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REVIEW ARTICLE

Management of patients with transection injury of the spinal cord

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The pathophysiology of spinal cord trauma and particularly, of the cervical and upper thoracic spinal segment, is often associated with immediate threat to live and with very serious temporal and permanent changes in the function of the whole organism of the trauma victims. As a result, the patients require special anesthetic and intensive care management. By conscious and cooperative patients, a quick neurological evaluation of the sensory and motor reflexes provides immediate information necessary to identify a partial or a complete transection injury of the spinal cord. Associate injuries (e.g. fracture or hemorrhage) are observed in about 10% of the cases and most frequently involve the cervical spinal segment. In unconscious patients or in patients whose level of consciousness is impaired, the cervical spine must be immobilized to prevent a potential neural damage, until spinal cord injury is excluded. In acute situation, the intensive care of such patients may extend from few weeks to many months. *Hippokratia 2005, 9 (1): 26-34*

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The pathophysiology of spinal cord trauma and in particular, of the cervical and upper thoracic segment, is often associated with immediate threat to live and with very serious temporal and permanent changes in the function of the whole organism of the trauma victims. As a result, the patients require special anesthetic and intensive care management. In acute situation, the intensive care of such patience may extend from few weeks to many months.

Emergency treatment

In cases of conscious and cooperative patients, a quick neurological evaluation of the sensory and motor reflexes provides immediate information necessary to identify a partial or a complete transection injury of the spinal cord. In unconscious patients or in patients whose level of consciousness is impaired, the cervical spine must be immobilized to prevent a potential neural damage, until spinal cord injury is excluded by means of thorough diagnostic examination in the hospital. Associate injuries are observed in about 10% of all patients with head and spinal cord trauma and the commonest associate injury involves the cervical spinal segment . Injury of thoracic spinal segment is commonly caused by thoracic trauma. Retroperitoneal hemorrhage and intra abdominal injury is seen and must be suspected by the involvement of lumbar spinal segment.

Falls with landing on both heels will result in most cases to an injury at the level of thoracic-lumbar spinal cord passage and to fracture of both heels.

Patients with complete transection injury of the spinal cord often have loss of pain sensation, loss of idiopathic reflex activity and flaccid paralysis below the level of injury. An acute cervical spine injure presents a clinical sign of pure diaphragmatic respiration. Male patients with higher level of complete transectional injury of the spinal cord may present with priapism.

Thorough neurological examination should be performed on conscious and cooperative Patients whenever spinal cord injury is suspected or whenever there is evidence of spinal fracture. A rectal examination should be performed to check "blow-bowel-function". Under normal physiological condition the ring muscle should contract during coughing.

The goals of resuscitation of patients with transection injury of the spinal cord at the site of the accident are rapid restoration and maintenance of the vital functions, stabilization of the cervical spinal and prevention of secondary injury. Patients who present signs of both normal heart frequency rate (HR 50 - 70/min) and hypotension have possibly sustained complete transection injury at the upper level of the spinal cord. Unconscious patients or patients with inadequate respiration should be intubated whereby torsion, flexion and hyperextension of the head should be avoided. Rigorous infusion of fluid should be undertaken in order to stabilize circulation and if necessary dobutamine should be administrated. The neck should be immobilized with neck brace and transportation should follow carefully with, for instance, vacuum mattress.

Terminology of transectional injury of the spinal cord

The term plegia is used to describe clinically the motor inhibition, which occurs at the location caudal to the level of a transectional injury of the spinal cord. Quadriplegia or tetraplegia defines the paralysis of all four extremities and is the result of a complete transectional injury of the spinal cord, which is located at a spinal level rostral to the arms. Paraplegia defines the paralysis of only the two legs and is the result of the spinal cord injury, which is located at a spinal level caudal to the arms. A complete transectional injury of the

spinal cord induces the following symptoms: complete loss of voluntary muscle movements, complete loss of voluntary and involuntary bladder and bowel control and anesthesia below the level of the spinal cord injury. Also present in the symptoms are signs of temporal or permanent functional disturbances of the autonomic tract (loss of circulation -, breathing - and temperature regulation).

The term paralysis is normally differentiated between flaccid and spastic paralysis. Flaccid paralysis is characterized by a total loss of muscle activity, while spastic paralysis is characterized by excessive increase of the basic muscle tone activity leading to contraction of the respective muscles. Generally, transectional injury of the spinal cord produces initially flaccid paralysis followed by spastic paralysis, while injury of peripheral nerves produces only flaccid paralysis. Also injury of cauda equina of the spinal cord produces only flaccid paralysis.

The level of transection injury is defined by naming the last intact spinal cord segment. For instance, transection injury below C5 means that the C5 segment of the spinal cord is still intact.

Knowledge of the cutaneous areas innervated by the spinal nerves enables the clinician to locate the level of the lesion in the spinal cord or spinal nerve. The innervation of the muscles and the dermatomes of the upper and lower extremities deserve special attention (Table 1). It should be noticed, that a branch of cervical plexus nerve (Supraclavicular nerve, C3/4) innervates the area of the skin, which extends from just below the clavicles to a little above the mammilla. The thoracic segments T1 - T2 supply part of the upper limb and the axilla respectively. The sensory innervation of the skin at the passage from cervical to ventral thoracic area is supplied by the direct passage of C4 to T2 (the so called "Hiatus cutaneous innervation"). In the dorsal part, the segments - C7, C8 and T1- lay paravertebrally in a small triangular area, which is supplied by the dorsal rami. Despite schematic demarcation, in actuality there is considerable overlap between nerve supply of adjacent segments. Especially, the border between C8 and T1 can be fluent.

