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TREATMENT OF SPINAL CORD INJURIES IN THE THORACOLUMBAR REGION

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ABSTRACT. Forty patients with spinal cord injuries in the thoracolumbar region were studied. Clinical and experimental data support the conservative approach. In some patients acute stabilisation is needed and in a few patients operative decompression may be considered. Promising experimental non-invasive techniques to improve recovery are presented, but there are no convincing clinical results so far. The authors believe that regeneration will be the key area for future research.

Key words: thoracolumbar spinal injuries, outcome of treatment, treatment alternatives.

If you line up ten neurosurgeons and orthopedic surgeons you will probably get five to ten different ways to treat a patient with a spinal cord injury in the thoracolumbar region. Probably no one is right because there have not been prospective randomized studies good enough to say what is right. Moreover, the details of the disturbances of nervous function following spinal cord injury are only roughly known to us. The discussion concerning the best treatment therefore has to be kept on a pragmatic level. The main questions are whether to operate or not and, if operation, how and when to operate.

CLINICAL OBSERVATIONS

Between 1961 and 1981, 46 patients were treated at our hospital for spinal cord injuries in the thoracolumbar region involving the Th 12 and/or the L 1 vertebra. Pathological fractures due to vertebral metastases and fractures without neurological deficit were excluded. The patients were treated conservatively or by laminectomy with or without fusion or with Harrington rods with fusion. The neurological status was assessed according to a modified Fraenkel scale (Fig. 1). The duration of follow-up ranged from two to 22 years. Six patients had died. The remaining 40 patients are presented in Table I classified according to treatment and neurological status at admission. There was no significant difference between the groups.

The results are summarized in Table II. The average improvement signifies how the average patient had moved on the modified Fraenkel scale. There is no difference between the treatment groups. This is in agreement with other studies, e.g. Osebold et al. (18) who found that no treatment method so far available was superior to the others with respect to neurological function.

Table III shows the duration of hospitalisation. There is no difference between conservatively treated and Harrington rod patients, while those subjected to laminectomy stay significantly longer in hospital. Patients with Harrington rods can be mobilised very early but that seems to be the only advantage of Harrington rod treatment over conservative treatment.

So, we have the choice between conservative treatment which means that the patient has to stay in bed for 6 to 12 weeks depending on what policy is chosen and Harrington rod treatment which means that he or she can be mobilised during the first week but has to have two operations. For some the choice may be easy, for others not. Early mobilisation has many advantages but two operations involve a certain risk. We agree with Bedbrook (2) when he states that the treatment procedures must be carried out in a comprehensive unit and then only after adequate assessment and consideration, not only by the surgeon, but principally by the overall physician whether he be surgeon, physician or paraplegist.

TRAUMATIC SPINAL CORD DISEASE

Now, let us analyse the problem from another point of view. A spinal cord injury is in many respects similar to a brain injury. The late Sir Geoffrey Jefferson spoke of brain concussion as a sometimes progres-

1. Complete paraparesis (complete absence of motor function)
2. Severe paraparesis (insignificant motor function in some muscle groups)
3. Moderate paraparesis (motor function in several muscle groups)
4. Slight paraparesis (motor function in most of the muscle groups)

Fig. 1. Classification of patients.

Table II. *Neurological improvement*

	Number of patients	Number of patients improved	Average improvement (number of step)
Conservative	16	13	1.3
Laminectomy	14	11	1.2
Harrington	10	9	1.3

sive disease and coined the expression brain injury disease (17). In the same way, the autodestructive process of the spinal cord starts at the moment of injury—if the impact is of sufficient magnitude—and proceeds up to a certain point. As for head injuries this process is governed by the force and mechanism of the injury. So far, there is no miracle drug or operation that can stop this process. Simultaneous with and intermingled with this destructive process reparative process starts. Macrophages migrate into the traumatised area and begin to remove dead tissue; intact but paralysed fibers and tracks start to conduct impulses; in disarranged fibers rebuilding starts and in interrupted pathways regeneration of axons occurs. Research today is concerned with the search for therapies which arrest the autodestructive process and enhance the reparative processes. Although some beneficial effects have been reported in animal experiments, we think it is right to say that there are no convincing clinical studies so far. Thus, in the acute phase of a spinal cord injury current knowledge supports the conservative approach. There does not seem to be any indication for early operation in the average patient.

