, the presence of a Chiari II malformation and other physical defects.<sup>[16]</sup> Prenatal Magnetic Resonance Imaging (MRI), with ultrafast T2-weighted sequences, can also be used to characterize the Chiari II and other malformations. Such prenatal imaging studies might help to predict neurological deficit and ambulatory potential.<sup>[17,18]</sup>

The prenatal diagnosis of SB is crucial for families who do not plan to terminate the pregnancy, in order to make a perinatal care plan.

## Management

Management of SB is a lifelong concept. Management of myelomeningocele begins with surgical repair. Early surgical repair of the defect site is essential in preventing further deficits and preserving the remaining function. Conventional early approach dictates the surgical repair in 48 hours of birth. Earlier the closure of the neural tube defect, better is the outcomes. Earlier closure results in increased protection of the infant’s spinal cord and nerve roots.<sup>[4]</sup> Prenatal surgery which recommends even earlier intervention compared to “conventional early approach”

is a relatively newer technique proven to be more effective than “conventional early approach” considering future complications and outcome.<sup>[19-21]</sup> Compared with post-natal repair results, in utero treated infants have a lower incidence of moderate to severe hindbrain herniation and hydrocephalus which requires shunting.<sup>[22]</sup>

## Clinical Course

Spinal cord disruption at the site of the defect causes paralysis in the lower extremities, urine and bowel incontinence, skin anesthesia, and musculoskeletal deformation of the hips, knees, and feet.

Clinical presentation depends both on the level and type of the spinal lesion. Type of the lesion occurs in three forms. Complete lesions, incomplete lesions and skip lesions. Complete lesions present with flaccid paralysis, sensorial and reflex loss below the level. In incomplete lesions, voluntary movement or sensation may be preserved to a degree. Skip lesions appear in an interesting feature, while the caudal segments have function, there may be non-functioning segments in between.<sup>[3]</sup>

Neurological impairment severity mainly depends on the affected level. The higher the lesion is located, more severe deficits appear which creates more drastic musculoskeletal symptomatology.<sup>[23,24]</sup> For instance, quadriplegia often caused by cervical lesions. Whereas paraplegia is mostly associated with thoracic and lumbosacral lesions are mostly associated with paraplegia.<sup>[25]</sup> While cervical defect rate is rare, the most common defect location is the lumbosacral region.<sup>[26]</sup>

Muscle imbalance can lead to a wide range of orthopaedical problems at lower extremities such as talipes equinovarus (clubfoot), rocker bottom foot, cavovarus foot and calcaneus foot (result of active dorsiflexion versus paralyzed plantar flexion), valgus deformity of the ankle, tibial torsion, flexion contracture of knees, femoral torsion, hip dysplasia and dislocation (%50), and vertebral deformities such as scoliosis.<sup>[27]</sup>

Orthotic devices are used to maintain appropriate alignment at the hip, knee, ankle and compensate for strength absence required for ambulation. While orthotic devices vary; Parapodium (supports mid-thoracic region to the floor), swivel walker (converts trunk rotation to forward motion) and reciprocal walking orthosis (works on the principle of counteracting hip flexion with hip extension) draw the attention when children with SB require therapeutic ambulation.<sup>[26]</sup>

The motor level is a useful tool to predict mobility expectations and in family education (Table 1).

Decrease in sensation, both superficial and deep, below the defect level is an essential clinical feature to remember. Pressure sores are the most common outcomes caused by superficial loss of sensation. Up to adulthood, 90% of children have a history of one or more pressure ulcers.<sup>[28]</sup> Burns also are not rare. It is important to keep in mind that insensate skin heals slower. In extreme cases, hospi-

**Table 1.** Functional mobility and equipment needs, based on level of impairment. (L4) (AFO: Ankle-foot orthosis, HKAFO: Hip-knee-ankle-foot orthosis, RGO: Reciprocal gait orthosis)

