

Rate of complications due to neuromuscular scoliosis spine surgery in a 30-years consecutive series

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Abstract

Purpose The aim of this study was to evaluate the rate of intraoperative and postoperative complications in a large series of patients affected by neuromuscular scoliosis.

Methods It was a monocentric retrospective study. In this study have been considered complications those events that significantly affected the course of treatment, such as getting the hospital stay longer, or requiring a subsequent surgical procedure, or corrupting the final result of the treatment.

Results Of the 358 patients affected by neuromuscular scoliosis treated from January 1985 to December 2010, 185 that met the inclusion criteria were included in the study. There were recorded 66 complications in 55/185 patients. Of that 66 complications, 54 complications occurred in 46/120 patients with Luque's instrumentation, while only 12 complications occurred in 9/65 patients with hybrid instrumentation and this difference was statistically significant ($p < 0.05$); 11/126 patients with pelvic fixation and 5/59 without pelvic fixation, as well as 45/156 patients treated by posterior approach alone and 10/29 patient that underwent combined anterior–posterior approach suffered complications but both this did not result in a statistical significant difference ($p > 0.05$).

Conclusions The surgical treatment in neuromuscular scoliosis is burdened by a large number of complications. An accurate knowledge of possible complications is

mandatory to prepare strategies due to prevent adverse events. A difference in definitions could completely change results in good or bad as well as in our same series the adverse events amounted at almost 30% of cases, but complications that due to complete failure would amount at 9.19% of patients.

Keywords Scoliosis · Neuromuscular scoliosis · Complications · Scoliosis surgery

Introduction

Patients with neuromuscular diseases frequently develop scoliosis that requires surgical correction [1–10]. Usually the deformity involves the entire thoracic and lumbar spine resulting in a C-shaped curve often associated with great pelvic obliquity. Spine fusion in neuromuscular scoliosis aims to balance the trunk in frontal and sagittal plane, center the head over the pelvis, and restore anatomical spine condition. Extension into the pelvis is meant to achieve global correction of both pelvic and spinal deformity.

Patients with neuromuscular scoliosis undergoing posterior spinal fusion are at higher risk for postoperative complications due to underlying comorbidities [11–14] such as decreased pulmonary function, inadequate nutritional status, decreased mobility, costo-pelvic impingement pain and cognitive impairment. Complication rate associated with spinal surgery in neuromuscular scoliosis ranges from 18 to 75% [15–27].

The aim of this study was to evaluate the rate of intraoperative and postoperative complications in a large series of patients affected by neuromuscular scoliosis and to determine if the rate of complications varies in different

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neuromuscular diseases and in the two different surgical instrumentations (Luque, older, and Hybrid, newer) used.

Materials and methods

It was a monocentric retrospective study. Between January 1985 and December 2015, 358 consecutive patients operated on for scoliosis by the same operators (senior authors F.T. and A.M.) were reviewed. Inclusion criteria were: diagnosis of neuromuscular scoliosis, all procedures consecutively performed, appropriate documentation by clinical records, minimum follow-up of 5 years. Demographic data, type of neuromuscular disease, age at surgery, surgical approach, pelvic fixation, instrumentation used and complications have been collected.

Indication for spinal surgery was a scoliosis greater than 40 degrees, when associated with pelvic imbalance affecting a comfortable sitting in the wheelchair and limiting the caregivers' actions, fixation has been extended to the pelvis.

Fusion was achieved by local bone graft mixed with synthetic bone after thorough decortications of laminae. The preoperative antibiotic prophylaxis was 50 mg/kg of cefazolin and 15 mg/kg of amikacin, continued postoperatively since the central venous catheter removal.

After surgery the patients were transferred to the intensive care unit (still intubated if necessary) for a minimum time of 48 h, and discharged to the orthopaedic unit when stable.

In this study have been considered complications those events that significantly affected the course of treatment, such as getting the hospital stay longer, or requiring a subsequent surgical procedure, or corrupting the final result of the treatment.