The Scale conceived by Frankel or the classification of American Spinal Injury Association (ASIA) can be used to evaluate the degree of the paralysis and to assess the process of the injury.

Frankel's scale is grouped into five degree of severity of the lesion and is based on functional criteria: A = complete paralysis together with complete loss of sensation; B = complete paralysis together with incomplete loss of sensation; C = incomplete paralysis without any functional benefit; D = incomplete paralysis with functional benefit; E = none paralysis (complete recovery).

The ASIA - Classification is comparatively more comprehensive and has been revised many times. The motor and sensory functions are assessed here on the bases of a point system, which include the modified Frankel's scale criteria as well as functional independence criteria - FIM.

Vertebra fracture is commonly present in spinal cord injury but especially in infants and younger children, there might be an injury without obvious fracture. Myelopathia, which occurs as a result of trauma but without any radiographic sign of fracture or instability of ligaments, is termed SCIWORA (spinal cord injury without radiographic abnormality). Patients, especially younger ones, who are suspected to sustain spinal cord injury based on medical history and clinical observation but have no radiographic evidence should be monitored carefully and the neck should be immobilized with neck brace, until the suspicion is cleared.

Table 1. *Upper extremity muscles innervated by the cervical segments*

Segment	Muscle	Function
C5	Deltoid	Arm abduction
C6	Biceps brachii	Elbow-Flexion
C7	Triceps brachii	Elbow-Extension
C8	Small hand muscles	Finger movements

Pathophysiology

The immediate response to spinal cord injury after trauma is a massive sympathetic stimulation and reflex parasympathetic activities that usually lasts 3 to 4 minutes and is mediated by alpha-adrenergic receptors. The hemodynamic effects are severe hypertension and reflex bradycardia or tachyarrhythmias.

After this initial response, loss of neurological function below the lesion causes what is called spinal cord shock. Spinal cord shock is characterized by flaccid paralysis of the affected limbs together with loss of all reflex activities. Flaccidity of the GI tract and the bladder causes generalized ileus and urinary retention. Loss of autonomic innervation causes vasodilatation in the respective area together with redistribution of the blood volume. In addition, lesion above the level of T5 causes bradycardia and arterial hypotension due to the interruption of the sympathetic innervation of the heart. The spinal cord shock phase lasts few weeks to many months

The spinal cord shock is followed by a phase with increasing degree of muscle spastic and the reappearance of spinal reflexes (hyperreflexia phase). The first spontaneous spastic movement in this phase is usually mistaken for voluntary movement and is the cause of false optimistic assessment of the healing process. Occasionally, hyperreflex activity is observed, which is characterized by extreme high values of arterial blood pressure during bladder and bowel manipulation and is due to the loss of inhibition control of the reflex activity in the region below the level of the lesion.

Radiographic Diagnosis

Conscious and cooperative patients with no clinical history or signs to indicate injuries of the cervical spinal

cord (mechanism of the trauma, neck pain, signs of neurological abnormality) do not need routine radiographic diagnosis. However, whenever vertebra fracture cannot be totally ruled out, radiographic diagnosis has to be performed, whereby the cervical spinal segment and the region of cervical- thoracic passage have to be regarded as imperative. Skull base fracture and fracture at the region of cervical - thoracic passage are difficult to diagnose with the conventional radiography. In doubtful cases, Computer Tomography (CT) of the spinal cord should be performed.

After excluding vertebra fracture or dislocation, suspicion of disc and ligament instability as well as SCIWORA (spinal cord injury without radiographic abnormality) has to be cleared with Magnetic Resonance Tomography (MRT)

The most common reasons why vertebra fractures are not diagnosed in the earlier phase of the injury are the following:

a) Associate injuries
b) Injury of several vertebra
c) Unconscious Patient

After the vital functions have been stabilized and the primary emergency surgery care has been accomplished, every polytraumatic Patient must undergo a complete diagnose of the all spinal cord segment. The neck must remain immobilized with a suitable neck brace, until vertebra fractures or instability is excluded.

Pharmacological interventions by symptoms of fresh transection injury of the spinal cord

Of all the numerous drugs administrated to prevent or treat neurological damage by acute injury of the spinal cord, only the administration of methylprednisolon (MP) is currently shown to have some clinical benefit. A number of multicenter trials have demonstrated the benefit of administration of methylprednisolon by acute injury of the spinal cord. In the NASCIS - 2 trials (National Acute Spinal cord Injury Study -2) a slight positive improvement was observed on motor and sensory function up till 6 months and only motor function up till one year after the trauma, in patients who received methylprednisolon. The studies showed also that methylprednisolon was effective only when the administration was initiated within 8 hours after the trauma and in the dosage shown in Table 2. However, when the initiation was delayed more than 8 hours after the trauma, the recovery was worst than in the control group.

This neurological recovery of patients treated with methylprednisolon is generally assessed as minimal.