Motor Function	Level of Muscle Involvement	Expected Potential for Ambulation	Recommended Orthoses for Functional or Therapeutic Ambulation	Durable Medical Equipment
T12	Abdominal paraspinal	Non-functional ambulation; therapeutic only	RGO	Stander (at young age) Manual wheelchair
L1	Hip flexors	Household and therapeutic	Long leg: RGO, HKAFO	Manual wheelchair, stander
L2-3	Hip adductors	Household and therapeutic	Long leg: RGO, HKAFO	Manual wheelchair, forearm crutches
L4	Knee extensors	Household and ± community	Short leg: AFO	Manual wheelchair, forearm crutches
L5-S1	Ankle dorsiflexors	Community ambulation	Short leg: AFO	±Forearm crutches, cane
S2	Ankle plantar flexors	Community ambulation	Foot orthoses	None

talizations and surgical interventions may be required.<sup>[29]</sup> Proprioception loss is a serious factor that exacerbates balance and movement deficits. The child's need for visual and auditory vestibular input to maintain balance and the risk of falling increases. It should be kept in mind that like skip motor lesions, skip sensory lesions may also be present and detailed sensory examination is crucial.

Postural defects are not rare. Kyphosis, scoliosis, increased lordosis, anterior pelvic tilt, rotational deformities of the hip and tibia, hip and knee flexion, and foot pronation are frequently encountered in clinical practice. Spinal deformities are more common in high-level lesions and tend to increase with puberty.<sup>[30-32]</sup>

Approximately 25% of SB cases are born with hydrocephalus. After the surgical closure of the lesion, an additional 60% of cases are added to the numbers.<sup>[7,33]</sup> To maintain intracranial pressure in the normal range is vital. Therefore approximately three quarters (70–85%) of children with hydrocephalus due to spina bifida require ventricular shunting.<sup>[7]</sup> If hydrocephalus is left untreated, cerebral cortex is lost as a result of ventricular overgrowth. This process results in both cognitive and motor function loss. However, it should be kept in mind that shunt itself may lead to complications due to dysfunction and infection. It has been observed that shunt dysfunction or cerebral infection can cause epileptic seizures in 30% of cases. Delay in recognition and intervention may result in loss of function or even death.<sup>[3]</sup>

The intellectual levels of the low-level spina bifida cases were higher than the thoracic level cases. Early closure of the lesion, good meningitis prophylaxis and regular follow-up of the shunt affect cognitive functions positively.<sup>[34]</sup>

It is important to monitorize the kidney functions in children with a diagnosis of SB. Kidneys of most of these children function normally at birth. However, sacral nerves (S2–S4), controlling the bladder are almost always dysfunctional since they are mostly located below the defect level. This etiology results in neurogenic bladder symptomatology. A neurogenic bladder which does not empty properly is a cause of urine residue. Residue urine is a facilitator for recurrent urinary tract infections. Its consequences may

be vesicoureteral reflux, hydronephrosis and subsequent kidney damage respectively. Encouraging the use of clean intermittent catheterization and prescribing anticholinergic medication in required cases to decrease bladder spasms play a key role in proper management.<sup>[35,36]</sup>

Similar to the innervation of bladder, the rectal sphincter is also innervated by the sacral nerves (S2). Therefore, neurogenic bowel is a common feature approximately affecting 90% of children.<sup>[4]</sup> Neurogenic bowel symptoms can be seen in a wide range from constipation due to decreased motility to fecal incontinence due to sensitivity loss and lack of voluntary control.<sup>[37]</sup> Bowel management goal is to prevent constipation and/or incontinence and end up with a regularly formed stool. In order to achieve the goals; sticking to a daily commode plan, encouraging fiber rich diet, provide guidance for staying away from carbonated, caffeinated fluids and maintaining proper medical support plays an important role.

Obesity is an insidious problem that is not uncommon. It occurs as a result of the sedentary life of the child and the decrease in the muscle mass of the lower extremities.<sup>[38]</sup> The basal metabolism of these children due to the lack of muscle mass in the legs is slower. Children who have difficulty integrating into social life due to symptoms such as mobility difficulties and incontinence are more attracted to domestic sedentary activities. Obesity should be followed with the utmost care, as it has adverse effects on ambulation potential.