For statistical analysis, Student's *t* test was used. Data are presented as mean values and range. For continuous parameters, when the distribution was not normal, a Mann–Whitney nonparametric test was used. Results were considered statistically significant when value was less than 0.05.

Results

Of the 358 patients affected by neuromuscular scoliosis treated from January 1985 to December 2010, 185 that met the inclusion criteria were included in the study. According to the definition of complication, we have excluded six cases of failure of the instruments (two broken rods, one overhang rod, and three loops derailment) that did not result in loss of correction or patient discomfort and the transient paresthesia in the innervation area of the lateral

femoral cutaneous nerve. There were included 86 males (46.49%) and 99 females (53.51%), mean age at surgery was 13.62 years (range 6–34 years) and mean follow-up was 10.7 years (range 5–25 years).

The stratification of patients was (Table 1): 51 (27.57%) cerebral palsy (CP), 48 (25.95%) muscular dystrophy (MD), 31 (16.76%) spinal muscular atrophy (SMA) including 26 SMA Type II and 5 SMA Type III, 15 (8.12%) Rett syndrome (RS), 12 (6.47%) poliomyelitis and medullar damages (PMD), 28 (15.14%) others neuromuscular disorders (Friedreich ataxia, Lennox–Gastaut disease, Aicardi syndrome, genetic syndromes, neuropathies).

One hundred and twenty (64.86%) patients underwent posterior arthrodesis using the Luque's instrumentation, 65 (35.14%) patients underwent posterior arthrodesis using hybrid instrumentation. Twenty-nine (15.68%) patients underwent anterior and posterior arthrodesis, 26 by a thoracotomy approach and three by a video-assisted thoracoscopy. One hundred and twenty-six (68.11%) patients underwent a modified trans-iliac pelvic fixation (Table 2).

There were recorded 66 complications in 55/185 (29.73%) patients (Table 1).

According the Rampersaud's Spine Adverse Event Severity System (SAVES) [28] the complications recorded can be graded as follow (Table 1): 16 complications grade I (10 ileus paralyticus and 6 mechanical complications); 9 complications grade II (3 delayed wound healing, 2 SIADH, 2 decubitus, 1 peptic ulcer, 1 heterotopic ossification of the gluteus); 39 complications grade III (9 mechanical complications, 16 infections, 3 neurological complications, 2 crankshaft phenomenon [22]); 2 complications grade IV (2 deaths).

Of that 66 complications, 54 complications occurred in 46/120 (38.33%) patients with Luque's instrumentation, while only 12 complications occurred in 9/65 (13.85%) patients with hybrid instrumentation and this difference was statistically significant ($p = 0.0005$); 11/126 patients (8.73%) with pelvic fixation and 5/59 without pelvic fixation, as well as 45/156 (28.85%) patients treated by posterior approach alone and 10/29 (34.48%) patients that underwent combined anterior–posterior approach suffered complications but both this did not result in a statistical significant difference ($p = 0.95$ and $p = 0.54$) (Table 2).

According to the neuromuscular disease, 21 complications were observed in 18 patients with CP, 14 complications in 13 patients with MD, 15 complications in ten patients with SMA, 6 complications in five patients with RS, 6 complications in six patients with PMD, 4 complications in three patients with other neuromuscular diseases (Table 1).

Mechanical complications were 15 in 16 (8.65%) patients; they included breaks, shifts and decubiti of the instrumentation and a case (without pelvic fixation) of

