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The cervical spine in Trauma : implications for the anaesthesiologist

V. BONHOMME[1], G. HARTSTEIN[2] and P. HANS[3]

Summary : In this paper, the authors review the most recent literature concerning the management of the cervical spine in trauma patients. They address the main topics of concern for the anaesthesiologist including pre-hospital care, clearance of the cervical spine, neuroprotective therapies, difficult tracheal intubation, and management during general anaesthesia, in the intensive care unit and in paediatric patients. The most widely accepted strategies are provided as well as alternative options.

Key words : Cervical spine ; trauma ; anaesthetic management.

Anaesthesiologists are called on to manage patients with traumatic injuries of the cervical spine (whether or not associated neurological deficits are present) in the operating theatre, the intensive care and emergency unit, as well as outside the hospital. Cervical spine trauma preferentially occurs in young males (37), but is also more and more often observed in older subsets of the population (over the age of 50), and, in this case, is more frequently noted after minor trauma (26). In general, the most common mechanisms of injury include motor vehicle accidents, falls, direct blows and sport injuries (37). Injury to the cervical spine generates specific management problems for the anaesthesiologist, such as initial clinical evaluation, supportive and preventive measures when taking care of the patient outside the hospital, clearing the cervical spine in the emergency unit, pharmacological neuroprotective therapies, difficult tracheal intubation, management during general anaesthesia and in the intensive care unit, and specific considerations with regard to the paediatric patient. Each of these problems will be discussed in this review paper, in the light of the most recent literature.

PREHOSPITAL CARE

As a general rule, spine injuries should be suspected in any trauma patient. Cervical spine trauma should particularly be suspected in head trauma (22) (4 to 8 %) and in maxillofacial trauma patients (28) (up to 20 %). Head trauma patients presenting with an initial Glasgow Coma Scale score less than 8 are at highest risk for concomitant cervical spine injury. Injuries of the midface are more frequently associated with injuries of the lower part of the cervical spine (its most mobile part) while injuries of the lower part of the face are more frequently associated with injuries of the upper part of the cervical spine.

Among the well defined steps of trauma patient care, careful clinical evaluation is of utmost importance. Speed and precision are determinant factors of the outcome. In the conscious patient, asking for the presence of back or neck pain, testing motor function of upper and lower limbs, as well as sensitivity to light touch and pin prick allow detection of lesions, their severity and their level. Cervical tenderness also seems to be a reliable sign for detecting unstable fractures necessitating surgical stabilisation (27). Clinical evaluation of cervical spine injuries and associated lesions is much more difficult, if not impossible, in the unconscious patient. In any case, the clinician must maintain a high degree of suspicion and apply preventive measures before being able to clear the cervical spine through radiological examination.

[1] Chef de Clinique Associé, University Department of Anaesthesia and ICM, CHR de la Citadelle & CHU de Liège, boulevard du 12ème de Ligne, 1, 4000 Liège, Belgium.

[2] Chef de Clinique, Department of Anaesthesia and ICM, CHU de Liège, Domaine Universitaire du Sart-Tilman, B35, 4000 Liège, Belgium

[3] Chef de Service, University Department of Anaesthesia and ICM, CHR de la Citadelle & CHU de Liège, boulevard du 12ème de Ligne, 1, 4000 Liège, Belgium.

Corresponding author : Vincent Bonhomme, M.D., University Department of Anaesthesia and ICM, CHR de la Citadelle, Bd du 12ème de Ligne, 1, 4000 Liège, Belgium. Tel : +32 4 225 7117. Fax : +32 4 225 7308. E-mail : vincent.bonhomme@chu.ulg.ac.be

As is the case with brain injury, attention should be paid to ensuring an open and secure airway. Tracheal intubation, if required, must be performed cautiously, either after placing a carefully fitted cervical collar, or at the very least after using helpers to insure axial stabilisation. This manoeuvre can be difficult and will be discussed in a separate paragraph. Ventilation with 100% oxygen is required for all trauma patients, whether by tight fitting non-rebreathing masks (for spontaneous ventilation) or via mechanical aids. Early and aggressive establishment of normal blood pressure, normovolaemia, and normoglycaemia are obligate steps to prevent secondary neurological insults (43). Mobilisation of the patient must also be very cautious and always be performed while maintaining a constant relative position ("en bloc" mobilisation) and axial stabilisation. Whenever possible, the use of a spine board/scoop is recommended.

