Pre-Hospital Management, Physical Examination & Polytrauma Management

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30.1 Introduction

This case will detail the following problems:

1. Pre-hospital management of spinal injuries
2. How to immobilize the spinal injured patient
3. Prioritization of treatment in multiple injured patients.

30.2 Case Description

On a weekday afternoon, a 50 year-old male was found lying beside a motorcycle in a small city nearby. Upon the time of paramedics' arrival, his eyes were open spontaneously, there was no verbal response at all, but he showed extension movements on painful stimuli (Decerebrate response, GCS = 4 + 1 + 2 = 7). Frothy secret was coming out of his mouth. The breathing sounds were attenuated bilaterally. Due to an obvious airway problem, a likely breathing disorder and an obviously impaired consciousness, the paramedic team placed two large-bore iv-lines and performed endotracheal intubation whilst manual c-spine immobilization.

He was ventilated with 100% oxygen. Using a log roll maneuver, he was put on a vacuum mattress and a hard cervical collar was mounted under continuous manual c-spine stabilization.

Emergency department (ED) delivery was about 1 h and 15 min after the accident.

At the time of ED delivery, his vital signs were: heart rate 140/min, blood pressure 99/75 mmHg, oxygen saturation 95%, respiratory rate 12/min (mandatory CPPV ventilation), body temperature 35.7 °C.

According to ATLS standard, a chest and pelvis X-ray were performed. This revealed a bilateral hematothorax, which was decompressed by chest tubes immediately. Right after placing the chest tubes, 300 ml blood was drained. Further drainage was not observed and cardio-respiratory parameters improved.

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Due to the major trauma mechanism, a CT trauma scan was done.

The CT-scan showed an obvious unstable Jefferson burst fracture of the atlas with fragmentation of both lateral masses (Gehweiler IIIB/IV) and a flexion-distraction injury T5-T6 with burst fracture of both vertebrae (AO Spine B2,NX).

A fracture of the sternal manubrium at the same level of the thoracic spine fracture indicated a severe instability, sometimes referred to as "floating thorax". Despite the complete burst morphology of T5 and T6, the spinal canal was not compromised. By the time of CT diagnostics, the thoracic spine injury appeared to have the highest treatment priority (Fig. 30.1).

Beside the hematothorax, there was no further thoracic or abdominal injury. There were no imaging signs of traumatic brain injury (TBI) or cerebral hypoxemia. The Jefferson type atlas injury was likely to cause a vertebral artery injury, so a CT angiogram was made subsequently, showing no injury of neither of the two vertebral arteries.

Another finding was a decent widening of the C4–5 disc space adjacent to the spontaneously fused cervical spine segments C5–7, which raised suspicion of a hyperextension injury (Fig. 30.2).

At this timepoint, there was no recent information about the motor function of the extremities. An injury to the spinal cord was likely due to the thoracic spine fracture morphology.