Table 1 Complications recorded

Complications	SAVES grade	Number of complication	Percentage in total patients	CP	MD	SMA	RS	PMD	Others
Infection	III	16 (24.24%)	8.65%	5 (23.81%)	5 (35.71%)	2 (13.33%)	2 (33.33%)	1 (16.67%)	1 (25.00%)
Mechanical	I (6) III (9)	15 (22.73%)	8.65%	5 (23.81%)	1 (7.14%)	5 (33.33%)	2 (33.33%)	–	2 (50.00%)
Ileus	I	10 (15.15%)	5.41%	4 (19.05%)	2 (14.29%)	2 (13.33%)	–	2 (33.33%)	–
Respiratory	III	9 (13.64%)	4.86%	3 (14.29%)	1 (7.14%)	3 (20.00%)	2 (33.33%)	–	–
Delayed wound healing	II	3 (4.55%)	1.62%	–	1 (7.14%)	1 (6.67%)	–	1 (16.67%)	–
Neurological	III	3 (4.55%)	1.62%	2 (9.52%)	–	–	–	1 (16.67%)	–
SIADH	II	2 (3.03%)	1.08%	–	1 (7.14%)	–	–	1 (16.67%)	–
Crankshaft	III	2 (3.03%)	1.08%	–	–	1 (6.67%)	–	–	1 (25.00%)
Death	IV	2 (3.03%)	1.08%	–	1 (7.14%)	1 (6.67%)	–	–	–
Decubitus	II	2 (3.03%)	1.08%	2 (9.52%)	–	–	–	–	–
Peptic Ulcer	II	1 (1.52%)	0.54%	–	1 (7.14%)	–	–	–	–
HPO of the gluteus	II	1 (1.52%)	0.54%	–	1 (7.14%)	–	–	–	–
Total complications	–	66	–	21	14	15	6	6	4
Patients with complications	–	55/185 (29.73%)	–	18/51 (35.29%)	13/48 (27.08%)	10/31 (32.25%)	5/15 (33.33%)	6/12 (50.00%)	3/28 (10.71%)

SAVES Spine Adverse Event Severity system, SIADH Syndrome of Inappropriate AntiDiuretic Hormone secretion, HPO Heterotopic Painful Ossification

Table 2 Complication in different surgical technique

Surgical technique	No patients	Patients with complications	%	<i>p</i>
Luque	120	46	38.33	0.0005
Hybrid	65	9	13.85	
Pelvic fixation	126	11	8.73	0.95
No Pelvic fixation	59	5	8.47	
Posterior approach	156	45	28.85	0.54
Anterior + posterior approach	29	10	34.48	

Bold value denotes statistical significance (*p* < 0.05)

Table 3 Most common complications in different instrumentation

Complication	Instrumentation	Patients	No complications	%	<i>p</i>
Mechanical	Luque	120	15	12.50	0.01
	Hybrid	65	1	1.54	
Infection	Luque	120	10	8.33	0.84
	Hybrid	65	6	9.23	
Respiratory	Luque	120	7	5.83	0.41
	Hybrid	65	2	3.08	
Ileus	Luque	120	10	8.33	0.02
	Hybrid	65	0	0	

Bold values denote statistical significance (*p* < 0.05)

recurrence of the pelvic obliquity (Table 3). These required 11 surgical procedures (4 rod resections, 3 instrument removals of and 4 revisions). In four cases a second surgery was not performed because in two patients the general health contraindicated a new procedure and in other two patients the parents refused.

There were recorded 16 wound infections in 16 patients (8.65%), nine early infections (in the first postoperative

month) and seven late infections (more than 1 year after surgery) (Table 3). Fifteen of these patients underwent the wound debridement and in nine patients it was necessary the removal of the instrumentation.

Respiratory complications were nine (4.86%), six pneumonias/bronchopneumonia and three respiratory failures that need a permanent tracheostomy in two patients and a temporary tracheostomy in one patient (Table 3).

There were recorded ten transient ileus in ten (5.41%) patients (Table 1).

Less common were 3 delayed wound healing in three patients (1.62%); 3 neurological complication in three (1.62%) patients (2 paraplegia in patients with CP and 1 neurogenic bladder in a patient with poliomyelitis); 2 syndrome of inappropriate antidiuretic hormone secretion (SIADH) in two (1.08%) patients; 2 crankshaft phenomenon in two (1.08%) patients, 1 with SMA II and 1 affected by Aicardi syndrome, both operated at the age of 9 years by the posterior approach alone (in the second case, the breakdown of rods led to a revision surgery to repair the damage, correcting loss of correction); two (1.08%) perioperative deaths, one female patient affected by congenital muscular dystrophy that leaved during the second postoperative day because a fatal cardiac arrhythmia and in one female affected by SMA II because an aeroembolism during the wound debridement for the treatment of an early infection; two (1.08%) patients suffered of a decubitus, both treated with vacuum therapy, one (0.54%) suffered of peptic ulcer and one (0.54%) suffered of a painful heterotopic ossification of the gluteus (Table 1).

