

The role of surgical treatment in the rehabilitation protocols of thoraco-lumbar spine injuries

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Abstract. – BACKGROUND: Rehabilitation is a crucial issue in the management of spinal cord injuries (SCI) but, in these patients, the primary treatment can bias the outcome of recovery protocols.

AIM: Purpose of this paper is to review our case load in the treatment of surgical failures and to define the role of surgery in thoraco-lumbar injuries rehabilitation.

PATIENTS AND METHODS: Between 2000 and 2009 seventy patients with post-traumatic paraplegia were referred to Surgical Department as rehabilitation was unfeasible due to inadequate spine injury treatment. Forty-six had had surgery, 24 were treated conservatively Twenty-five patients had a thoracic lesion, 9 a lumbar lesion and 36 a lesion of the thoraco-lumbar junction. A total of 44 surgical procedures were performed (by anterior, posterior or anterior-posterior).

RESULTS: On postoperative imaging sagittal alignment was found good in 93% of cases and acceptable in 7%. All patients regained the sitting position within 5 days after surgery. Wound healing problems requiring revision were observed in 4 cases. Major complications were a cerebro spinal fluid (CSF) leakage and a massive pulmonary embolism case in the early post-op.

CONCLUSIONS: Wrong primary treatment frequently leads to demanding revision procedures with increased risks for the patient and more than double costs for the health care system. Whatever the technique a stable spine is the target in surgery of SCI allowing a quick and effective rehabilitation without external orthosis.

Key Words:

Spinal cord injury, Surgical treatment, Rehabilitation.

Introduction

Spinal cord injury (SCI) is a devastating event for the person who suffered such damage. Both the acute surgical and the rehabilitation phase and the reduction of productivity of patients, of-

ten young, lead to a high level of expenditure for the overall management of the disease. In the last 20-30 years, a continuous improvement in morbidity and mortality rates associated to SCI was observed, due to the improvement of the overall level of care through the prevention of secondary and tertiary damage, e.g. to kidney, lung and skin. The rehabilitation protocols are critical in the management of spinal cord injuries. Early start is an accepted prognostic element¹. For this reason life expectancy of SCI patients is now comparable to that of healthy people. Also spine stabilization techniques helped to increase both quality and quantity of those therapeutic exercises needed to achieve the maximum overall level of autonomy. Spine stability, correct alignment, pain control are mandatory requirement to start the rehabilitation. These targets, however, are sometimes missed and the consequences on the outcome are relevant both due to the impairment of rehabilitation programs and due to the need of surgical revision. Surgical revision can be necessary for instability or lack of balance, as well as algo-dysesthetic and hypotonic syndromes not responsive to pharmacologic approach. In particular, the postural issue refers to the ability of maintaining balance against internal and external perturbances, with the goal of keeping the body center of mass within the base of support². After injury to spinal cord, the balance automatism may be affected and the individuals begin to adopt new patterns of postural control. The spine implants, their geometry and the bending of the rods deeply affect the new balance and create an overloaded area in the regions above and below the fused area. These elements are fundamental to plan rehabilitation exercises. The ability to maintain constraints above and below the lesion can also reduce friction phenomena, seen as potential generators of the neuropathic pain syn-

drome, and allows early adaptation of the patient to the appropriate positions for the rehabilitation process, such as sitting in a self-propelling or electric wheelchair and staying in upright position when standing. A correct surgical stabilization also determines a potential reduction of symptoms of autonomic dysreflexia, when injury is above T6 and involves the orthosympathetic component³.

The target of this paper is to analyze the reasons of surgical failures of acute spinal injuries, and discuss the consequences on the rehabilitation programs and on the outcome, without forgetting the increasing costs in terms of reimbursements and resources. The endpoint is to focus on the pitfalls of surgical treatment of acute spine injuries and to stress on the criteria to plan revision surgery.

Patients and Methods

A retrospective study has been performed on a series of 70 consecutive patients affected by different severity of post-traumatic paraplegia, referred to our Spine Center from a Rehabilitation Center in a period of ten years (2000 to 2009). These patients had been treated conservatively or surgically for thoracic and lumbar traumatic injuries, but rehabilitation was ineffective or impossible for reasons considered related to the primary treatment.