When neurological deficits are suspected or confirmed, neuroprotective measures should be considered as soon as possible. The precise strategy, which is still a matter of controversy, will be discussed in a separate paragraph. Lesions of the cervical or thoracic spinal cord are frequently associated with early cardiovascular and respiratory complications. The causes of cardiovascular instability are related to sympathetic denervation, which results in bradycardia (T1-T4 lesions), arteriolar dilation and pooling of blood in the venous compartment. The syndrome associating decreased heart rate, blood pressure and systemic vascular resistance is referred to as neurogenic shock, and must be treated aggressively using volume expansion and inotropic/chronotropic agents such as atropine, dobutamine or epinephrine (40). Early apnoeic respiratory arrest occurs with complete injury above C3. Lower level lesions are associated with variable degrees of respiratory depression, mainly due to respiratory muscle dysfunction. During the acute phase, mechanical ventilation is often the only alternative to insure adequate oxygen delivery and carbon dioxide elimination (40).

There is no specific rule regarding the use of anaesthetic agents for induction, intubation and sedation in the cervical spine injured patient. The same rules as those recommended for multiple trauma and brain injured patients apply, and the personal experience of the practitioner plays an important role (41). One should prefer short acting medications to permit neurological examination "on demand", and within a reasonable timeframe. Analgesia can be provided by opioids, but the possibility of prolonged apnoea should be kept in mind in case of an unanticipated difficult tracheal intubation. Muscle relaxants may be of help for tracheal intubation and alleviate unexpected and uncontrolled movements in case of a very unstable spine fracture, without jeopardising haemodynamic stability by use of a deep plane of anaesthesia. Non-depolarising muscle relaxants should be preferred, as they do not increase neuraxial pressure and do not induce fasciculation, which may provoke movement along the axis of the spine. Rocuronium at the high dose of 1.2 mg/kg offers good intubation conditions within a delay of 60 seconds, but has a prolonged duration of action (29). Therefore, the use of succinylcholine is often necessary, especially when a difficult tracheal intubation is anticipated in a patient with a full stomach. In this case, cricoid pressure should be applied with caution, preferably using two hands, one on the cricoid and one on the back of the neck to limit movement during the procedure (19, 47). Among the available hypnotic medications, a short acting agent, which produces minimal hypotension and no potentially harmful effects on the central nervous system (CNS) should be chosen. The use of etomidate for induction, and a continuous infusion of propofol for maintenance (once haemodynamic stability has been achieved) would appear to be a perfectly acceptable plan in practice. Indeed, induction with propofol, benzodiazepines or barbiturates may induce profound hypotension in hypovolaemic patients and should be used with caution. Ketamine may increase neuraxial pressure, which may be deleterious in a combined brain and spine injured patient with raised intracranial pressure, but this effect can be counterbalanced by the concomitant use of low doses of hypnotic drugs such as propofol (38). It is noteworthy that ketamine may also have neuroprotective effects. The contra-indication to the use of ketamine in this situation is therefore relative. Halogenated compounds are not easily usable outside the operating room ; nitrous oxide may increase neuraxial pressure and is potentially toxic for the CNS (2).

Clearing the cervical spine

Confirming the absence of cervical spine or cervical spinal cord injury in a trauma patient may be problematic, especially in patients with an altered mental status. Indeed, plain radiographs may miss a substantial proportion of injuries, primarily because of inadequate visualisation, while

soft tissue lesions often exist without any visible radiological abnormality (33). Moreover, non-contiguous spinal injury may be encountered in a cervical spine trauma patient (15). A consensus exists that a fully conscious patient (GSC = 15), not under the influence of sedative drugs or alcohol (or with no significant concussive symptoms), with no neck pain, swelling or tenderness, no neurological deficit and no distracting pain due to traumatic injuries to other parts of the body is at very low risk of cervical spine injury (14, 36). In this case, only pain on mobilisation (passive or active) should require radiological exploration. Conscious patients presenting one of the above-mentioned symptoms necessitate cervical spine imaging. Plain radiographs remain the gold standard. Lateral and antero-posterior views are mandatory, as well as an open-mouth view to detect axis peg lesions. Any detected abnormalities or poorly visualised areas will be explored through a targeted CT scan. Helical CT scan with reconstruction of the entire cervical spine or of suspicious and poorly visualised areas can be of help. An urgent MRI scan is recommended in case of any neurological deficit referable to the spine (32). It is particularly suited to detect soft tissue lesions but may miss lesions to the posterior wall of the spine. This modality will also detect non-contiguous lesions. In the unconscious patient, the cranio-cervical junction can only be explored by a CT or MRI scan. Furthermore, normal plain films and targeted CT scans do not exclude ligament injuries. In addition to those techniques, four options can therefore be proposed to the clinician for exploring the cervical spine in unconscious patients (36). The first consists in leaving the cervical spine uncleared and maintaining the rigid collar, and full spinal precautions until the patient has recovered consciousness and can be assessed clinically. This option imposes limitations to the mobilisation of the patient, raises the risk of decubitus sores and may impair the control of intracranial pressure in concomitantly brain-injured patients. It may be preferred if the patient is expected to regain consciousness within less than 24 to 48 hours. In young children, because of their relatively large heads, a roll placed under the shoulders or an occipital recess in the bed may help preventing flexion of the head and neck. Performing an urgent MRI scan is the second option, but it may be unfeasible in an unstable patient. The third option involves the assessment of the stability of the cervical spine by dynamic fluoroscopy. As this procedure can be dangerous for the spinal cord, it must be performed by skilled senior personnel only, while applying gentle axial stabilisation and, eventually, while monitoring the spinal cord integrity through the recording of somatosensory-evoked potentials. The fourth option consists of imaging the entire C-spine with a helical CT scan with reconstruction, and a plain lateral view (instead of a set of plain views and targeted CT's). In our opinion, this option is the most attractive when an appropriate scanner is available.