Discussion

This study has been conducted to help surgeons in predicting and managing possible complications in neuromuscular patients undergoing scoliosis surgery. It certainly shows some limitations as to be a retrospective study and to not report surgery time and blood loss, due to the not guarantee about data accuracy in the oldest paperwork. On the other hand, there are some strong points that add value as the mono-équipe procedure along 30 years, the accuracy in definition of complications, the long term follow-up, the wide size of the study group that allows an intergroup comparison, so that for the first time has been shown possible differences among most known neuromuscular diseases (CP, DMD, SMA, RETT).

The surgical treatment of neuromuscular scoliosis has a high rate of complications. The prevalence of the complications of the surgical treatment ranges from 18 to 75% [23–38].

Adverse events, called complications, are classified in different ways among the literature. One common criterion is time, so to have intraoperative, early and late postoperative. Another one is major and minor complications. Another one is following categories (infections, hardware, organ failure). While some authors report only the mechanical complications that required a procedure [29], someone else report other minor issues such as coccydynia [30].

These different criteria to define complications could explain this wide range of complications rate, that is,

because we looked for a reasonable way to classify complications, and we excluded all those events that did not affect the final result. Even a rod breaking if does not affect the correction (because biological fusion is already done) and does not request a new surgery, has not to be considered a complication.

Data from this retrospective study show as the rate of complications in different neuromuscular diseases varies from 10.71 to 50% (Table 1).

Interesting is the comparison among the most known neuromuscular diseases (CP, MD, SMA, Rett). Showing results as percentage of that complication over total adverse events in that group, CP patients were more likely to develop mechanical complications (23.81%, 5 mechanical complications over 21 total complications in CP group) and wound infections (23.81%, 5/21); 35.71% (5/14) of MD patients developed wound infections; SMA patients were more likely to suffer of mechanical (33.33%, 5/15) and respiratory (20.00%, 3/15) complications; RS patients had similar prevalence of mechanical and respiratory complication and wound infections (33.33%, 2/6).

The overall rate of complication was similar in these four groups and it was not statistically significant ($p > 0.05$).

The largest rate of complications was recorded in the PMD group, 6 complications in 12 patients, 2 mechanical complications, 2 wound infections and 2 respiratory complications that seem to be the higher risk group, even if its small size could affect the significance of these data.

Conversely, the smallest complication rate was recorded in the group Others with an overall rate of 10.71% ($p < 0.05$).

About complications related to hardware, it is pretty evident how the newer Hybrid instrumentation is definitely more affordable that the old Luque instrumentation (that have been used in the first patients, Table 3). This has been confirmed by the statistical analysis that shows a $p < 0.05$.

Removal of instrumentation has been needed in 12 cases, 9 for infection and 3 due to mechanical issues. In the 50% of removals had loss of correction: four patients with early infection and two patients with mechanical issues.

In others six cases, five late infections and one broken rod, correction has been maintained at follow-up due to the arthrodesis.

Total failure of treatment has been observed in 17 patients: two deaths, six permanent instrumentation removals with loss of correction, five mechanical breakdowns, four severe permanent outcomes.

Therefore, if complications were observed in 29.73% of the patients, true failures were 9.19%.

Compared with idiopathic scoliosis, neuromuscular scoliosis patients requiring spine surgery have a higher risk of adverse perioperative complications because of

underlying comorbidities [31, 32]. Comorbidities commonly associated with neuromuscular scoliosis are decreased pulmonary function, inadequate nutritional status, decreased mobility, and communication and cognitive impairment. Complication rate after surgical correction of neuromuscular scoliosis is variable according to different authors but remains high [31, 33–43]. In these different studies, complication rate ranges from 17 to 74%, Benson et al. [38] reporting the highest rate with 17 complications in 24 patients, predominantly infectious and respiratory problems. Our results are consistent with an overall complication rate of 30%. Curve magnitude and non-ambulatory status have been described as risk factors of major postoperative complications [34].