It is crucial to be alert about tethered cord (tension on the spinal cord) which may lead to progressive neurological disorder. Tethered cord is usually an asymptomatic phenomenon. However, 25% of children may present some symptoms. Back pain in mechanical nature (worsened by activity and relieved with rest), pain in the leg, hypertonia, spasms, decreased sensation, muscle weakness in innervated parts of the legs, hyperreflexia including clonus, gait deterioration, aggravated constipation, increasing scoliosis, and decrease in urodynamic functions require medical examination. If symptoms above are positive and progressing; neurosurgery consultation is indicated.<sup>[4]</sup>

**Table 2.** Goals of mobility according to Mobility Guideline by SB Association. (40)

Primary	<ul style="list-style-type: none"> <li>• Develop expectations for mobility based on age and neurologic level.</li> <li>• Understand and utilize appropriate mobility devices and therapy interventions to optimize mobility across the age spectrum.</li> </ul>
Secondary	<ul style="list-style-type: none"> <li>• Reduce the threats and effects of pain, aging, neurologic deterioration, and obesity on mobility.</li> <li>• Reduce risk of pressure injuries.</li> <li>• Maximize safe functional mobility and acquisition of developmental milestones for social and environmental exploration.</li> <li>• Maximize safe and functional mobility for Activities of Daily Living (ADL), as well as, social, recreational, and pre-vocational/vocational goals.</li> </ul>
Tertiary	<ul style="list-style-type: none"> <li>• Understand how primary and secondary outcomes affect quality of life.</li> </ul>

## Rehabilitation

In every human being physiological and psychological factors complement each other. It is important to keep in mind that children with SB is not an exception to this rule and rehabilitation programs should be planned accordingly. Detailed clinical examination and setting age-appropriate goals is the first step on this hard-packed road for achieving the best possible outcome. Promoting overall wellness, encouraging self-care management and independence by supporting mobility delineates the rehabilitation motto.<sup>[39]</sup>

Mobility impacts not only physical parameters like preserving range of motion, muscle mass, bone density, cardiovascular fitness and endurance but psychological parameters like stress management. It also has beneficial side effects like encouraging community engagement and nurturing cognitive abilities.<sup>[40]</sup> Therefore, each child should be heartened to move in the best possible way even he/she is facing significant limitations, even in the risk of losing that mobility as an adolescent or adult.<sup>[27]</sup>

Since mobility is the key aspect in rehabilitation planning, SB Association (the national organization in the United States representing individuals of all ages) declared a guideline in year 2018.<sup>[40]</sup> According to the guideline the goals of mobility is set in three consecutive and complementary stations (Table 2).

## CONCLUSION

Spina bifida is a congenital neurological defect that may require lifelong follow-up and management of comorbidities that can affect multiple organ systems. Given the complexity of diagnosis, an orchestrated management is crucial.

Regardless of the lesion level, independence in mobility is pivotal and should be encouraged in every possible way.

### Informed Consent

Not applicable. This study did not involve human participants or patient data.

### Peer-review

Externally peer-reviewed.

## Conflict of Interest

There is no conflict of interest to declare.

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## Spina Bifida: Genel Bakış

Spina bifida (SB), fertilizasyon sonrası dördüncü haftada embriyonik nöral tüpün kapanmasındaki defekt sonucu oluşan bir konjenital malformasyondur. Spina bifida prevalansı 1000 doğumda 1-10 olarak verilmiştir. Tanı 16. gebelik haftasında anne serumunda alfa fetal protein ölçümü veya 18-20. gebelik haftasında fetüsün ultrasonografisi ile doğum öncesi konulur. Oluşan defekt nedeniyle alt ekstremitelerde paraliz, idrar, gaita inkontinansı, duyuşsal kusur, alt ekstremitelerde deformasyonlar ile prezente olan klinik tablo oluşur. Klinik tablo spinal lezyonun seviyesi ve tipine göre şekillenir. Erken cerrahi onarım, defisit kontrolü ve nörolojik hasarın progresyonunun önlenmesinde esastır. Konvansiyonel yaklaşım ile, doğumdan en geç 48 saat sonra yapılan defekt tamirinin progresyonu önlemede etkili olduğu bilinmektedir. Bu prensibin uygulanması ile bebeğin omurilik ve sinir köklerinin korunma oranı artmıştır. Daha erken girişim imkanı sağlayan prenatal cerrahi ile daha başarılı sonuçlar alındığı bildirilmektedir. SB tanılı çocukların dikkatle değerlendirilmesi ve çok yönlü, yaşa göre değişen hedeflerle planlanmış rehabilitasyon programları ile yüz güldüren sonuçlar almak mümkündür.

**Anahtar Sözcükler:** Alfa fetö protein; folik asit; meningomyelose; mobilizasyon; spina bifida.