Neuroprotection and the use of steroids

Based on experimentation in animals and identification of secondary injury mechanisms following spinal cord injury, several pharmacological neuroprotective strategies have been proposed and, for some of them, tested in randomized human trials (18, 42). Unfortunately, the results of those studies have been disappointing or controversial and the optimal strategy to be followed remains uncertain (24). High dose methylprednisolone was the first therapeutic measure to be tested in randomized controlled trials (11-13). Although significant neurological improvement has been demonstrated in patients receiving high dose methylprednisolone within less than 8 hours following trauma (30 mg/kg over 15 minutes followed 45 minutes later by a 48 hour infusion at 5.4 mg/kg per hour), the main criticisms reside in the fact that neurological improvement was not necessarily clinically relevant and that such high doses induce potentially severe side effects including hyperglycaemia, depression of the immune system, GI bleeding (31) and myopathy (34). No definitive answers to these questions are yet available and position statements of the concerned medical societies recommend the use of methylprednisolone as an option, not as a treatment standard (10). Other compounds have been evaluated in clinical trials, with promising positive results for some of them such as GM-1 ganglioside or gacyclidine, and negative results for others such as tirilazad or naloxone (24). However, the evidence is not strong enough to support the use of any of these agents as a standard of care. Many other substances are promising but still need to be tested in large randomized clinical trials. Among them, thyrotropin-releasing hormone, free radical scavengers, calcium channel blockers, magnesium, sodium channel blockers, glutamate receptor antagonists, arachidonic acid modulators, neurotrophic growth factors, serotonin antagonists, and anti-apoptotic agents are the most frequently cited (18, 42). Hypothermia is gaining increasing

popularity with regard to its neuroprotective properties demonstrated in animal models (44). However, deep and prolonged hypothermia may predispose to complications including coagulation disorders, cardiovascular instability, and infections. Because no definite arguments in favor of its beneficial effect have been obtained in clinical trials yet, most authors suggest the use of mild hypothermia or low normothermia during the management of these patients (21).

Tracheal intubation and anaesthetic management

Tracheal intubation in a cervical spine injured patient can be challenging, especially in case of concomitant maxillofacial trauma. In addition to possible pre-existing anatomical aggravating factors, these patients present with an immobilised neck, a rigid collar, a full stomach, an airway that must be rapidly secured, and are sometimes placed in halo traction prior to the need for tracheal intubation. Several options are proposed in the literature to circumvent these difficulties, but the final attitude will again always be dictated by the personal experience of the practitioner. The goal to achieve during tracheal intubation is limiting neck movement as much as possible. As already stated, cricoid pressure should always be applied with two hands, and axial stabilisation is mandatory. Muscle relaxation is usually very helpful when intubation is performed under general anaesthesia. In most of cases, the use of a classical curved laryngoscope blade and a stylet will allow easy canulation of the trachea. However, other adjunctive devices should always be available. Very simple devices may be of great help such as lighted stylets (1, 16, 23), fiberoptic laryngoscopes (25), or levering laryngoscopes. Failure to intubate may necessitate the use of alternative airway control devices such as the Combitube' (17), or the intubating laryngeal mask airway (LMA-Fastrach') (45). Extreme emergencies and failure of classical techniques and adjuncts may require retrograde tracheal intubation (20). When tracheal intubation is necessary for planned surgery under general anaesthesia, and when difficult intubation is anticipated, awake tracheal intubation is recommended. This can be accomplished with a fiberoptic bronchoscope or by fluoroscopic radioscopy (35, 39, 46).

