Intensive Care Med (1998) 24: 1221–1225

J. Piek
on behalf of the Working Group for Neurosurgical Intensive Care of the European Society of Intensive Care Medicine

Guidelines for the pre-hospital care of patients with severe head injuries

Reprint requests to the European Society of Intensive Care Medicine,
Av. J. Wybran 40, B-1070 Brussels, Belgium
email: esicm@pophost.eunet.be
Tel. + 32.2.529.58.29; Fax + 32.2.527.00.62

Introduction

Assessment and stabilization of patients with head injuries begins at the scene of the injury by emergency medical personnel. It includes the following tasks:

- securing the patient's airway,
- maintenance of oxygenation and normal ventilation,
- initiation of haemodynamic resuscitation and fluid administration,
- assessment of the level of consciousness,
- stabilization of the cervical and thoracolumbar spine,
- identification and stabilization of extracranial injuries.

Other critical components of the initial management of such patients are to obtain information about the circumstances of the injury as well as to provide transport to a qualified medical center.

The present guidelines were drafted by the Working Group for "Neurosurgical Intensive Care" of the European Society for Intensive Care Medicine. The document is the general consensus on the minimal care which should be provided to patients with severe head injuries in all European countries.

Influence of systemic adverse events on outcome in patients with head injuries

Incidence

In large series of patients with traumatic brain injury the incidence of pre-hospital hypotension/shock varies from 12.2 to 34.6 % [1–6]. Hypoxaemia is present in 14.3 to 45.6 % of these cases. Even in patients with moderate injuries, the incidence of hypoxaemia is 14.8 % [1–6]. Hypercarbia will occur in up to 6.1 % [6]. The incidence of hypocarbia in this setting has not been studied.

Influence on outcome

Adverse events, such as arterial hypotension, hypoxaemia or hypercarbia eventually determine adjunctive brain damage to the primary direct traumatic damage to neural tissues. This secondary brain damage adversely influences the outcome of the majority of head trauma patients.

Extracranial complications occur frequently in patients with severe head injuries. Although the outcome of an individual patient may be adversely affected by a number of different complications, only a few have been identified as having an independent influence on outcome including hypotension, pneumonia, coagulopathy and septicaemia [5, 7–21]. If pre-hospital hypoxia and/or hypotension is present in such patients, the mortality rate is twice that of patients without these insults. Conversely, normotensive/normoxic patients are twice as likely to make a good recovery [1, 4, 7, 9, 18, 21]. The risk of pneumonia increases with the presence of coma and with impairment of airway reflexes [22]. Intubation in patients with severe head injuries reduces the rate of aspiration and helps to prevent respiratory insufficiency [23].

Conclusion

Primary care of the patient with traumatic brain injury is aimed at preservation of a clear airway and adequate circulation at the scene and during the entire transport.

Initial administration of oxygen is mandatory in all patients with an isolated traumatic brain injury. Patients with a Glasgow Coma Scale [24] score of 8 or a motor score of less than 5 should be intubated and ventilated as soon as safely possible. In patients with better motor scores and associated injuries, the risk of acute hypoxia, intubation and ventilation should also be considered. Aspiration should be avoided and/or vigorously treated. Artificial ventilation should be adjusted to achieve an arterial saturation of more than 95 %. Aggressive hyperventilation should be avoided in the early phase of the injury when cerebral blood flow is typically at its lowest [25]. Aggressive hyperventilation can be considered only when signs of impending brain herniation are present. If end-tidal CO_2 can be measured, it should be kept between 30–35 mmHg (4–4.5 kPa) in normotensive patients [26, 27].

At least two large peripheral i. v. cannulas should be in place and secured. The first step in establishing an adequate cerebral perfusion pressure is establishing normal blood pressure. Treatment of low blood pressure should be aimed at a systolic blood pressure of more than 120 mmHg (16 kPa) for adults. An increase in blood pressure is usually caused by inadequate sedation and analgesia. If this is not the case, treatment of raised blood pressure (> 200 mmHg = 26.6 kPa) by vasodilating agents is usually not indicated and may cause fatal hypotension. It should be kept in mind that hypotension is rarely caused by an isolated head injury [14] and that the most common cause for this event is an extracranial injury (exception: newborns).