To gain more information on spinal cord compression/injury and on the assumed hyperextension injury at C4–5, an MRI of the cervical and thoracic spine was added immediately.
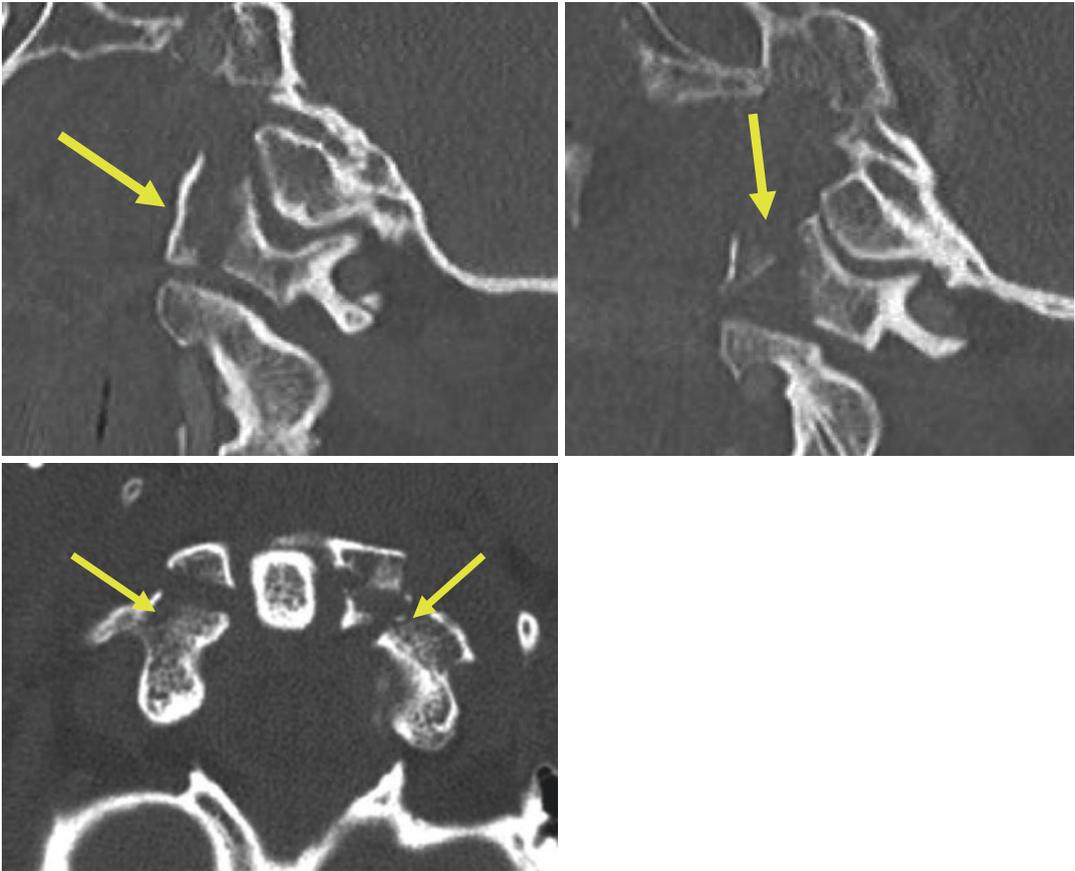

Fig. 30.1 Jefferson type atlas fracture with fragmentation of both lateral masses. It was classified as Gehweiler IIIB / IV; Dickman IIA

Fig. 30.2 Sagittal CT-scan of the cervical spine. The subtle widening of the disc space compared to the adjacent segments and the spontaneous fusion below this raised suspicion for a disco-ligamentous injury of this segment. MRI was added

The MRI showed no definite signs of spinal cord injury at neither level, but some retropulsed posterior wall fragments in contact with the anterior cord at the T5–6 level. The C4–5 disc was ruptured with some prevertebral hematoma and a hyperintense disc signal on T2-imaging, confirming a hyperextension injury adjacent to a bisegmental spontaneous fusion of C5–7 (AO Spine B3,M3,NX) (Fig. 30.3).

Despite a small effusion in the anterior atlantodental joint, there were no further signs of craniocervical instability, such as a lesion to the transverse atlantal ligament, to the tectorial membrane or widening of the occipito-atlantal joint space.

After having completed diagnostics with CT traumascan, CT angiogram and MRI about 90 min after ED delivery, the injurity severity score (ISS) could be calculated and added up to an ISS of 29.

The final diagnoses were:

1. Severe blunt chest injury with
   (a) multiple bilateral rib fractures
   (b) bilateral hematothorax
   (c) bilateral pulmonary contusion
   (d) sternal fracture
2. Jefferson Fracture of the Atlas, Type Gehweiler IIIB/Dickman IIA
3. Hyperextension injury C4–5, Type AOSpine B3, NX
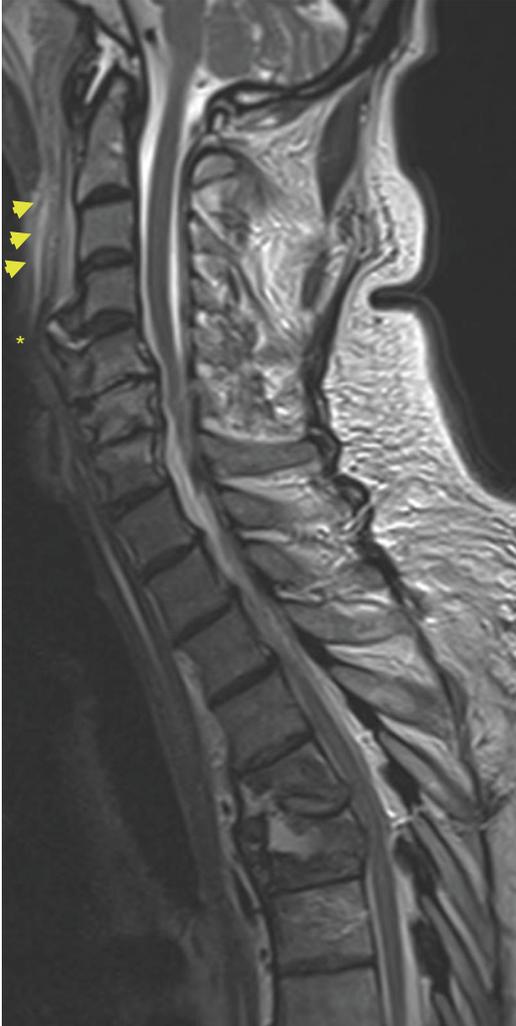4. Flexion-Distraction injury T5–6, Type AOSpine B2, NX

Fig. 30.3 T2-weighted sagittal MRI of the cervical and thoracic spine. The disc space C4–5 showed a hyperintense signal (asterisk) and a prevertebral fluid effusion was visible (arrowheads), both indicating a transdiscal injury in this segment. The spinal cord appears intact at all three injury sites, but at T6, moderate anterior as well as posterior compression might be present

30.3 Treatment

Initial treatment of the immediately life-threatening hematothorax was finished about 10 min after ED delivery, then the next step was surgical stabilization and decompression of the most unstable and most dangerous spinal injuries as an urgent day-1-surgery.

So, **anterior cervical discectomy and interbody fusion (ACDF) at the C4–5 level** was performed first and then the patient was turned to perform **posterior thoracic decompression and fusion T3–4 to T7–8**. OR time was 70 min for ACDF and 2 h and 5 min for the posterior procedure. Blood loss was 50 cc and 700 cc, respectively. There were no complications during the two procedures. Intraoperatively, the unstable rupture of the C4–5 disc could be confirmed. Day-1 surgical procedures were finished about 6.5 h after ED delivery and approximately 8 h after trauma. The patient was kept ventilated and sedated for another 3 days, until respiratory circulatory and inflammatory parameters had improved slightly (Figs. 30.4 and 30.5).

The final surgical step – **temporary posterior occipitocervical (C0-C3) stabilization** for treatment of the Jefferson type atlas fracture was performed on the fourth day after trauma. In this procedure, OR time was 2 h and 10 min, blood loss was about 200 cc (Fig. 30.6).

After this last procedure, there were no further unstable lesions, which facilitated **rotorest kinetic therapy**.

Due to his severe thoracic trauma, respiratory weaning was prolonged significantly. Extubation was achieved 14 days after trauma and he could be transferred to regular ward on the 16th day after admission. Neurologic examination after extubation showed full motor and sensory function of all extremities.

He was able to walk without any aids and could be discharged to outpatient treatment approximately 4 weeks after trauma.

30.4 Discussion of the Case

This case demonstrates very well many aspects of trauma treatment in the prehospital and early clinical period.