Principles governing management during general anaesthesia are the same as those that prevail during pre-hospital care : maintenance of normal blood pressure, normovolaemia, normoxia, and normoglycaemia. Because no evidence exists that hypothermia is beneficial, low normothermia should be the rule (see above). There seems to be no advantage in administering supplemental prophylactic steroids to patients who have already received methylprednisolone on hospital admission (31). Induction and maintenance of anaesthesia, when performed at distance from the initial trauma and in a stabilised patient, is much easier than at the site of trauma. In neurologically disabled patients, neither succinylcholine nor nitrous oxide should be used. Succinylcholine may induce severe hyperkaliemia in cord-injured patients. The risk of such an event is increased from 24 hours after the initial trauma to up to 18 months. Hemodynamic management requires attention to an increased risk of hypotension in patients with impaired sympathetic tone, particularly when changing the patient's position, and to possible autonomic dysreflexia (40). Autonomic dysreflexia is characterised by the occurrence of paroxysmal hypertension and bradycardia in response to a stimulus occurring below the level of spinal cord injury. This syndrome is usually not present during the first days following the trauma, but, when it occurrs, it may require the use of vasodilating medications and deepening the level of anaesthesia (40). Whenever possible, early emergence and extubation should be planned for in order to allow rapid neurological examination.

Management in the intensive care unit

All acute spinal cord injured patients, and particularly those with severe cervical injuries, should be managed in the intensive care unit to allow adequate neurological, cardiac, haemodynamic and respiratory monitoring (7). Maintenance of a mean arterial blood pressure of at least 90 mmHg is recommended for 7 days after the initial trauma (3). These patients are at very high risk of thromboembolic complications and aggressive prophylaxis for three months is necessary, using a combination of low-molecular-weight heparin and rotating beds, elastic or pneumatic compression stocking, or electrical stimulation (4). These have increased caloric requirements and appropriate nutritional support should be provided (9). An increased risk of infection exists : aspiration, prolonged tracheal intubation, reduced ability to clear secretions, atelectasis, high dose steroids, and dysfunctional immune responses all favour the occurrence of respiratory and/or urinary tract infections. Other issues of con-

cern are stress ulcer, upper gastrointestinal bleeding, ileus and occult peritonitis.

As already mentioned, mobilisation should be performed with caution as long as the cervical spine is not cleared or stabilised. In that respect, indications for surgery will be discussed on a case by case basis. Common sense imposes early decompression of the compressed spinal cord, particularly if the compression is focal or anterior (6). Otherwise, decision-making will be guided by the type of lesion to the spine, its stability, and the status of the patient. Early surgical stabilisation will reduce length of stay and the incidence of respiratory complications, but is not demonstrated to improve neurological outcome (30), and is not necessarily possible for all types of lesions. In fracture-dislocation injuries, early closed reduction using a traction device is beneficial before open surgical stabilisation. Caution should be paid during closed reduction of the cervical spine in the unconscious patient because significant concomitant disc herniation is frequently observed and any further spinal cord compression during the realignment manoeuvre can be missed (5).

Management in the paediatric patient

As opposed to adults, young children are characterised by a large head volume compared to the volume of the torso. This status favours rostral lesions to the cervical spine rather than caudal lesions. The principles governing pre-hospital management and cervical spine clearance are the same as those recommended for adults, except that young children may be less cooperative and may therefore necessitate more intensive radiological investigation (8). Immobilisation and in-line axial stabilisation of the cervical spine can be difficult in these patients and, as already mentioned, thoracic elevation using a shoulder roll or an occipital recess may be of help to prevent flexion of the head or neck. Most of the cervical lesions in children can be treated with external immobilisation and not open surgery, except for ligamentous injuries that may generate progressive deformity in the absence of appropriate surgical repair. Special attention should be paid to the axis synchondrosis between the body and the odontoid, as it is particularly fragile. The incidence of spinal cord injury without radiological abnormality (SCIWORA) is relatively common in children ; when detailed clinical neurological examination is not possible, especially in the presence of a suggestive mechanism of injury, normal radiological studies must never be taken to imply absence of cord injury. In these cases, specialised paediatric neurosurgical consultation is required, and transfer to a specialised facility should be considered if required.

Conclusions

The management of the cervical spine in trauma patients necessitates meticulous knowledge of and attention to the potential dangers associated with this entity. The dangers include iatrogenic secondary neurological insults, missing a lesion in an unconscious, uncooperative, agitated or distracted patient, and associated complications such as deep venous thrombosis, infection, cardiovascular collapse or respiratory insufficiency. The rules to be followed for optimal management are well defined in the literature, but, beside surgical decompression and stabilising interventions, and advanced life support, the therapeutic options for protecting the CNS and restoring function are still goals for the future rather than clinical choices today. In this field, intensive research that is underway will probably provide more efficient neuroprotective and neuroregenerative solutions for the near future.

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