Table 2. *Dosage of methylprednisolon by acute transection injure of the spinal cord (NASCIS II – Formula)*

Initial:	30mg/kg BW as bolus
Followed by:	5,4/kg BW/h as continuous infusion for over 23 hours

However, it should be noticed that even minimal improvement can considerable raise the quality of live of tetraplegic patients. In the first 24 hours of the treatment with methylprednisolon no substantial harmful side effect normally occurs but after the first 48 hours an increasing incidence of sepsis and pneumonia is observed.

The NASCIS- studies are considered by experts to have some methodological faults. In the "Guideline for the management of acute cervical spine and spinal cord injuries" of "Section on Disorders of the Spinal and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons" the treatment with methylprednisolon in the acute phase is mentioned as an option (Evidence grade III "experts opinion") with the following comment: *treatment with methylprednisolon for either 24 or 48 hours is recommended as an option in the patients with acute spinal cord injuries and should be undertaken only with the knowledge that the evidence suggesting harmful side effect is more consistent than any suggestion of clinical benefit.*

The German Association of Anesthesiologist and Intensive medicine (Deutschen Gesellschaft für Anästhesie und Intensivmedizin - DGAI) through its work-group "Neuroanesthesia" recommend that the decision for or against the treatment with methylprednisolon should be left to be taken by the physician, who has the responsibility for such treatment[1].

The following guideline is recommended in the treatment of acute spinal cord injuries with methylprednisolon:

a) The treatment should be initiated as soon as possible - possibly within the first 3 hours but definitely not later than 8 hours after the injury

b) The continuous infusion should not exceed 24 to 36 hours because of the expectable harmful side effects

c) The decision against the treatment with methylprednisolon by acute spinal cord injuries should not be evaluated as negligence of therapy.

Suitable time of surgical intervention

Suitable time of surgical intervention by acute spinal cord injuries with or without neurological abnormality is currently an object of continued controversy. Data from animal experiments suggest that an early decompression of the spinal cord (< 6 h after compression) unambiguously leads to neurological recovery[2]. Pressure for an immediate decompression and stabilization should be applied depending on the general condition of the patients and other associated injuries[3]. Moreover, stabilization of the patients within the first days of the injuries will provide huge advantage for further intensive care treatment. Retrospectives studies of surgical interventions within 72 hours of acute spinal cord injuries with neurological abnormality showed better neurological recovery and early discharge from the hospital. Furthermore, complication rate was not higher when compared with a group where the surgical interventions were undertaken in the 3rd day of the injury[4].

Cardiovascular Management

The maintenance of sufficient perfusion pressure is of vital importance in the management of spinal cord trauma. Although without available data, it is advised to aim at maintaining a Mean Arterial Pressure (MAP) of above 85 – 90 mm Hg in the first 7 days after the trauma. Hypotension (systolic blood pressure < 90 mm Hg) should be avoided or corrected as soon as possible ("expert opinion"). Hypotension and bradycardia are usually common in cases of transection injuries of the spinal cord because of the loss of sympathetic innervation. The vasodilatation of the capacity vessels causes vein "pooling" which reduces blood flow toward the heart.

Procedure of Cardiovascular Management

The goal of the cardiovascular management of spinal cord trauma is the stabilization of the blood circulation. This is achieved primarily with a judicious administration of fluid. Administration of sympathomimetic agents for the same purpose could follow later[5-7]. *Dolan* and *Tator,* as earlier as 1982 in their studies, demonstrated the advantage of rigorous volume substitution therapy over the administration of dopamine for improving the blood circulation of the spinal cord[8]. Although there are different suggestions regarding which fluid (colloid or crystalloid) should be used for the volume substitution therapy, preference should to be given to colloid administration. When the volume substitution therapy alone is not able to stabilize the circulation, it should be combined with the administration of sympathomimetic agent and the first choice here is dopamine. A pure alphamimetic agent should be avoided because under certain circumstances it could deteriorate the situation.

Dopamine increases the cardiac output as well as the heat frequency. Atropine should be administrated when, in spite of a stable blood circulation, there is bradycardia. In cases of persistent bradycardia a continuous alupent infusion should be initiated. Irritation of the vagus nerve together with hypoxia can cause reflex bradycardia. The implantation of a temporal or a permanent heart pacemaker is rarely indicated, and concerns, in most cases, patients with previous bradycardia disorder.

Monitoring

The suggestions given for the hemodynamic monitoring in the acute phase of the injury is variable. (Table 3). Basically, arterial line should be inserted both for a continuous blood pressure measurement as well as for blood gas analysis. The insertion of central vein catheter for measuring the central vein pressure (ZVP 10 – 15 cm H_2O recommended) and for measuring the pulmonary arterial pressure (PCWP 18 mm Hg) is recommended. Recently, the transesophagus echocardiography is applied to assess the preload and the contractibility of the heart. Also new volume indicator dilution methods like PiCCO (Pulse Contour Cardiac Output), which are less invasive than the pulmonary arterial catheter are increasingly being used to evaluate and to control the Hemodynamic of instable Patients.