INDICATIONS FOR SURGERY

But there are exceptions. Firstly, when there is an obvious instability, i.e. when there is marked anterior-posterior or lateral displacement between the involved vertebra, we think it is necessary to stabilize immediately to prevent secondary damage. This applies only to a limited number of patients. The majority are stable enough to be treated conservatively. Bedbrook (1) reports in a review of thoracolumbar injuries that some 5% might be considered for technical fixation. The second exception concerns those patients in whom there is compression of the spinal cord and nerve roots by bony elements or disc material. In these cases it seems logical to remove compression to create better conditions for the reparative processes. Fig. 2 a and *b* show cross-sections at the level of the Th 12–L 1 disc and the L 1–L 2 disc. The cross-section area has to be reduced by at least 50% before the cord and roots are significantly compressed at L 1–L 2 but only with about 20% at the Th 12–L 1 disc level. Since the position of the conus differs between individuals one has to make the decision from patient to patient. To visualize the conus a small amount of contrast must be introduced into the subarachnoidal space.

The dislocation of fragments into the spinal cord is sufficiently reduced after application of Harrington rods in 90% of the patients (20). In the remaining 10%, decompression can be performed. A lateral approach to the spinal canal is then recommended. It is our experience that the degree of recovery does not correlate to the time of compression. Therefore, the removal of the compression can be postponed until the cord is in a more stable cytochemical condition and less vulnerable not only for additional mechanical impact but also for a drop in blood pressure (7). How long one has to wait is difficult to predict, but a week seems a reasonable time for the cytochemical

Table I. *Neurological status at admission*

	Conservative $n=16$	Laminectomy $n=14$	Harrington $n=10$
Complete	4	3	2
Severe	5	5	3
Moderate	2	2	3
Slight	5	4	2

Table III. *Duration of hospitalisation*

	Weeks	SD
Conservative	29	14
Laminectomy	39	10
Harrington	23	18

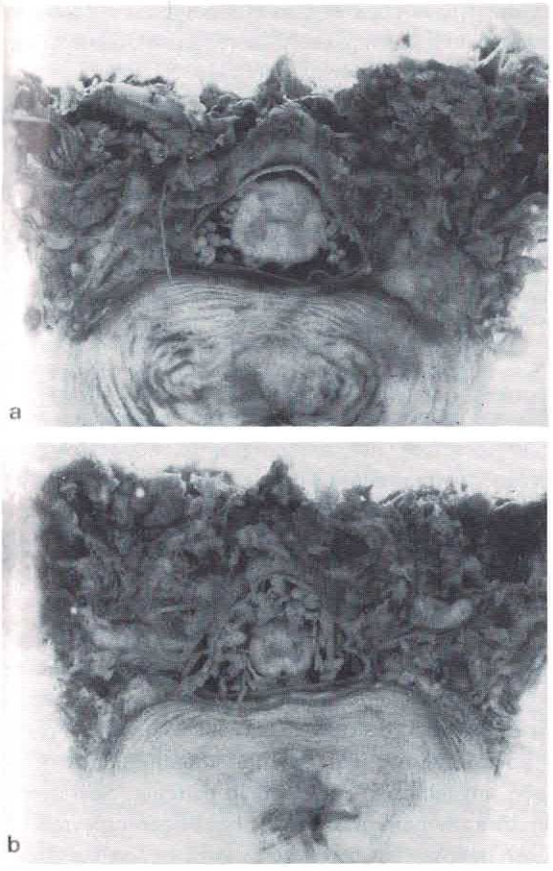

Fig. 2. For explanation see text.

processes to stabilize, the edema to vanish and the autoregulation and changes in the arteriovenous blood flow pattern to normalise.

CURRENT TREATMENT METHODS

We differ between acute methods, which aim to prevent further damage as stabilization or to arrest or reduce the effects of the destructive processes which start at the moment of injury and elective methods, which aim to enhance reparative processes or to maintain what the patients have by using various techniques of rehab engineering.

Surgical treatment (Fig. 3). We have already discussed stabilization as an acute treatment and decompression as an elective treatment. The basis for using cooling of the injured area is its ability to lower the metabolic and oxygen demand of nerve cells and possibly also that it could reduce the swelling of the injured cord (24). Omental transposition is interesting not only for spinal cord injuries but also for cerebral injuries and cerebral ischemic lesions (22). The omentum has powerful capacity to reduce edema and to revascularize the injured area.

ACUTE	ELECTIVE
Stabilisation	Decompression
Hypothermia	Neural bypasses
Omental transposition	Functional electrical stimulation

Fig. 3. Surgical.