Among complications, prevalence of wound infections ranges from 8.7 to 20% [34, 44–46]. Degree of patients' cognitive impairment, malnutrition, respiratory problems, and intraoperative bleeding are associated with an increased infectious rate [45, 47–49]. In our series, a wound infection was diagnosed in 24.3% of the population.

Respiratory complications are a major concern in these patients, occurring in 23.5 to 57% of cases [38, 43, 50]. The analysis of our series found respiratory complications in only 13.6% of the population. This observation may be the consequence of the respiratory preparation patients underwent before surgery (noninvasive ventilation and physiotherapy). It has been previously proved that patients' preoperative general status was correlated to complication rate [29]. Thus, we believe that respiratory preparation is of major importance in these patients' management [51–54].

Digestive complications remain relatively rare in the literature [32, 38, 43]. However, this kind of complications may be serious. In our series, one patient had a peptic ulcer that could turn in perforation and become a serious complication. In the same way, Master et al. [34] reported major gastrointestinal complications with two cast syndrome cases and one case of concomitant gallbladder hydrops and pancreatitis. Risk factors for digestive complications are hypotensive anesthesia [55], intraoperative position, and malnutrition, especially in cast syndrome occurrence [47, 56]. Attention should be given to this patient again in preparation to surgery and post-care, to prevent these apparently minor but potentially major complications.

About hardware related problems in the literature the prevalence ranges from 3.4% to Mohamad [31] to 21% of Gau [27], 32% of Nectoux [43] 44.4% of Modi [30]. It depends most of the time, as showed in our study, by the type of instrumentation used. Among last 30 years, several different hardware were followed. Different results most of the time reflect different hardware.

We have to mention Reames [39] that carried out a well done large retrospective multicentric study of 19,360

patients with an overall complication rates 10.2% (1971 patients); 4897 were neuromuscular scoliosis in which the complication rate was 17.9% (835 complications in 4657 neuromuscular scoliosis). The neuromuscular group included post spinal cord injury and neural tumor that maybe should consider in a different group; conversely syndromic diseases were placed in the group named "Others". Despite we appreciated the paper, maybe groupage is questionable, and it could affect the final result.

Sharma [42] performed an accurate meta-analysis of the past 15 years' literature recording an overall pooled rate of 22.71% pulmonary complications, 12.51% of implant related complications and 10.91% of infections. Implant revision and removal were 7.87%.

This study is in agreement with our beliefs because authors noticed as level of evidence among the literature ranged between 2+ and 2– with a large heterogeneity in methodology and outcome types that could well explain the wide range of outcomes.

Conclusions

Our study confirms that, as reported in the literature, the surgical treatment in neuromuscular scoliosis is burdened by a large number of complications. Complications were observed in 55 patients out of 185 (29.73%). The mechanical complications seem to be more frequent in cases operated with Luque instrumentation compared to those made with hybrid instrumentation. However, most of the complications have been addressed and resolved with medical therapy or with use of secondary procedures. Although the amount of complications in the surgery of neuromuscular scoliosis is still remarkable, most of complications can be successfully treated. A standardized preoperative patient evaluation and preparation including respiratory rehabilitation and nutritional care are mandatory prior to surgery. Perioperative management strategy may decrease postoperative complications and increases outcomes. An accurate knowledge of possible complications is mandatory to prepare strategies due to prevent adverse events.

Moreover, the study shows as data analysis is a questioned and significant aspect in research. A difference in definitions could completely change results in good or bad as well as in our same series the adverse events amounted at almost 30% of cases but complications that due to complete failure would amount at 9.19% of total patients.

Compliance with ethical standards

Conflict of interest None.

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