Table 3. *Hemodynamic Monitoring of patients with acute transection syndrome*

Routine	Facultative
-Arterial Line	-Pulmonary arterial catheter
-CVC	-Trasnsesoph. Echocardiography (TEC)
-Bladder Catheter	-PiCCO
-Lung (radiographic control)	

Respiratory Management

Innervation of the respiratory muscles

The diaphragm, which plays a very important role in the inspiratory part of the breathing is innervated from C3 - C5 spinal segment. The intercostal muscles, which are responsible for the chest breathing are innervated from T1 - T11 spinal segment. Normally, expiratory part of breathing is passive but active expiration (cough) requires the abdominal muscles, which are innervated from T7 - L1 spinal segment (Table 4).

Respiratory failure

Survival of patients with acute spinal cord injuries depends on their ability to breath spontaneously. Lesions above the level of C3/4 segment do not permit spontaneous breathing and as a result do lead to the death of the patients, when there is no immediate first aid intervention. Such patients, when they are successfully resuscitated, could require long-term artificial ventilation (eventually, live long).

Respiratory problems must also be anticipated by lesions, which are at the level of C3/4 and upper thoracic segment, especially when lung disease, old age and associate injuries (Lung contusion has to be suspected by trauma of the thoracic segment[1]) are present. Significant reduction of the vital capacity as a result of loss of the intercostal muscles function, a paradoxical breathing with altered excursion mechanic, loss of the abdominal muscles function together with loss of the ability to mobilize secretions and cough, normally promote atelectasis and infection.

Therapy of respiratory insufficiency

The indication for intubation and artificial ventilation should be made as early as possibly, whereby a laryngeal access should be seen only as a temporal mea-

Table 4. *Innervation of respiratory muscles*

Inspiration	
Diaphragma	C3 – C5
Intercostal muscles	T1 – T11
Expiration	
Abdominal muscles	T7 – L1

sure and tracheotomy is recommended. Evidence indicates that patients, who sustain total transactional injury at the level of C4, C5 or C6 segments, require long-term artificial ventilation. Also patients with associate disorders (thoracic trauma, pulmonary disease, unconsciousness due to head and brain trauma) and injury of the lower cervical or the upper thoracic segment usually require long-term artificial ventilation too. An earlier extubation of these patients should be avoided. Blood gas analysis and the degree of spontaneous breathing are not reliable index upon which to base a decision for an extubation of these patients at the early phase of the injury. Loss of the abdominal muscles function together with impaired ability to mobilize secretion and to cough leads to accumulation of pulmonary secretion. An attempted extubation can easily lead to retention of secretions and infection of the airway within a very short time so that these patients, who already have impaired vital capacity, are easily exhausted and as a result are reintubated. Repeated unsuccessful attempts could deteriorate dramatically the general situation of the patient, leading to a longer-term need for artificial ventilation. The non-invasive method of artificial ventilation is not an alternative because it provides no possibility for endotracheal suction of the pulmonary secretion.

An early tracheotomy provides several more advantages to the patients than the endotracheal intubation (Table 5).

Tracheotomy leads to significant reduction of the pulmonary airway resistance and increase of functional residual capacity. This can be of great relief especially for patients who breathe spontaneously but whose breathing force, airway resistance, lung compliance and functional residual capacity are compromised. Tracheotomy offers also the possibility of suction of endotracheal secretion without trauma and independent of the phase of ventilation. It facilitates the changes of phases of ventilation (spontaneous to artificial phase and vice verse), which might be necessary during the treatment. Generally, tracheotomy offers more flexibility for extubation of the patients because the phases of artificial ventilation can be reduced significantly.

Emergency intubation

Endotracheal intubation could be necessary (acute respiratory failure) at a site of an accident. The neck hereby should be stabilized. Succinylcholine can be administrated within the first 12 hours after the spinal cord trauma for the intubation of the patients, but should not be used after this period because of the risk of hyperkaliamia. Torsion-, flexion- and hyperextension movement of the head should be avoided.

Table 5. *Advantages of tracheotomy by acute high transection syndrome*

Minimal airway resistance
Minimal residual volume
Better suction of pulmonary secretion
No analgesic or sedation needed
Early speaking possible
More flexibility in the waning phase

Planed Intubation

Studies demonstrate that spinal cord injury could result from endotracheal intubation in patients with undiagnosed cervical spine fractures. As a result, there are suggestions on procedures of intubation by cervical spine injuries, which include the following:

a) Laryngoscopic endotracheal Intubation

b) Fiberoptic intubation of awaked patients

c) Fiberoptic intubation of anesthetized and relaxed patients.

Although there are no data to validate any specific procedure, the following practices are recommended: after examining the possibility of adequate mask ventilation, direct laryngoscopic intubation of the anesthetized and relaxed patient should follow under stabilization of the cervical spine. A flexible bronchoscope should be at standby. When the laryngeal opening cannot be easily identified with laryngoscope, an oral or nasal tracheal fiberoptic intubation is performed.

Fiberoptic intubation of awaked patients is assessed rather skeptically because of the cough reflex, which is associated with the maneuver and which could dislocate the spine and might jeopardize the patient. Non-depolarizing muscle relaxants should be administrated for the relaxation of patients whose injury has exceeded 12 hours. Rocuronium or Rapacuronium in combination with Propofol, when necessary, should be used for "Crush-Intubation". During the surgery, supplementary muscle relaxants (if needed at all) should be administrated carefully, especially if extubation of the patient after the surgery is planed.

