**Spina Bifida: alternative approaches and treatment, based on evidence through gait analysis**

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**Abstract**

Myelomeningocele results from failure of the neural tube to close in the developing fetus and is associated with neurological impairment (Incidence 1:1000 births). The level of the anatomic lesion generally correlates with the neurological deficit and ranges from complete paralysis to minimal or no motor involvement. Myelomeningocele or Spina bifida can lead to health problems, physical disabilities, and learning problems. Generally associated paralysis of the lower extremities and neurogenic bladder. Treatment requires multidisciplinary participation. The functional classification that concerns us in this review includes three types and were obtained through gait analysis.

**Keywords**

Spina bifida, instrumental gait analysis, kinematics and kinetics, orthotics.

**Introduction**

The term spinal dysraphism1 refers to those conditions that result from a defective development in the midline of the dorsal aspect of the embryo, resulting in bone or nervous system deformities. They can be accompanied by cutaneous manifestations but they are not always present.

Spina bifida belongs to a group of developmental disorders of the vertebral arches or the cranial vault. They are often associated with disorders of the formation of structures derived from the neural tube and meninges and can lead to cystic formations. the causes of spina bifida appear multifactorial. Folic acid deficiency is a significant factor and there appears to be a genetic component.

Three types of spina bifida can be described: The severity ranges from occult, in which no obvious abnormalities are seen, to protruding sacs (cystic spina bifida), and to a completely open spine with severe neurological disability and death.

*Occult Spina bifida* is a defect located in one or more vertebral arches. It develops as a failure of the vertebral arches, remaining unfused in the third month. The spinal cord and meninges remain within the vertebral canal.

The *meningocele i*s a cystic mass of the dura and arachnoid that protrudes through a defect in the vertebral arches under the skin. The spinal cord is completely confined to the vertebral canal, but abnormalities can occur.

*Myelomeningocele*, or open spina bifida, where the exposed elements of the spine are fully exposed.

The spectrum of clinical presentation is huge, from lethal rachischisis to asymptomatic occult spina bifida with a small lipoma. The diversity of presentations suggests that causal factors exert their effects in different periods of development, in addition to genetics and the environment that must be considered. Other associated abnormalities found in spina bifida are congenital spinal deformity, Sprengel deformity, tethered cord, neurogenic bladder, and clubfoot. A high incidence of allergy to latex has also been observed.

Progressive neurological deterioration can occur because hydrocephalus in association with an Arnold-Chiari type II defect is common and develops in 80% of children with thoracolumbar myelomeningocele 2,3,4,5.

Within this spectrum are all grades of myelomeningocele, meningocele, diastematomyelia, diplomyelia, fibrous bands, tight terminal filum, intra, and extradural lipomas, dermoid cysts, neurenteric cysts, and congenital malformations of the nerve roots. Skin lesions include dermal sinus, nevi, hypertrichosis, and open lesion.

**Instrumental Gait Analysis**

The instrumental gait analysis is the record of the biomechanical variables of human movement related to the way we walk. Allowing to know the principles that govern the human movement, making its analysis more objective and able to be measurable.

Nowadays it is compound by:

* The clinical exam using muscular force measurement through dynamometry
* Observational Analysis (three-dimensional video)
* Kinematics and muscle length
* Kinetics
* Muscle activity (dynamic EMG)
* Energy consumption
* Baropodographic

This type of analysis has made it possible to identify the prerequisites for normal gait, making it easier to recognize deviations that occur in pathological gait.

**Functional impact**

Regarding independence in daily life, at present, the most accepted classification is the one that arises from the available motor function6,7,8, so it should be clear what the patient's motor resources are, mainly the antigravity muscles, which are also related to the prognosis of gait and its maintenance over time.

Ambulation is also affected by age, obesity, spasticity, orthopedic deformities, etc.9. The greater the commitment, the greater the disability and implications such as survival, associated deformities, and the ability to walk.

Two main factors affect the ability to walk and the degree of support required in this patient population: motor level and balance.

**Motor level**

***Classification and motor implications:***

The level of neurological involvement is one of the key determinants of a child's ambulation.

The most accepted classification of spina bifida is based on the neurological level of the lesion6,7,8 (see Table 1). Patients are divided into three groups according to the level of injury, functional ability, and ambulation.

**Table I**. Functional classification for outpatients with myelomeningocele

|  |  |  |
| --- | --- | --- |
| *Group* | *Level* | *Comments* |
| 1 | Thoracic /High Lumbar Level | Thoracic/high lumbar: (mínimum lower limb motor resource, short-term ambulation; highest risk of associated deformities. Approximately 7% become sedentary between 7 and 10 years of age. |
| 2 | Low Lumbar Level | Low lumbar (quadriceps and hamstrings function mainly internal): 70% to 80% maintain walking capacity at adulthood. |
| 3 | Sacral Level:  - Group I High Sacral  - Group II Low Sacral | Sacral level - they practically have a normal gait. 98% maintain walking capacity in adulthood. this group has been subdivided into two subgroups:  High Sacrum, defined by the absence of plantar flexors, and Low Sacrum by the presence of usually weak plantar flexors. |

Source: Swank and Dias, 1994.