The series includes 42 males and 28 females ageing 16 to 78 years old (median 46). The lesions occurred at the thoracic spine (T1 to T10) in 25 cases, at the lumbar spine (L2 to L5) in 9, at the thoracolumbar junction (T11-L1) in 36.

Twenty-four patients had been treated conservatively and 46 had been treated surgically.

Pain under functional request (sitting, attempt to standing) was reported by 35 patients and was defined as superior to 7 according to the VAS by 21 patients. Fifteen patients reported continuous pain unrelated to their posture.

Thoracic Spine (25 Cases)

According to the ASIA scale 21 patients were classified as A, two as B and one as D. Twenty-one patients had a post-traumatic local kyphosis ranging from 10 to 35 degrees over the physiological range. Minor axial malalignment in the frontal plane was reported in 12 of them. Hardware failure (either mobilization or breakage) was detected on preoperative standard x-rays in 8

of these cases. According to the NPUAP classification⁴ 10 patients had pressure sores above the spinous processes line ranging from stage II to stage IV. Pain on sitting or attempt to stand was reported in 10 patients out of 25 while 7 had continuous pain unrelated to posture and severe hypertonus affected 5 patients in this second group. All patients were unable to keep the sitting position for long time due to pain or severe misalignment. Eighteen patients were wearing a three-point stiff orthosis at time of consultation.

Ten patients were sent back to the Rehabilitation Institute, as the kyphotic deformity was rigid and not so severe (less than 15 degrees). Surgery was considered inappropriate due to unacceptable risk to benefit ratio. Different approach to rehabilitation was proposed. Surgery was performed in fifteen patients, all showing a local kyphosis greater than 15°. Lack of anterior mechanical support had been recognized in all these patients by mean of preoperative CT. Ten also reported pain on weight bearing while two had pain and spasticity unrelated to positioning. Surgical procedures were performed by anterior approach only in 5 cases, by posterior approach only (via pedicle subtraction osteotomy) in 2, and by combined posterior-anterior approach in the remaining 8 (all the cases with a posterior hardware failure). In the two patients with neuropathic pain posttraumatic spinal stenosis was also found and they received spinal canal decompression during revision surgery in the belief that spinal canal clearance could be helpful in reducing neuropathic pain. In two patients with stage IV pressure sores plastic surgery had to be delivered two months before spinal fixation, while in 3 patients skin coverage was performed simultaneously with posterior stabilization.

Lumbar Spine (9 Cases)

According to the ASIA scale 5 patients were classified as B, three as C and one as D

All patients had a post-traumatic local kyphosis ranging from 15 to 35 degrees. Minor axial misalignment in the frontal plane was observed in one patient. No pressure sores above the spinous processes were identified. Pain on sitting or attempt to stand was reported only in 4 patients out of 9 while 3 had continuous paraesthesiae unrelated to posture and interfering with night sleep. All patients were able to keep the sitting position for at least 30 minutes. They were referred mainly to evaluate the stability of posterior constructs and to free them from external bracing.

ing. A semi-rigid lumbar corset was worn by all patients at time of consultation. Five patients were sent back to the rehabilitation program as no signs of instability were detected: radiographic appearance of anterior column healing, no hardware failure and no increase of kyphosis over the last 5 weeks. Surgery in this case cannot provide better possibilities to rehabilitation. The remaining 4 underwent surgery (2 anterior approaches and two double approaches in a single stage).

Thoracolumbar Junction (36 Cases)

According to the ASIA scale twenty patients were classified as A, nine as B and seven as D

All of them had a post-traumatic local kyphosis ranging from 10 to 40 degrees. Axial malalignment in the frontal plane (scoliosis) was reported in 11 cases and was severe in 5. Six patients had pressure sores above the spinous processes line ranging from stage II to stage IV. Pain on sitting and attempt to stand was reported in 21 patients out of 36 while 5 had continuous pain unrelated to posture. Severe hypertonus also affected 4 patients in this second group. 25 patients were unable to keep the sitting position for long due to pain or severe malalignment. Twenty-two patients were wearing a three-point stiff orthosis at time of consultation.