Tracheotomy

Cutaneous tracheotomy can be performed at the bedside of the patient 24 to 48 hour after the surgical stabilization of the cervical spine. The first change of the intubation tube should not be performed early than one week after the insertion and should be under vigilance for immediate reintubation because, especially in the initial phase, the tracheotomy closes upon removal of the tube. If the tracheotomy is left for a longer period, a canal normally forms, which enables tube changes without any problem.

Influence of body posture on spontaneous breathing

For prophylactic reasons and for the therapy of atelectasis, secretion accumulation and decubitus ulcers, frequent changes of body position of patients with transection injuries of the spinal are imperative. Tetraplagic patients with spontaneous breathing react very sensitively to changes of body posture in the first weeks of the injury.

High positioning of the upper body part (20°) can lead to increase of the Functional Residual Capacity (FRC) as a result of depression of the diaphragm and

to reduction of Forced Vital Capacity (FVC). The abdominal organs facilitate the passive expiration when the patient is in the supine position and with slight elevation of the upper body (20˚). However, with higher elevation of the upper body this advantage is lost because the abdominal organs descend much lower and as result do not contribute to passive expiration. The positioning of the body in depressed upper body position (Trendelenberg) is usually performed in the intensive care unites for better suction of pulmonary secretions. This procedure could lead to reduced Functional Residual Capacity (FRC) and Forced Vital Capacity (FVC) of tetraplagic patients with spontaneous breathing, hereby worsening the oxygenation. The lateral position of the body is better tolerated.

Long-term ventilation

In the first weeks of injury, tetraplagic patients are at increased risk of sustaining pulmonary complications but after this period the respiratory condition stabilizes as a result of the spastic paralysis of the intercostal muscles that normally follows the spinal cord shock and counteracts against the paradoxical thoracic excursion during an inspiration . The prognosis as to when such patients should be extubated is difficult to make. It should depend on the level of the lesion in the spinal cord, the present of complications, the present of complete or incomplete paralysis and the extent of neurological recovery observed during the treatment.

Patients with lesion at the level of C0 - C3 normally depend on livelong ventilation although there are few cases in the literature where such patients were extubated many months after the injury. Spontaneous breathing patients, who are dependent on their voluntary abdominal muscle for breathing, should need supplementary ventilation at nights because the breathing will otherwise "sleep". The non-invasive ventilation can be helpful in such phase. The life expectance of ventilator-dependent patients has risen. Self- assessment of the quality of life of patients who are livelong dependent on ventilation does not differ from patients, who are independent. Most of these patients integrate their home ventilator apparatus in their home surroundings and with the use of various needles the inspiration air could be directed towards the glottis, making phonation possible for the patients. Implantation of a diaphragm pacemaker can be indicated in few patients.

Management of urogenital tract -, water- and electrolytes disorders

The urinary output is reduced at the initial phase in patients with acute spinal cord injury as a result of hormonal changes. But, hyponatremia and polyuria usually follow the acute phase. The insertion of transurethral- or suprapubic- catheter for the control of the urinary flow is imperative at the initial phase of the treatment. Administration of Ascorbic acid may acidify urine and help prevent infection. It should be considered as early as possible. At a later phase, when intermittent catheterization cannot be performed, suprapubic catheter should be considered to facilitate a continuous urine outlet. Administration of anticholinergic drug (Oxybutynin) could prevent crumpled bladder.

Management of gastrointestinal tract disorders / Nutrition

The presence of gastrointestinal tract atony in the earlier phase of the injury makes the insertion of gastric tube imperative. Small portions of enteric feeding together with parenteral nutrition should be aimed at. No data has determined the required amount of calories needed in the early phase of transaction injury. Formulas, which are used to calculate the energy requirement, for example the Harris-Benedict-Formula that is based on activity and stress factors in patients with tetraplegia, often overestimate the calorie requirement. Reliable values could be obtained from indirect calorimeter. This procedure, however, is not common in the clinical practice. The calorie requirement is estimated to be 1.500 - 2000 kcal/day. In contrast, McBride and Rodts suggest the value of 30 - 40 kcal/kg BW/day. A negative nitrogen balance due to metabolism of denervated muscles normally occur independent of an adequate calorie supply.

Metoclopramide or Dompridon can be administrated to treat the motility disorder of the upper gastrointestinal tract. Regular defecation requires concrete activity. Mechanical action, for instance, manual digital clearance of the rectum or insertion of a rectal tube, should be part of the treatment.

The treatment of the initial bowel atony is in accordance with such treatment at the intensive care unites. Erythromycin administration is successful at the beginning of paralytic Ileum. Care should be taken by administration of parasympathicomemetic agent (Prostigmin) for the promotion of the bowel motility, because of the influence of such agent on already existing bradycardia.

Bowel atony of transactional spinal cord injury patients are occasionally accompanied with pancreatitis, probably due to the effect of an overreaction of parasympathetic nerve with resultant contraction of sphincter Oddi muscle.