Drugs

Volume replacement

Adequate volume resuscitation should be initiated. Isotonic solutions (e. g. Ringer's solution, NaCl 0.9 %) and colloids are advocated. Although controversial [28], hypertonic saline has recently been used in the acute resuscitative phase after head injury both experimentally and clinically [29–38]. Hypertonic saline [39–43] is a therapy which is not generally accepted for resuscitation in this patient group. If given, hypertonic saline (250 cc of NaCl 7.25 %) should be administered first, followed by rapid infusion of colloids. Hypotonic crystalloids (e. g. Glc 5 %, Ringer lactate) may worsen cerebral oedema [44].

Sedation/analgesia

Adequate sedation and analgesia are essential in patients with head injuries, especially if ventilated. Sedatives and analgesics should be carefully titrated as overdosing may cause profound hypotension, especially in hemodynamically unstable patients. Short-acting drugs should be preferred.

Muscle relaxants

When needed, short-acting muscle relaxants are advocated.

Vasopressors

Vasopressors should be considered if volume replacement fails to assure an adequate systemic blood pressure within minutes. From a neurosurgical/neuro-anaesthetical point of view no one vasopressor has been shown to be superior to others, subsequently no recommendations concerning the type of vasopressors can be given.

"Neuroprotective" agents

So far no "neuroprotective" agents (e. g. steroids, nimodipine, barbiturates) have been used in large, randomized, placebo-controlled pre-clinical trials in patients with severe head injuries, and they have shown minor effects in patients in the clinical setting [45–48].

Mannitol

Although mannitol has been shown to be effective in reducing intracranial pressure [49–55], its general use is not advocated during pre-hospital care. In emergency situations (dilating of a formerly contracted pupil) however it can be administered (0.5–1 g/kg with an infusion time of 10–15 min).

Transport

Although controversial [56, 57], the patient's head should be elevated at a 15–30° angle. About 5 % of head injury victims sustain cervical spine injury [58–63]. A rigid collar should be applied in order to secure the cervical spine as soon as possible and this should be kept in position until radiographic images verify, beyond any doubt, the absence of any cervical spine lesion down to the second thoracic vertebra. The

spine should always lie in a neutral position on a rigid plate.

Unstable fractures should be immobilized. Rolled sheets, sandbags, or commercially available devices should secure the position of the head. Endotracheal tubes should be secured by tapes, but the tape should not be passed around the neck in order to avoid compromsing jugular venous return.

After his/her clothes have been removed, the patient should be carefully checked for further injuries. Of particular importance are thoracic, abdominal, pelvic and limb injuries which carry a high risk for hypotension and/or hypoxaemia. The patient's temperature should be kept at normothermia [64–67].

A complete system of transport with the patient "packed" together with monitoring and therapeutic devices is very useful.

Stretcher (trolley)

The patient should be positioned on a stretcher that will allow various radiological imaging (X-ray, computer tomography) in hospital so that he can remain on the one from the scene of the injury until admission to the ward/ICU/OR.

Transporting team

Besides the driver (transport and communication) at least two people should be devoted to the patient's care. One of the team members should be a physician. Members of the team should be very familiar with the equipment and have personally checked it before use. They should have received a specific training in:

- airway care and tracheal intubation,
- ventilation by mask and portable mechanical ventilator,
- peripheral and central vein access,
- drainage of tension pneumothorax,
- neurological examination of unconscious patients.

Neurological assessment and documentation

A complete and comprehensive chart should be compiled by the transporting team. A protocol should be used which is standardized at the regional level, at least. The chart should contain additional copies to provide the referring hospitals with the information. Documentation should include information (minimum) on:

- patient's name, gender, address, birth date
- time, nature, cause of the injury
- medical history (if possible)
- neurological state: GCS scale (broken down into visual, verbal and motor), pupil reactivity, focal neurological deficits
- extracranial injuries
- trauma score (any score which is standardized at least on a regional level)
- repeated documentation of pulse, blood pressure; SO_2, end-tidal CO_2 (if possible)
- medication administered (type, dose, timing)
- interventions (type, timing)
- free space for comments
- name and telephone number of the transporting physician.