Nine patients were sent back to the rehabilitation center, as kyphotic deformity was rigid and not so severe (less than 15 degrees). Osteotomy seemed to be too aggressive and morbid for these patients. Surgery was performed in the remaining 25, all showing both a local kyphosis greater than 15°, and lack of anterior support on CT scan. Hardware failure (either mobilization or breakage) was easily detected on standard x-rays in 14 of these cases. Kyphosis correction and anterior support restoration was performed by anterior approach only in 7 cases, by posterior approach only (via pedicle subtraction osteotomy) in 4, and by combined posterior-anterior approach in the remaining 14 (all the cases with a posterior hardware failure). Spinal canal decompression was also carried on in the 5 patients with a spinal canal stenosis greater than 40%.

Results

Overall 44 surgical procedures were carried on. Six only posterior, 14 only anterior and 24 posterior-anterior. The average time of surgery

was 260' for the posterior only procedures, 160' for the anterior only procedures and 356' for the combined posterior-anterior procedures. Follow-up of these patients ranged 2 to 7 yrs.

Thoracic Spine (15 Cases)

An acceptable sagittal balance (less than 8° local kyphosis) was regained in all patients. All patients were put in sitting position on day three postoperative except 3 who underwent thoracotomy for anterior column reconstruction and who were seated on day 5. All of them could follow the rehabilitation course without bracing. At two month follow-up local pain was reduced for at least 3 points on the VAS in 9 patients out of 10; pain was always related to weigh-bearing (sitting or attempt to stand). No major improvement was found in the two patients submitted to spinal canal decompression for neuropathic pain. Further revision surgery was required in one patient because of surgical wound dehiscence with no major delay in the rehabilitation program. Neurologic improvements in ASIA scale were only minor and did not affect the practical life of patients.

Lumbar Spine (4 Cases)

Local kyphosis after revision surgery was less than 5° in all cases. Patients regained the sitting position on day 3 postoperative and wore a soft elastic corset for further 5 weeks. At 12 months follow-up pain under load greatly improved or disappeared in all patients and none of them required external spine support. Neurologic recovery improved from ASIA B to C in one patient and all the three ASIA C patients were able to walk with supports at final control.

Thoracolumbar Junction (25 Cases)

Realignment on the frontal plain was anatomical in all cases. Correction on the sagittal plane was considered good in 22 patients (less than 5° of local kyphosis) and acceptable in 3 patients submitted to anterior approach only (8 to 12 degree of local kyphosis left). All patients regained the sitting position on day 5 postop except two who suffered from pleural effusion after thoracic drainage removal. Eighteen patients wore a soft lumbar brace for 5 weeks postoperatively; no stiff external orthosis was required. Five patients suffered from wound dehiscence and 3 of them required a surgical revision from two to four weeks postoperatively. At final follow-up pain during weigh bearing significantly improved in 17 patients out of 21, while no major improvement was found in the 5

patients with neuropathic pain and hypertonus. From a neurologic point of view all ASIA A and C patients were unchanged, while 5 ASIA B patients turned into C and regained the capability of walking with supports.

Complications

The most severe complication was one lethal pulmonary embolism, which occurred in the 3rd post-op day. A case of CSF leakage healed with intra thecal drainage.

Discussion

Analyzing the strategy of treatment, the indications, planning and surgical technique can be helpful to understand the reasons of primary treatment failure and to dictate criteria finalized to refer a patient to Rehabilitation Center in the best conditions for effective rehabilitation program.

Whenever the treatment of a spine fracture with cord or cauda involvement fails to achieve the correct healing of the lesion, non-union and or mal-union occur, possibly combined with hardware failure, resulting in a variable combination of pain, deformity, instability, and neurological deterioration.

In this clinical setting, rehabilitation becomes more problematic, sometimes impossible and revision surgery is needed.