Acute abdomen is stated as the cause of death in 10 - 15 % of cases of spinal cord injury patients. The presentation of clinical signs of sepsis (tachycardia, circulatory insufficiency, inflammatory parameter) should stir to suspicion of an acute abdomen, which does not present with the typical symptomatic in these patients and as a result is not diagnosed. Also fever and increased white blood count can be absence in patients with spinal cord injury. In doubtful cases an abdominal x-ray should be performed to determine the presence of free air in the abdomen or an abdominal CT. Acute abdomen is usually unrecognized in the transactional spinal cord injury patients because of the absence of typical symptomatic.

Spastic, autonomic hyper reflex

The spinal cord shock phase is followed by a phase

with uncontrolled hyper reflex activities at regions below the level of the lesion, resulting in the development of muscle spastic. The first spontaneous spastic muscle movement is usually mistaken for voluntary movement. Muscular spastic movement is treated with the administration of baclofen in increasing dosage (Table 6).

Occasionally, continuous intrathecal administration of baclofen through implanted pump could be necessary. The procedure should be initiated only in centers, which are specialized with such treatment, because finding the right dose for each patient under intrathecal continuous infusion of baclofen could cause significant harmful side effect.

Table 6. *Baclofen for treatment of muscular spastic movement*

Initiation of therapy: 3 x 5 mg p.o.
Dose increment by 5 mg every 3 days
Maximum daily dose 30 mg – 75 mg.
By compromised kidney- und liver function: Dose reduction
By inadequate effect under maximum dose: consider intrathecal administration.

Lesions at the level of T7 and above could cause, in this particular phase of the injury, excessive rise of the blood pressure (systolic> 250 mm Hg) as a result of an over extension of the bladder and the rectum. In combination hereby could also be a massive headache, sweating, flush reaction in the region of the face, neck and back. Reflex bradycardia combined with changes in the ECG is occasionally observed. In extreme cases, sedation, unconsciousness and epileptiformic episode could be observed. We are talking about autonomic hyper reflex, which could be provoked by any type of vegetative irritation but also pregnancy could provoke uncontrollable sympathetic activities in the paralyzed region of the body with vasoconstriction, accompanied by a reflexive parasympathetic response from the normal region of the body. The prophylaxis is the administration of anesthesia (deep general anesthesia or spinal anesthesia) before any intervention, even when the patients show loss of sensation in relevant region. Pregnant patients should be given epidural anesthesia during delivery. The treatment of autonomic hyper reflex activities include the removal the causes (empting the bladder, empting the rectum) and the administration of antihypertensive agents.

Thromboembolism prophylaxis

Patients with transactional injury of the spinal cord are at a very high risk of sustaining thrombosis, so that beside adequate volume substitution by the initiation of the treatment, a thrombosis prophylaxis measures should be instituted as well. The Low Molecular Weight Heparin (LMWH) is more effective than the unfractionated Heparin[1].

Nursery

Patients with transactional injury of the spinal cord are at extreme risk of developing decubitus ulcer. The bed positioning of these patients should be attended with much care from the very beginning. A two hourly change in the postural positioning of the patients should be aimed at. Special bed could be applied. Also during surgical intervention the positioning of the patients on the surgical bed should be carefully done. Special attention should be paid to the positioning of the shoulder. A "tunnel" formed for patients in the oblique position could prevent intensive shoulder pain, which is common in tetraplegic patients[2].

Special anesthetic aspects

Anesthesia for the primary care of patients with acute spinal cord trauma

Attention should be paid to sufficient infusion therapy, in order to maintain a sufficient perfusion pressure for the spinal cord before the initiation of any general anesthesia. Furthermore, the administration of catecholamine (Dobutamine) should be considered. All these require the insertion of one or two peripheral venous line or lines as well as a central venous line. Catheterization of the jugular vein might not be appropriate by the involvement of cervical spinal segment. Insertion of arterial line for a tight control and for a continuous measurement of the arterial blood pressure is advisable. Pre oxygenation of the patients before the initiation of the anesthesia is mandatory. Intubation should be in accordance with the principals outlined (s. emergency and planed intubation p. 221). Orotracheal fiberoptic intubation is advisable on relaxed and anesthetized patients with unstable cervical spinal segment who are scheduled for surgical intervention, as long as manual ventilation without relaxant was not a problem.

The anesthesia should be initiated and titrated so carefully as to avoid inducing hypotension. Succinycholine could optionally be administrated within the period of 24 hours after the injury for the relaxation of patients but it should not be administrated thereafter till up to 8 months after the trauma because of the increased risk of inducing hyperkalemia. Balanced anesthetic or total intravenous procedure could be applied for the maintenance of the anesthesia. Bladder catheter for controlling the urinary output and a gastric tube are mandatory. Thermometer for the monitoring of the body temperature should be inserted, because especially the tetraplegic patients have loss of ability to regulate the body temperature. Hypothermia should be avoided through active warming system. During an operation decubitus prophylaxis of the patients should be applied. Patients with pre anesthetic respiratory insufficiency or failure should remain intubated after the operation and must be transferred to intensive care unite, where the decision to extubate or to longer ventilate the patient through traechostomy, should be made.

Anesthesia of patients with chronic transection paralysis

A series of particular events makes the presence of

anesthetist by patients with chronic transection paralysis inevitable (Table 7). The development of problem in the urinary tract is relatively frequent in these patients. Diagnostic or therapeutic intervention in the areas of the urinary tract and the rectum demands an effective suppression of the hyperreflex reaction, which such intervention normally provokes following the result of autonomic hyperreflex activities. This can better be achieved with spinal anesthetic procedure. Alternatively, a deep general anesthesia can be performed. Further cases for frequent surgical intervention in patients with chronic transection paralysis are listed in Table 8.