Precautionary radio communication of the patient's clinical status to the receiving hospital medical staff is strongly advocated and deserves standard local guidelines.

Feed-back and quality assessment

After handover of the patient, members of the hospital medical staff should compile a form containing any observation (especially problems) related to the handover of the patient. This form (standardized at least at a regional level) should be given to the transporting team in order to assure the quality of patient transport. Regional conferences on a regular base should be held between emergency teams and the receiving hospitals to assure and to improve the quality of pre-hospital care.

The members of the Working Group on Neurosurgical Intensive Care of the European Society for Intensive Care Medicine:

Piek J (Germany) Chairman; Aerdts S (The Netherlands), Ansec-Letonja D (Slovenia), Asgeirsson B (Sweden), Bahar M (Turkey), Bellinzona G (Italy), Berré J (Belgium), Beuret P (France), Bochicchio M (Italy), Bruzzone P (Italy), Candiani G (Italy), De Deyne C (Belgium), Dive A (Belgium), Dobb G (Australia), Esen F (Turkey), Ferdinande P (Belgium), Floros J (Greece), Futo J (Hungary), Gemma M (Italy), Grande P (Sweden), Hemmer M (Luxemburg), Karlis P (Greece), Korfali G (Turkey), Moretti M (Italy), Rebelo A (Portugal), Ruetsch Y (Switzerland), Sonkajahru E (Finland), Spec-Marn A (Slovenia), Specht M (Germany), Telles de Freitas P (Portugal), Wöbker G (Germany)