Based on our case load it is possible to propose some suggestions for the best treatment of spinal injuries, allowing starting early rehabilitation and possible achieve the best possible outcome.

Incorrect Diagnosis Ends in Incorrect Treatment

The most frequent case of incorrect diagnosis is underestimation of the severity of the lesion. It is relevant to remind that torsional moments – responsible of most severe bone and ligamentous injuries – can be appreciated even on frontal view standard radiograms⁵ and better defined by CTscan: alignment of the spine processes and pedicles, rib head dislocation, transverse processes multiple fractures. Even undiscovered lesions of the posterior ligamentous complex, suspected in standard radiograms by widening of the spinous process interspace, and best found on MRI, must change the treatment strategy (Figure 1).

Conservative treatment – or surgical treatment planned on underestimation of the lesions – mostly end in non-union or post-traumatic deformity.

Incorrect Treatment Can Follow Correct Diagnosis

Severely unstable C type fracture⁵ must be treated immediately even in polytrauma patients. Long rest in bed in ICU (Intensive Care Unit) does not prevent from the development of severe post-traumatic deformity which interferes or makes impossible rehabilitation programs (Figure 2).

The most frequent surgical pitfalls are:

Laminectomy without fixation is mostly followed by severe kyphosis. This treatment has been frequently performed in emergency in the past to reduce the post-traumatic stenosis. This practice should be completely abandoned. Even in emergency a posterior fixation should

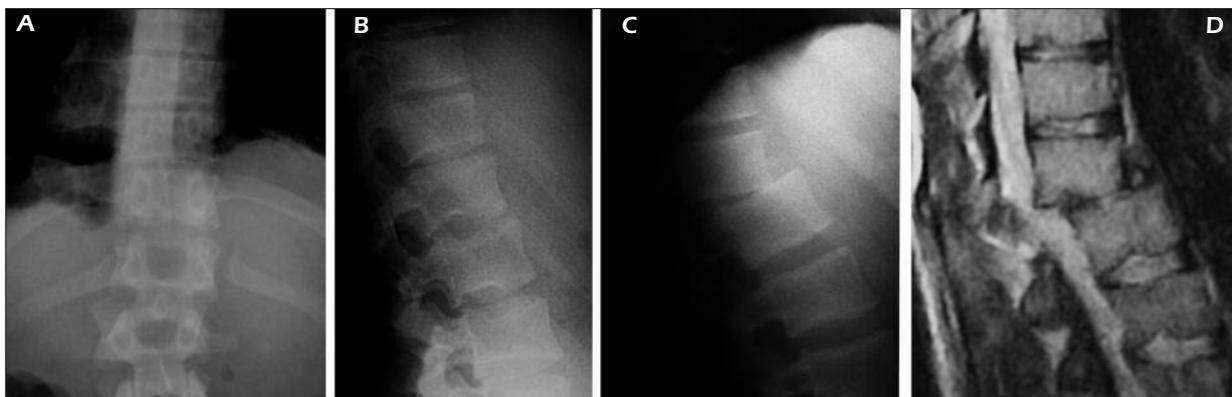


Figure 1. *A-B*, Male, 21 yrs. High energy road accident. Unrecognized C-type fracture. No consideration was given to the lost alignment of the spinous processes and pedicles and to the dislocation of the 12th left rib. *C-D*, Standard radiogram and MRI three months later, after conservative treatment. Frank T12-L1 dislocation.



Figure 2. 3D CTscan reconstruction in a 64 yrs old man, who underwent severe work accident. Head and chest closed trauma, ventilatory failure, paraplegia. Five weeks recovery in ICU. Surgery was not considered safe due to the general conditions. Malunion and non union preventing from any possibility of rehabilitation program, as even sitting position is possible.

always be performed. According to the “damage control” philosophy in the treatment of polytrauma^{6,7}, the less aggressive surgery should be performed to decompress the cord and deliver stability. In case of additional requirement, these can be accomplished later on, once systemic conditions are stabilized. Laminectomy alone can decompress the cord, but reduces the spine stability as it removes the elements of stability leaving unsupported the fractured anterior column.