By incomplete transactional lesions it should be examined if there is any sensitivity in the area of intervention but it should also be stressed that even when there is anesthesia in the particular area of intervention, as is the case by complete transaction lesion, spinal anesthesia or general anesthesia might still be necessary. Apart from the problems of hyperreflexes mentioned above an extreme spastic can present a problem of positioning the patients for an operation.

If the operation is to be done with the patient in the abdominal position, then the ability of the patient to tolerate this position should be cleared. The spontaneous breathing could be insufficient, especially in tetraplegic patient, when they are positioned in the abdominal position. In such cases general anesthesia is preferable. Occasionally, anesthetists are requested to be on "stand by" for intervention, which does not require anesthesia. Their task thereby is in the first instance to monitor and eventually to maintain the vital functions of the patient. Anesthetist, who overtakes such duty, should not compromise the usual safety standard measures. A venous line together with control ECG and Pulse oxygenometer are regarded as the minimum requirement for an orderly anesthetic monitoring of a patient. The recommended points for anesthetic care of patients with chronic transection paralysis are shown in Table 9.

Centers for the treatment of spinal cord injury patients

The acute treatment and early rehabilitation of spinal cord injury patients require specialized trauma team and special instrumental equipment, which, in analogue to the burn patient, is only possibly at specialized centers. Because these centers are normally equipped also for the primary surgical care of the spinal cord and associate injuries it is advisable to transfer such patients there as soon as possible.

Table 7.

Reasons for anesthetic care:	Normal anesthetic procedure:
-Autonomic hyperreflex (Hypertension/ Bradycardia)	-Spinal-/General anesthesia
-Spastic	-Spinal-/General anesthesia
-Compromised respiration (Abdominal position)	-General anesthesia (ITA)
-Circulation control/- therapy	-Stand-by

Table 8. *Frequent indication for surgical intervention in patients with chronic transection paralysis*

Problem in the urinary tract
Decubitus ulcer
Fractures (osteoporoses)
Thrombosis
Soft tissues calcification
Spastic (e.g. implantation of Baclofen pump)

Table 9. *Recommended procedures for anesthetic care*

a) Agents that are administrated for the treatment of the spastic should be continued also on the day of the operation
b) Relaxation of patients for the general anesthesia, when necessary at all, should be such that must not have residual effect after the intervention
c) Succinycholine is contraindicated in the period after the first day to up till the 8 months of the injury
d) General anesthesia that is applied to suppress the automatic hyperreflexes should be very deep
e) Care should be taken during positioning of the patients and especially the pressure points should be attended to
f) Spinal anesthesia is possible and is the most effective means to suppress the autonomic hyperreflexes and spastic in the respective region of application
g) Sufficient blood units should be secure for an emergency transfusion when needed and emergency equipments should be at disposal for immediate use if the anesthetist is only on a "stand by" call

References

1. Holly LT, Kelly DF, Counelis GJ, et al. Cervical spine trama associated wit moderate and severe head injure: incidence, risk factors and injury characteristics. J Neuorosurg; 2002 96 (3 Suppl):285-291
2. Frankel HL, Hancock DO, Hyslop G, et al. The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. Paraplegia 1969; 7:179-192
3. American Spinal Injury Association/International Medical Society of Paraplegia. Standard for Neurological and Functional Classification of Spinal Cord Injur Revised 1996, Chicago, American Spinal Injury Association, 1996
4. Joint Section on Disorders of the Spinal and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons: Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries. Neurosurgery 2002; 50(Suppl):7-35
5. Stürmer KM (Herausgeber): Leitlinien Unfallchirurgie. Stuttgart: Georg Thieme Verlag, 1999
6. Bracken MB, Holford TR. Effects of timing of methyprednisolone or naloxone administration on recovery segmental and long-tract neurological function in NASCIS 2 J Neurosurg 1993; 79:500-507
7. Bracken MB, Shepard MJ, Collins Wf, et al. A randomized, controlled trial of methyprednisolone or naloxone in the treatment of acute spinal cord injury: Result of the Second Nation Spinal Cord Injury Study (NASCIS-2). N Engl J Med