References

1. Chesnut RM, Marshall SB, Piek J, Blunt BA, Klauber MR, Marshall LF (1993) Early and late systemic hypotension as a frequent and fundamental source of cerebral ischemia following severe brain injury in the Traumatic Coma Data Bank. Acta Neurochir Suppl (Wien) 59: 121–125
2. Chesnut RM, Marshall LF, Marshall SB (1993) Medical management of intracranial pressure. In: Cooper PR (ed): Head Injury, 3rd edn. Williams and Wilkins, Baltimore, pp 225–246
3. Gaab MR and the German GUDHIS Study Group (1995) Ultrahohe Dexamethason-Gabe beim akuten Schädelhirntrauma. Ergebnisse einer prospektiven randomisierten Doppelblind-Multicenter-Studie (GUDHIS). Zbl Neurochir 55: 135–143
4. Marshall LF, Becker DP, Bowers SA, Cayard C, Eisenberg H, Gross CR, Grossman RG, Jane JA, Kunitz SC, Rimel R, Tabaddor K, Warren J (1983) The National Traumatic Coma Data Bank. Part 1: Design, purpose, goals and results. J Neurosurg 59: 276–284
5. Piek J, Chesnut RM, Marshall LF, Van Berkum-Clark M, Klauber MR, Blunt BA, Eisenberg HM, Jane JA, Marmarou A, Foulkes MA (1992) Extracranial complications of severe head injury. J Neurosurg 77: 901–907
6. Wahjoepramono EJ, Piek J, Bock WJ (1993) Pre-hospital airway care and control of ventilation in patients with head injuries. A retrospective analysis in 1623 head trauma victims.In: Lorenz R, Brock M, Klinger M (eds) Advances in Neurosurgery 21. Springer, Berlin Heidelberg New York, pp 184–187
7. Bowers SA, Marshall LF (1980) Outcome in 200 consecutive cases of severe head injury in San Diego County: a prospective analysis. Neurosurgery 6: 237–242
8. Chesnut RM (1995) Secondary brain insults after head injury: clinical perpectives. New Horizons 3: 366–375
9. Chesnut RM, Marshall LF, Klauber MR, Blunt BA, Baldwin N, Eisenberg HM, Jane JA, Marmarou A, Foulkes MA (1993) The role of secondary brain injury in determining outcome from severe head injury. J Trauma 34: 216–222
10. Gentleman D (1992): Causes and effects of systemic complications among severely head injured patients transferred to a neurosurgical unit. Int Surg 77: 297–302
11. Jennett B, Carlin J (1978) Preventable mortality and morbidity after head injury. Injury 10: 31–39
12. Klauber MR, Marshall LF, Luerssen TG, Frankowski R, Tabaddor K, Eisenberg HM (1989) Determinants of head injury mortality: importance of the low risk patient. Neurosurgery 24: 31–36
13. MacIver IN, Frew IJC, Matheson JG (1958) The role of respiratory insufficiency in the mortality of severe head injuries. Lancet 1: 390–393
14. Miller JD, Sweet RC, Narayan R, Becker DP (1978) Early insults to the injured brain. JAMA 4: 439–442
15. Miller JD, Becker DP (1982) Secondary insults to the injured brain. J R Coll Surg Edinb 27: 292–298
16. Newfiled P, Pitts L, Kaktis J (1980) The influence of shock on mortality after head trauma. Crit Care Med 8: 254–257
17. Piek J, Chesnut RM, Marshall LF, Van Berkum-Clark M, Klauber MR, Blunt BA, Eisenberg H, Jane JA, Marmarou A, Foulkes M, et al. (1993) The influence of nosocomial pneumonia on outcome of severely head-injured patients. In: Lorenz R, Brock M, Klinger M (eds) Advances in Neurosurgery 21. Springer, Berlin Heidelberg New York, pp 192–196