Fixation without grafting. Long-term stability can be negatively affected by stabilization without grafting⁸, if disk movements are preserved or disk traumatic lesion occurred. Anterior instability, even worse if fracture is not healed, eventually will produce loosening of hardware failure.

Inadequate 3D balance reconstitution. Primary unreconstructed anterior column or incorrect alignment will evolve to scoliotic and/or kyphotic deformity. Although kyphotic deformity is better tolerated in a paraplegic patient, pain can result from non-union, interfering with the rehabilitation programs.

Anterior column lack of support. Surgical technique for unstable thoracic and lumbar injuries has been extensively discussed in many reports^{9,10,11} most of them concluding that this is the most frequent reason for treatment failure (Figures 3 and 4).

Severe osteoporosis can be a primary cause of screw loosening¹². Today fenestrated screws for cement injection and augmentation are available¹³, as well as expandable screws¹⁴. Bicortical technique of implant^{12,15} can improve the grip in the vertebral body cancellous bone.

Revision surgery is always complex and morbid. To restore the correct alignment, posterior approach alone^{16,17} can be considered: in the thoracic spine, in flexible deformities, whenever an appropriate anterior support is available. Anterior approach alone¹⁸⁻²⁰ can be considered in isolated anterior column deficiency, and in moderate deformities, if posterior approach is not available (pressure sores). Anterior reconstruction by posterior approach can be an option in both lumbar and thoracic lesions. Double approach surgery^{21,22} is a good option in case of severe and fixed deformities or in anterior and posterior columns deficiency not approachable just from posterior (Figure 5).



Figure 3. In case of lack of anterior support, additional hooks are not able to improve the implant stability, neither preventing the screw breakage.



Figure 4. Male, 48 years old. Vertebroplasty cannot provide enough stability in a burst fracture in a young patient. Pain and spine instability prevent from any attempt even to restore sitting position.

Revision surgery is highly demanding^{17,23,24}: long duration procedures, frequently requiring approaches encroaching vital structures are often required. A careful biomechanical planning must be performed and possible significant blood loss must be considered²³. Morbidity is, therefore, an important issue: all the possible complications related to the anterior and enlarged approaches, CSF leakage, infection, occur more frequently in revision surgery.

Pulmonary embolism is also a major risk, related to the difficult venous flow in paraplegics.

Costs Analysis

The burden for the health care system of a patient referred to the Rehabilitation Center without appropriate surgical treatment is obviously higher. Longer hospitalization for attempts to start rehabilitation, referral to tertiary Center for Revision Surgery, variable time in the ICU, re-admission the Rehabilitation Center and effective start of rehabilitation. Coding and billing of this course is different in different health care systems.

We have tried to evaluate this cost in our system.

The costs for the health care system can be calculated (based on Regione Emilia Romagna DGR 69/2011) as follows:

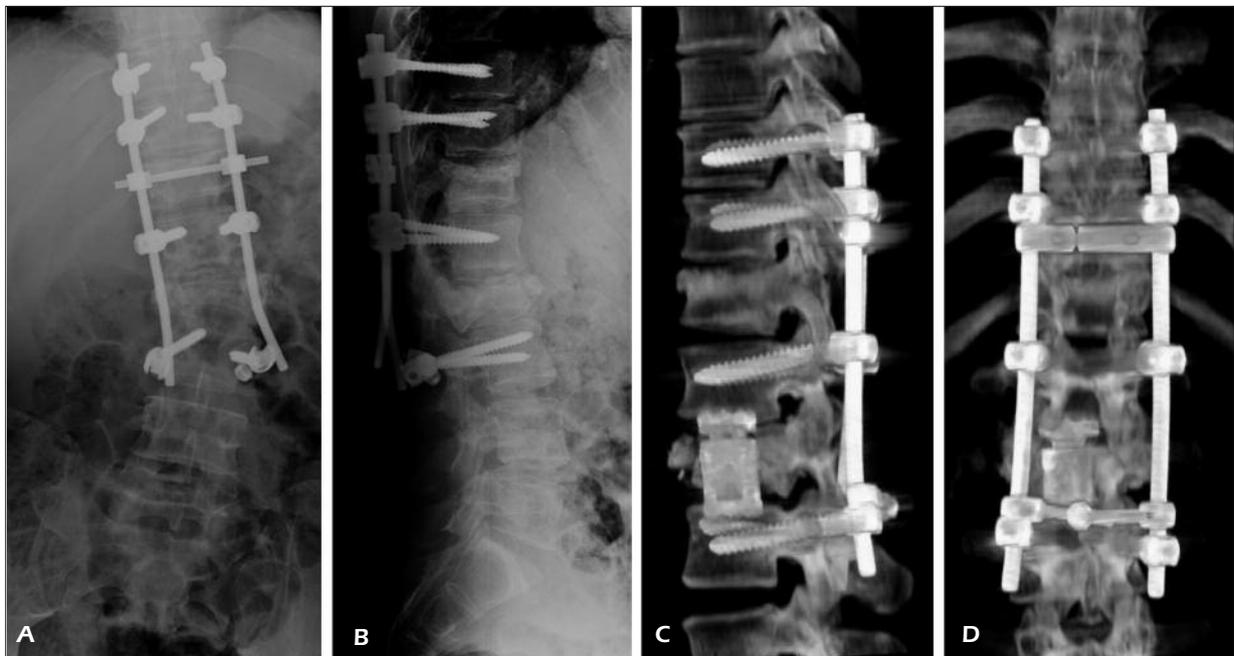


Figure 5. A-B, Male, 29 yrs. L2 Spine injury, ASIA C. Rehabilitation impossible due to instability and pain. **C-D,** Appropriate treatment include restoration of sagittal balance, circumferential fixation and graft to promote fusion. Rehabilitation starts few days after revision surgery.

- The first hospital admission costs can be calculated based on DRG 498 (spine fusion – cervical excluded – without complications), corresponding to € 10.581. The costs for the first attempt to rehabilitation can be calculated to € 16.320 (€238 for 30 days + €153 for 60 days). The total cost calculation is € 26.901
- In case of referral to spine center for revision surgery, the costs can be calculated adding DRG 496 (spine arthrodesis with double approach, complicated), corresponding to €19.670, to which the new admission to rehabilitation center must be added ranging to a final cost of 19.890 (€238 for 45 days + €153 for 60 days)

In conclusion, adding the costs of the first admission 26.901, to the costs of the second 39.560 the total is 66.461 that means 147% more.

Resource occupancy must also be considered: longer hospitalization, Intensive care unit occupancy, Radiological and Laboratory exams, spine hardware. Obviously, more morbid surgery means risk of further surgeries for the treatment of complications.

Conclusions

The treatment of spinal cord traumatic injuries can be decided according to many classification systems and guidelines^{5,25,26}, but the final goal must be a stable and pain free spine, flexible as possible, compared to the required fusion. If this target is not achieved, rehabilitation cannot be performed and local and systemic complications can worsen the quality of life of the patient.

A list of bedridden or reduced motility correlated problems includes: skin lesions; skin, soft tissues and muscle atrophy; cardiovascular pulmonary urinary problems.

Complex surgery is then required, as in this paper it has been analyzed, to restore balance and stability. The morbidity of these surgeries is well known²⁴ and must be carefully considered. The costs for the patient is very high, in terms of exposition to surgical and anaesthesiological risks, of longer hospitalization, of delayed or impossible return to work and social life. The costs are very high also for the society, as an increasing cost of 147% has been calculated (based on regional health care cost calculations).

Detailed patient information is mandatory: if something goes wrong the last surgeon is usually

the one to be blamed. But the target of a stable spine, allowing full recovery of the rehabilitation programs, counterbalances all the risks of revision surgery.

A prospective study is needed to better correlate different technique of surgical fixation, surgical approach and fusion area extension with the effectiveness of the rehabilitation protocols and the outcome. Neuropathic pain is also an issue requiring further and deeper approach, as at least in this series, surgery was not always able to relieve.

Conflict of Interest

The Authors declare that there are no conflicts of interest.

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