ACUTE	ELECTIVE
Hyperbaric oxygen	Rehab. engineering
Pulsed electromagnetic fields	

Fig. 4. Non-invasive approaches.

On the elective side we have neuronal bypasses which means that we try to shunt activity from roots or nerves which have a central connection to roots belonging to the isolated spinal segment (6). Functional electrical stimulation refers to implantable systems, e.g. conus stimulation (5) or stimulation of sacral roots to achieve bladder emptying (3) and epidural spinal stimulation to normalize a detrusor-sphincter dysenergia to reduce spasticity and to improve coordination of movements in partial lesions (8). It also includes high technology computerized systems implanted on peripheral nerves to make paralysed individuals walk as reported by a group in Vienna (23).

Non-invasive approaches (Fig. 4). Experimental work on sheep has shown that hyperbaric oxygen can modify the degree and extent of the pathology in the spinal cord following an injury (25). It has been shown that contusion of the spinal cord causes massive Ca entry into cells, which is known to have deleterious effects on cellular function and survival. Electromagnetic fields applied to spinal cord shortly after contusion reduces Ca accumulation and is associated with a better recovery of motor and sensory functions (16, 27).

On the elective side rehab engineering has exploded as a field (12). Paralysed patients have nervous tissue that is viable but not functioning. By

ACUTE	ELECTIVE
Antiadrenergic compounds	Neurotrophic (growth)
Naloxone	factors
Dimethyl sulfoxide	
Anticoagulants	
Corticosteroids	
Nimodipine	

Fig. 5. Pharmacological

Spinal cord: feeble sprouting; functionally not useful
Dorsal roots: fibers regenerate in central direction but do not enter spinal cord; functionally not useful
Ventral roots: regenerate similar to peripheral nerves; functionally useful

Fig. 6. Regenerative capacity.

application of high technology you can convert this tissue to functional tissue. It is a matter of maximizing of what the patients have. Through various techniques with surface electrodes it is possible to improve a patient's functional capacity by changing the muscle bulc and strength, to help the patients to find their muscles by biofeedback to strengthen osteoporotic bones with vibration and to reduce spasticity with low intensity laser.

Pharmacological treatment (Fig. 5). Osterholm et al. (19) proposed that toxic amounts of noradrenaline (NA) is released at the site of injury. This NA accumulated is considered to be responsible for the necrosis and haemorrhage that has been observed within 1–2 hours after injury. Subsequently a number of compounds that could decrease the level of central NA have been used in animal experiments. Alphamethyl thyrosine was reported to be very effective in controlling the post-traumatic progression pathological picture with necrosis and haemorrhage. Other investigators however found no increase of NA in the injured area (21). Sympathectomized cats did not exhibit the posttraumatic ischemia typically produced by contusion injury (28). The critical factor appears to be the presence of the paravertebral sympathetic ganglia and not the adrenal glands.

Naloxone (11, 13), dimethyl sulfoxide (9), anticoagulants (15) and cortico-steroids (26) have been found in animal experiments to improve spinal cord blood flow and neurological recovery at the experimental spinal cord injury. Nimodipine, a calcium channel blocker markedly increased blood flow in the spinal cord in normal rats (14).

On the elective side neurotrophic factors are mentioned as a common title for all drugs that could possibly enhance regeneration. The reader is referred to the excellent review by de la Torre (10).

At present there is no breakthrough in regeneration and the situation is described in Fig. 6.

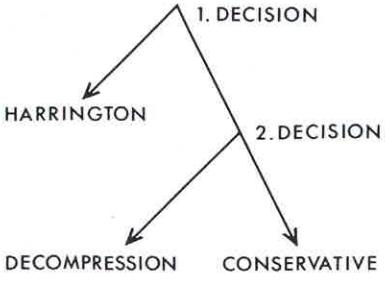

Fig. 7. For explanation see text.

CONCLUSION

The lack of knowledge in this area is tremendous and it is therefore not meaningful to advocate any method or treatment as better than the others. With this reservation in mind we would summarize our view of the treatment as follows (Fig. 7): The first decision has to be made at admission because markedly unstable fractures must be stabilized. The majority of patients can be treated conservatively. After a week it is time to make the second decision. If there is significant compression of the spinal cord and roots, it should be removed.

The promising experimental therapies have not been satisfactorily evaluated in patients. So far no significantly beneficial effects have been reported.

We believe that regeneration will be the key area for future research since in the long run we probably have better possibility here than we have to arrest the autodestructive processes which start at the moment of impact.

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