18. Price DJE, Murray A (1972) Influence of hypoxia and hypotension on recovery from head injury. Injury 3: 218–224
19. Rose J, Valtonen S, Jennett B (1977) Avoidable factors contributing to death after head injury. BMJ 21: 615–618
20. Van Wagoner FH (1961) Died in hospital: a three-year study of deaths following trauma. J Trauma 1: 401–408
21. Wald SL, Shackford SR, Fenick J (1993) The effect of secondary insults on mortality and long-term disability after severe head injury in a rural region without a trauma system. J Trauma 34: 377–382
22. Chevret S, Hemmer M, Carlet J, Langer M (1993) Incidence and risk factors of pneumonia acquired in intensive care units. Results from a multicenter prospective study on 996 patients. European Cooperative Group on Nosocomial Pneumonia. Intensive Care Med 19: 256–264
23. Singbartl G (1985) Die Bedeutung der präklinischen Notfallversorgung für die Prognose von Patienten mit schwerem Schädel-Hirn-Trauma. Anaesth Intensivther Notfallmed 20: 251–260
24. Teasdale G, Jennett B (1976) Assessment of coma after head injury. Acta Neurochir (Wien) 34: 45–55
25. Bouma GJ, Muizelaar JP, Stringer WA, Choi SC, Fatouros P, Young HF (1992) Ultra-early evaluation of regional cerebral blood flow in severely head-injured patients using xenon-enhanced computerized tomography. J Neurosurg 77: 360–368
26. Gopinath SP, Robertson CS, Contant CF, Hayes C, Feldman Z, Narayan RK, Grossman RG (1994) Jugular venous desaturation and outcome after head injury. J Neurol Neurosurg Psychiatry 57: 717–723
27. Muizelaar JP, Marmarou A, Ward JD, Konto HA, Cho SC, Becker DP, Gruemer H, Young HF (1991) Adverse effects of prolonged hyperventilation in patients with severe head injury: a randomized clinical trial. J Neurosurg 75: 731–739
28. DeWitt DS, Prough DS, Deal DD, Vines SM, Hoen H (1996): Hypertonic saline does not improve cerebral oxygen delivery after head injury and mild hemorrhage in cats. Crit Care Med 24: 109–117
29. Berger S, Schürer L, Hartl R, Deisbock T, Dautermann C, Murr K, Messmer K, Baethmann A (1994) Acta Neurochir Suppl (Wien) 60: 494–498
30. Hartl R, Schürer L, Goetz C, Berger S, Rohrich F, Baethmann A (1995) The effect of hypertonic fluid resuscitation on brain edema in rabbits subjected to brain injury and hemorrhagic shock. Shock 3: 274–279
31. Berger S, Schürer L, Hartl R (1995) Reduction of post-traumatic intracranial hypertension by hypertonic/hyperoncotic saline/dextran and hypertonic mannitol. Neurosurgery 37: 98–107
32. Freshmann SP, Battistella FD, Matteucci M, Wisner DH (1993) Hypertonic saline (7.5 %) versus mannitol: a comparison for treatment of acute head injuries. J Trauma 35: 344–348
33. Gunnar WP, Merlotti GJ, Barrett J, Jonasson O (1986) Resuscitation from hemorrhagic shock: alterations of the intracranial pressure after normal saline, 3 % saline and dextran 40. Ann Surg 204: 686–692
34. Holcroft JW, Vassar MJ, Turner JE, Derlet RW, Kramer GC (1987) 3 % NaCl and 7.5 % NaCl/dextran 70 in the resuscitation of severely injured patients.Ann Surg 206: 279–288