In the prehospital trauma setting, it is important to "read" the trauma scene and to get a feeling of the involved energy acting on the patient's body. In this case, the emergency team had to assume a high speed bicycle accident, which has a high probability for any kind
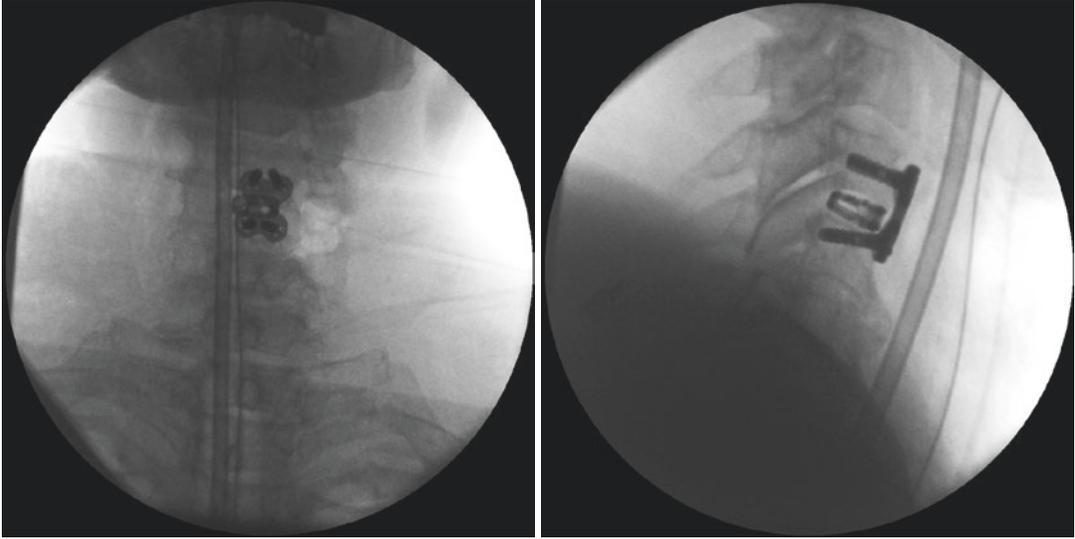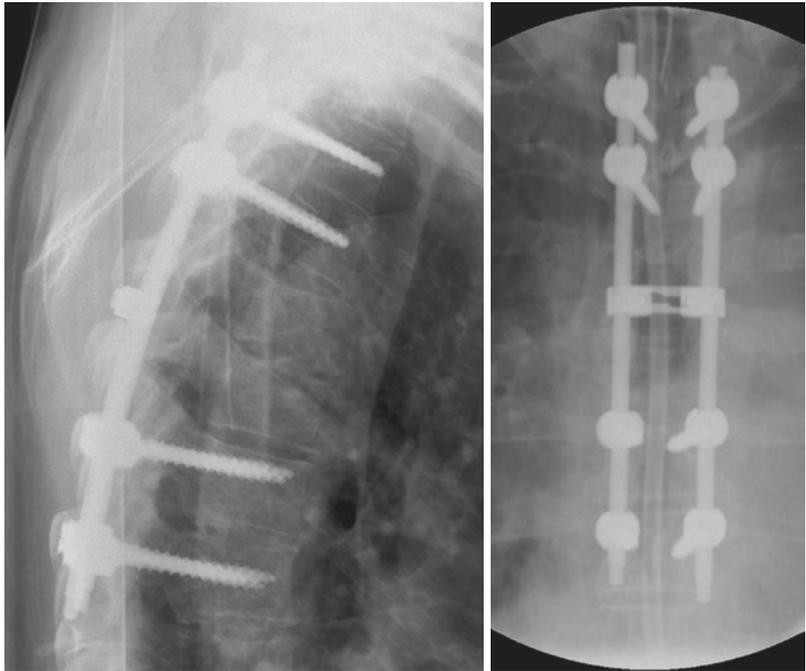
Fig. 30.4 Intraoperative fluoro view after decompression and plate stabilization of C4–5

Fig. 30.5 Postoperative x-ray after thoracic stabilization T3–4 to T7–8 and decompression T5–6

of severe injury, especially spinal injuries. Patients with multiple injuries (ISS >16) have a probability of 30–36% for a severe spinal injury [1, 2].

The first step in this case is to ensure a proper airway without putting any further movement to the cervical spine. Manual immobilization is the safest way to protect the c-spine while airway

Fig. 30.6 Postoperative x-ray after final occipito-cervical stabilization

Fig. 30.7 Manual inline stabilization of the head and cervical spine after mounting a hard cervical collar. Cervical collars alone do not provide sufficient stability and should always be combined with other measures

management. A cervical collar alone is not able to sufficiently protect the cervical spine against dangerous movements (Fig. 30.7) [3, 4].