1990; 322:1405-1411
8. Bracken MB, Shepard MJ, Collins Wf, et al. Methyprednisolone or naloxone treatment after acute spinal cord injury: 1-Year follow-up data- Result of the Second Nation Spinal Cord Injury Study J Neurosurg 1992; 76:23-31
9. Bracken MB, Shepard MJ, Hellenbrand KG, et al. Methyprednisolone and neurological function one year after spinal cord injury: Result of the Second Nation Spinal Cord Injury Study J Neurosurg 1985; 63:704-713
10. Bracken MB, Shepard MJ, Holford TR, et al. Administration of methyprednisolone for 24 or 48 hours or tirilazad mesylate for 48 hours in the treatment of acute spinal cord injury: Result of the Third Nation Acute Spinal Cord Injury randomized controlled trial-National Acute Spinal cord Injury Study. JAMA 1997; 277:1597-1604
11. Bracken MB, Shepard MJ, Holford TR, et al. Methyprednisolone or tirilazad mesylate administration after acute spinal cord injury: 1-Year follow-up. Result of the Third Nation Acute Spinal Cord Injury randomized controlled trial. J Neurosurg 1998; 89:699-706
12. Himmelseher S, Bótter J, Baethmann A, et al. Zur Gabe von Kortikosteroiden nach akuter spinaler Traumatisierung. Anðsth Intensivmed 1999; 10:716-726
13. Delamarter RB, Sherman J, Carr JB. Pathophysiology of spinal cord injury. Recovery after immediate and delayed compression. J Bone Joint Surg Am 1995; 77:1042-1049
14. Delamarter RB, Coyle J. Acute Management of spinal cord injury. J Am Acad Orthop Surg 1999; 7:166-175
15. Mirza SK, Krengel WF, Chpman JR, et al. Early versus delayed surgery for acute cervical spinal cord injury. Clin Orthop 1999; 359:104-114
16. Albin MS. Spinal cord injury. In: Cotrell JE, Smith DS (eds). Anesthesia and Neurosurgery. St. Louis, Mosby, 1994: 713-743
17. McBride DQ, Rodts GE. Intensive care of patients with spinal trauma. Neurosurg Clin N Am 1994; 5:755-766
18. Vale FL, Burns J, Jackson AB, et al. Combined medical and surgical treatment after acute spinal cord injury: results of a prospective pilot study to assess the merits of aggressive medical resuscitation and blood pressure management. J Neurosurg 1997; 87:239-246
19. Dolan EJ, Tator CH. The effect of blood transfusion, dopamine and gamma hydroxybutyrate on posttraumatic ischemia of the spinal cord. J Neurosurg 1982; 56:350-358
20. Glaesener JJ, Hasse W, Exner G. Lungenkontusion, Pneumo- und Hämatothorax als häufige komplikation von BWS- Verletzungen. In: Zäch GA (Hrsg.) Rehabilitation. Berlin, Heidelberg: Springer Verlag; 1992, pp. 49-57
21. Muckart DJJ, Bhagwanjee S, Van der Merwe R. Spinal cord injury as a result of an endotracheal intubation in patients with undiagnosed cervical spine fractures. Anesthesiology 1997; 87:418-420.
22. Hasting RH, Marks JD. Airway management for trauma patients with potential cervical spine injuries. Anesth Anal 1991; 73:471-482
23. Fuchs G, Schwarz G, Baumgartner A, et al. Fiberoptic intubation in 327 neurosurgical patients with lesion of the cervical spine J Neurosurg Anesthesiol 1999; 11:11-16
24. Nakazawa K, Tanaka N, Ishikawa S, et al. Using the intubation laryngeal mask airway LMA-Fastrach TM) for blind endotracheal intubation in patients undergoing cervical spine operation. Anesth Analg 1999; 89:1319-1321
25. Kihara S, Watanabe S, Brimacombe J, et al. Segmental cervical spine movement with the intubating laryngeal mask during manual in-line stabilization in patients with cervical pathology undergoing cervical spine surgery. Aneth Analg 2000; 195-200
26. Ali J. Pulmonary function and postural in traumatic quadriplegia. J Trauma 1995; 39:334-337
27. Bergofsky EH. Mechanism for respiratory insufficiency after cervical cord injury: A source of alveolar hypoventilation. Ann Intern Med 1964; 61:435-447
28. Wicks AB, Menter RR. Long-term outlook in quadriplegic patiens with initial ventilator dependence. Chest 1986; 90:406-410
29. DeVivo MJ, Ivie CS. Life expectancy of ventilator-dependent persons with spinal cord injuries. Chest 1995; 108:226-232
30. Maynard FM, Muth AS. The choice to end life as a ventilator-dependent quadriplegic. Arch Phys Med Rehabil 1987; 68:862-864
31. Bach JR, Tilton MC. Life satisfaction and well-being measure in ventilator assisted individuals with traumatic tetraplegia. Arch Phys Rehabil 1994; 75:626-632
32. Silver GR, Doggart JR, Burr RG. The reduced urinary output after spinal cord injury: a review. Paraplegia 1995; 33:721-715
33. Soni BM, Vaidyanthan S, Watt JW, et al. A retrospective study of hyponatremia in tetraplegic/paraplegic patients with a review of the literature. Paraplegia 1994; 32:597-607
34. Rodriguez DJ, Benzel EC, Clevenger FW. The metabolic response to spinal cord injury. Spinal Cord 1997; 35:599-604
35. Laven GT, Huang CT, DeVivo MJ, et al. Nutritional status during the acute stage of spinal cord injury. Arch Phys Med Rehabil 1989; 70:277-282
36. Juler GL, Eltorai IM. The acute abdomen in spinal cord injury patients. Paraplegia 1985; 23:118-123
37. Green D, Chen D, Chmiel JS, et al. Prevention of thromboembolism in spinal cord injury: Role of low molecular weight heparin. Arch Phys Med Rehabil 1994; 75:290-292
38. Glaesener JJ, Denker M, Petersen W. Lagerungstechniken zur Prophylaxe von Schulterschmerzen in der Fróhphase der Tetraplegie. Deutsche Krankenpfege-Zeitschrift 1991; 11:781-784