The classification criteria for patients, based on the muscle resource present in the lower limbs, are summarized in Table II:

**Table II. Muscle resources versus motor level in myelomeningocele.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Muscle group** | **Thoracic / High Lumbar** | **Low Lumbar** | **High Sacral** | **Low Sacral** |
| Hip flexors | May or may not be present | present | present | present |
| Hip adductors | May or may not be present | present | present | present |
| Hip extensors | absent | absent | present | present |
| Hip abductors | Absent | absent | present | present |
| K exte | Absent | present | present | present |
| K flex | Absent | Medial present &  Lateral may or may not | present | present |
| Ankle plantar flexor | Absent | absent | absent | Present (weak) |
| Ankle dorsal flexors | absent | absent | May or may not be present | Present (weak) |

Source: authors.

It is important to note that the lesion tends to be asymmetric in most cases, therefore the classification leans towards the more involved side.

**Balance**

Balance also affects the ability to walk and the extent of support required and is related to the presence or absence of shunt10, the function of the shunt, the number of shunt reviews.

Statistical reports from the literature of specialized centers8 show that of 70 - 80% of the lower lumbar level and 98% of the sacral level retain their ability to walk independently in adult life, whereas thoracic or upper lumbar levels, 7 % lose the ability to walk between 7 and 10 years 6,7,8.

**Quality of ambulation and Gait Analysis**

Factors affecting gait quality include11: muscle weakness, severe scoliosis, flexion contracture of the hip, abduction contracture of the hip, subluxation or dislocation of the hip (with or without soft tissue contracture), rotational deformities of the hip (internal or external)12, flexion contracture of the knee13,14,15 and tibial torsion (internal or external) 16,17.

Since a large percentage of outpatients maintain their ability to walk, its quality must be considered. Gait analysis can be used to access and help quantify its quality during ambulation 9.

Generally, a clinical assessment of strength alone rarely reflects the asymmetry noted during gait. An instrumental gait analysis should be the standard of expert care for children with movement abnormalities secondary to spina bifida.

The instrumental analysis of gait has made it possible to measure the impact of the orthoses with the use of kinematics20 and kinetics on the loads applied to the joints of the lower limbs during movement 8 17 21 22. With which the benefit or not, of walking aid options is documented, and their impact on biomechanics 23.

It allows observing the knee moments in the frontal plane to define if there are valgus forces24, as well as documenting the rotation patterns of the trunk and pelvis in the transverse plane25 due to the combination of bone deformities and muscle weakness.

Shows muscle function, especially in the ankle, due to muscle hyperactivity, muscle shortening, or weakness22 26 27 resulting from growth, puberty, or cord retention, when a given treatment is considered.

Documents postoperative changes that are used for subsequent decision making. All this information allows the specialist to formulate treatment plans and protocols in order to develop the maximum potential and independence of the patient 8 17 21 22.

**An Overview of Current Treatments**

In this review, we wanted to show the current state of disease management, its approach with “in utero” interventions, and future treatments based on the knowledge obtained through gait analysis. In future publications, we will examine in more detail its characteristics and the existing treatment protocols, which depend on the anatomical level (muscle resources), balance, and bilaterality or not, present.

Spina bifida is the most common congenital defect, presenting in a wide range of severity and with poor postnatal treatment options. The resolution "in utero" 28 29 30 has shown beneficial results such as the absence of a sac over the lesion, an improvement in the functional level, per example: an L3 lesion is significantly associated with independent ambulation 31 32. The decrease in the need for ventriculoperitoneal shunts remains controversial, as does the incidence or not of Chiari malformation 30. Improved surgical techniques have controlled a large percentage of obstetric risks such as premature births and maternal complications derived from the procedure.

Due to the variety of medical comorbidities involved, for the evaluation and management of these patients, the competence of a team that involves members of multiple specialties, such as neurosurgery, pediatrics, physiatry, urology, orthopedic surgery, orthotics, physiotherapy, and social work.

The goal of the orthopedic surgeon is to correct deformities and improve function and mobility. This is where instrumental gait analysis plays an increasingly important role in behaviors, decision-making, and treatment 33.

In relation to orthopedic surgery treatments, the indication of splints on the feet, ankles, and knees is accepted, as long as an improvement in function is demonstrated. It is established only to treat hip dislocation in patients with L5 level or lower and the release of contractures is limited to being functionally significant.

**Conclusión**

In general, a clinical evaluation alone rarely provides an approach to compromise in detail what the asymmetries and compensatory responses are used during gait. Instrumental gait analysis should be the standard of care for children with walking abnormalities secondary to spina bifida or any other pathology that alters movement. The main objective of the gait analysis is to define the consequences derived from the neural tube injury in relation to functional activity and future independence of the patient.

Instrumented gait analysis can also provide clinicians with a better understanding of how neurological impairment affects walking, the compensations or compensatory responses used, and further define the functional level of the patient. The current trend is to minimize dependence on orthosis for ambulation during childhood and optimizing mobility and independence within the expectations and functional level of the patient.

**Authors' Contributions**

Both authors contributed equally in the development, writing, translation and formatting of this work.

**Availability of Data and Materials**

None.

**Conflicts of Interest**

All authors declared that there are no conflicts of interest.

**Ethical Approval and Informed consent**

Not applicable

**Consent for Publication**

Not applicable

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