After completion of the primary survey, transport priority has to be set. In critically injured patients, with severe, life-threatening injuries, a whole body immobilization might be skipped to accelerate transfer to definitive surgical care. In our case, these instability criteria were met (impaired consciousness, attenuated breathing sounds), so the indication for a whole body immobilization could be discussed.

For any other patients with trauma mechanisms susceptible to spinal injuries, whole spine immobilization is recommended. For immobilization of the whole spine, there are basically two methods established: after having stabilized the cervical spine with a hard cervical collar, the patient is either placed and strapped onto a spine board or molded into a vacuum mattress [5]. The authors prefer the vacuum mattress, because this method can better adopt to specific needs in the individual patient, such as severe hyperkyphosis

in Bechterev's disease or lifting the upper body in traumatic brain injury.

When placing the patient onto a flat surface one must also consider the relationship between the occiput and the thorax: adult patients, especially with thoracic hyperkyphosis might need a pillow beneath the head to prevent hyperextension of the cervical spine, whereas children have an occiput greater than the thorax, so the thorax should be put on some blankets or pillows to prevent hyperflexion of the spine (Fig. 30.8).

Since hard collars alone will not sufficiently stabilize the c-spine during transport, it is mandatory to fix the head additionally: either with so called head blocks or by molding the vacuum mattress tightly around the head [6]. The head fixation to be placed AFTER strapping the rest of the patient's body to the spine board/vacuum mattress, otherwise inadvertent displacement of the body against the fixed head might lead to fatal damage of the cervical spine (Fig. 30.9).

During transportation in a critically injured patient, oxygenation and blood pressure

Fig. 30.8 Note the different relationship between the occiput and the rest of the body in children and adults. For a proper spinal immobilization in children, putting the body on some extra blankets is recommended
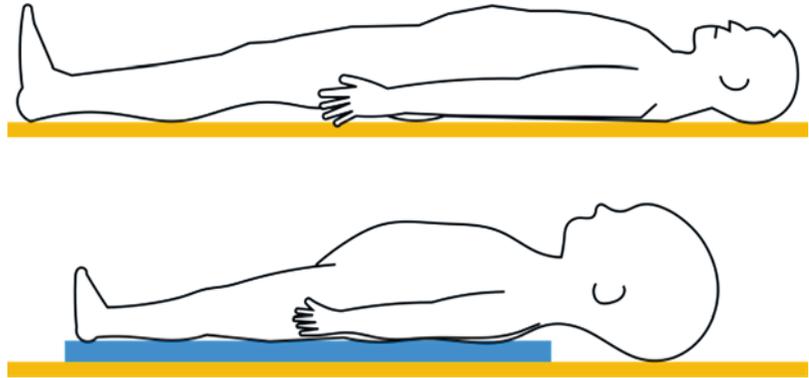

Fig. 30.9 For transportation, additional head fixation is mandatory. It can be easily solved by molding the vacuum matress around the head

management are the major issues, especially in spinal trauma. The spinal cord is very sensitive to hypoxia, so oxygen saturation should be kept over 95% and the mean arterial blood pressure should be kept above 85–90 mmHg [7].

In our case, early *inhospital* treatment followed strictly the ATLS-protocol, with initially solving the breathing disorder (Type "B" problem) by decompression of the thorax. After exclusion of any further thoracic, abdominal and pelvic lesions, which might have led to a circulatory disorder (Type "C" problem), the spinal injuries with potential spinal cord injury (Type "D" problem) had the highest priority [8].

A high dose steroid regime to protect the spinal cord was abandoned due to the concomitant pulmonary injuries and an unclear neurological status. The neuroprotective effect of high-dose steroids is questioned, while pulmonary and gastro-intestinal complications have been reported. So recent guidelines recommend this as an *optional* treatment regimen only in an isolated spinal cord injury, not in the multiple trauma setting [4].

Early surgical decompression and stabilization of spinal injuries within <72 h has shown to improve patient outcome in terms of hospital stay, ICU-stay, ventilator hours and sepsis rate. Especially thoracic spine fractures in combination with a severe thoracic injury will benefit from early surgical treatment [1].