35. Sheikh AA, Matsouka T, Wisner DH (1996) Cerebral effects of resuscitation with hypertonic saline and a new low-sodium hypertonic fluid in hemorrhagic shock and head injury. Crit Care Med 24: 1226–1232
36. Taylor G, Myers S, Kurth CD, Duhaime AC, Yu M, McKernan M, Gallagher P; O'Neill J, Templeton J (1996) Hypertonic saline improves brain resuscitation in a pediatric model of head injury and hemorrhagic shock. J Pediatr Surg 31: 65–70
37. Worthley LI, Cooper DJ, Jones N (1988) Treatment of resistant intracranial hypertension with hypertonic saline. Report of two cases. J Neurosurg 68: 478–481
38. Zornow MH, Scheller MS, Shackford SR (1989) Effect of hypertonic lactated Ringer × s solution on intracranial pressure and cerebral water content in a model of traumatic brain injury. J Trauma 29: 484–488
39. Maningas PA, Mattox KL, Pepe PE, Jones RL, Feliciano DV, Burch JM (1989) Hypertonic saline-dextran solutions for the pre-hospital management of traumatic hypotension. Am J Surg 157: 528–533
40. Nakayama S, Sibley L, Gunther RA Holcroft JW, Kramer GC (1984) Small-volume resuscitation with hypertonic saline (2,400 mOsm/liter) during hemorrhagic shock. Circ Shock 13: 149–159
41. Rocha-e-Silva M, Negraes GA, Soares AM, Pontieri V, Loppnow L (1986) Hypertonic resuscitation from severe hemorrhagic shock: patterns of regional circulation. Circ Shock 19: 165–175
42. Vassar MJ, Perry CA, Gannaway WL, Holcroft JW (1991) 7.5 % sodium chloride/dextran for resuscitation of trauma patients undergoing helicopter transport. Arch Surg 126: 1065–1072
43. Valesco IT, Potieri Y, Rocha-e-Silva M, Lopes OU (1980) Hyperosmotic NaCl and severe hemorrhagic shock. Am J Physiol 239:H664–673
44. Tommasino C, Moore S, Todd MM (1988) Cerebral effects of isovolemic hemodilution with crystalloid or colloid solutions. Crit Care Med 16: 862–868
45. Duhaime AC: Conventional drug therapies for head injury. In: Narayan RK, Wilberger JE, Povlishock JT (eds) Neurotrauma. McGraw Hill, New York St. Louis San Francisco, pp 365–374
46. Gaab MR, Dietz H (1989) Ultrahohe Dexamethason-Kurzzeittherapie bei Schädel-Hirn-Trauma. Rationale und Design einer Multicenter-Studie. Neurochirurgia 4: 93–100
47. Grumme Th, Baethmann A, Kolodziejczyk D (1995) Treatment of patients with severe head injury by triamcinolone: a prospective, controlled multicenter clinical trial of 396 cases. Res Exp Med 195: 217–229
48. Harders A, Kakarieka A, Braakman R and the German tSAH Study Group (1996): Traumatic subarachnoid hemorrhage and its treatment with nimodipine. J Neurosurg 85: 82–89
49. Cotrell JE, Robustelli A, Post K Turndorf H (1977) Furosemide- and mannitol-induced changes in intracranial pressure and serum osmolality and electrolytes. Anesthesiology 47: 28–30
50. Wise BL, Chater ML (1962) The value of hypertonic mannitol solution in decreasing brain mass and lowering cerebro-spinal pressure. J Neurosurg 19: 1038–1042
51. McQueen JD, Jeanes LD (1964) Dehydration and rehydration of the brain with hypertonic urea and mannitol. J Neurosurg 21: 118–128
52. Miller JD, Leech P (1975) Effects of mannitol and steroid therapy on intracranial volume-pressure relationships in patients. J Neurosurg 42: 274–181
53. Muizelaar JP, Lutz HA III, Becker DP (1984) Effects of mannitol on ICP and CBF and correlation with pressure autoregulation in severely head-injured patients. J Neurosurg 61: 700–706
54. Rosner MJ, Coley I (1987) Cerebral perfusion pressure: a hemodynamic mechanism of mannitol and the post-mannitol hemogram. Neurosurg 21: 147–156
55. Shenkin HA, Goluboff B, Haft H (1962) The use of mannitol for the reduction of intracranial pressure in intracranial surgery. J Neurosurg 19: 897–901
56. Feldman Z, Kanter M Robertson CS, Contant CF, Hayes C, Sheinberg MA, Villareal CA, Narayan RK, Grossman RG (1992) Effect of head elevation on intracranial pressure, cerebral perfusion pressure, and cerebral blood flow in head-injured patients. J Neurosurg 76: 207–211
57. Rosner MJ, Cooley IB (1986) Cerebral perfusion pressure, intracranial pressure, and head elevation. J Neurosurg 65: 636–641
58. Gentleman D, Teasdale G, Murray L (1986) Cause of severe head injury and risk of complications. BMJ 292: 449–453
59. Hills MW, Deane SA (1993) Head injury and facial injury: is there an increased risk of cervical spine injury? J Trauma 34: 549–553
60. Miller JD, Butterworth JF, Gudeman SK, Faulkner JE, Choi SC, Selhorst JB, Harbison JW, Lutz HA, Young HF, Becker DP (1981) Further experience in the management of severe head injury. J Neurosurg 54: 289–299
61. Moskopp D, Böker DK, Kürthen M, Solymosi L, Elatan E (1990) Begleitende Wirbelsäulentraumata bei Schädel-Hirn-Verletzten. 34 konsekutive Patienten aus drei Jahren. Unfallchirurg 93: 120–126
62. Pagni CA, Massaro F (1991) Concomitant cranio-cerebral and vertebro-medullary injuries. Analysis of 121 cases. Acta Neurochir (Wien) 111: 1–10
63. Vollmer DG, Torner JC, Jane JA (1991) Age and outcome following traumatic coma: why do older patients fare worse. J Neurosurg 75:S37–S49
64. Busto R, Globus MY, Dietrich WD, Martinez E, Valdes I, Ginsberg MD (1989) Effect of mild hypothermia on ischemia-induced release of neurotransmitters and free fatty acids in rat brain. Stroke 20: 904–910
65. Clifton GL, Allen S, Barrodale P, Plenger P, Berry J, Koch S, Fletcher J, Hayes RL, Choi SC (1993) A phase II study of moderate hypothermia in severe brain injury. J Neurotrauma 10: 263–271
66. Marion DW, Obrist WD, Carlier PM, Penrod LE, Darby JM (1993) The use of moderate therapeutic hypothermia for patients with severe head injuries: a preliminary report. J Neurosurg 79: 354–362
67. Shiozaki T, Sugimoto H, Taneda M, Yoshida H, Iwai A, Yoshioka T, Sugimoto T (1993) Effect of mild hypothermia on uncontrollable intracranial hypertension after severe head injury. J Neurosurg 79: 363–368