The effect of early decompression on neurologic outcome is still under discussion, but data supporting a positive effect are increasing [9].

In this special case, it was necessary to prioritize three different spinal injuries (upper cervical, lower cervical and thoracic spine), which is not uncommon in polytrauma patients [10].

Our decision to start with the lower c-spine lesion was driven by several factors:

1. The anterior procedure could be performed without turning the patient, so further manipulation of the whole spine was minimized,

whereas treatment of the thoracic spine first would have necessitated a prone position with a high risk of cervical dislocation.

2. An impending C4–5 spinal cord injury will impair the patients functional ability much more than a possible T5–6 lesion.

3. The anterior procedure is usually a quick procedure with little blood loss, so the risk of general decompensation before fixing the other injuries is minimized.

The decision to fix the upper c-spine lesion as the last step was driven by the fact, that Jefferson/Gehweiler III Type lesions are usually quite benign in terms of acute neurologic damage. The instability symptoms associated with these injuries usually develop at a later timepoint, due to chronic instability and joint incongruence. Additionally, the procedure is sometimes technically demanding and might be associated with a significant amount of blood loss, so it is recommended to be performed at a later timepoint, when the most critical period is over.

Usually, in typical Gehweiler Type III fractures, a C1–2 stabilization or even a C1-ring osteosynthesis is sufficient and will save as much motion as possible for the patient's head movement. In this case, the lateral masses of C1 were involved into the fracture (Gehweiler Type IV component), which put some doubts on screw purchase in the C1- lateral masses. Although significantly reducing the patient's flexion-extension ability, temporary occipito-cervical stabilization was favored therefore. Implant removal after bony consolidation of the fracture is planned.

The ACDF procedure in lower cervical spine fractures is an established method with a low approach-related morbidity, good decompression options and high stabilization performance with modern angle stable implants. Especially in the hyperextension (Type B3) injuries, restoration of the anterior tension band is the most important step from a biomechanical point of view – and this is best achieved by placing a plate in front of the spine.

Posterior long-segment stabilization with pedicle screws and decompression via laminectomy is also an established method for treatment of unstable thoracic burst fractures. An additive anterior column support could be discussed, but in the thoracic spine the lesion is usually subjected to bending moments rather than axial compression like in the thoraco-lumbar junction [11]. Furthermore, the anterior surgical approach in T5–T6 is challenging, while adding more fixation points in the rigid thoracic spine will not cause a significant loss of motion.

30.5   Conclusions and Take Home Message

The incidence of spinal injuries in multiple injured patients is high, so a spinal injury should be assumed in every major trauma until the opposite is proven.

Prehospital treatment basically consists in the sensible application of spinal immobilization and providing a sufficient perfusion to the potentially injured spinal cord.

During inhospital polytrauma management, spinal injury treatment has a lower priority than Airway management ("A"), breathing disorders ("B") or circulatory disorders ("C"), but even then, fixing spinal injuries will support the treatment of these injuries also.

This justifies surgical treatment of unstable spinal fractures as emergency procedures, so called "day-1-surgeries".

When priorizing different spinal injuries, one must balance the ongoing risk for further spinal cord injury against the "second hit" effect of the surgical trauma.

Pearls
- Every major trauma MUST rise suspicion for a spinal injury
- If a spinal injury is suspected, spinal immobilization is mandatory until the spine is cleared definitely
- Whole body spinal immobilization can only be skipped in critical, life-threatening injuries, which require immediate surgical intervention

- In the multiple trauma setting, the most important and most difficult issues are
  - to keep the overview,
  - to prioritize properly
  - to stay sensitive to subtle details, which may have fatal consequences and
  - to react flexible on unexpected findings

Pitfalls

- To overlook subtle signs for significant injury. Being distracted by the most severe injury or skipping important diagnostic measures in order to save time might drive you into catastrophy
- To rely on solitary cervical collar for spinal stabilization
- To fix a hyperkyphotic patient onto a flat spineboard might worsen or even create a spinal injury.

Editorial Comment

This chapter illustrates and underscores the most important principle for pre-hospital and early in-house care following trauma with suspected injury to the spine: Know your pre-defined, structured modus operandi and never deviate from it!

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