

Transportation of Patients With Acute Traumatic Cervical Spine Injuries

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KEY WORDS: Definitive SCI care facility, Early expeditious transfer, Transport after SCI

Neurosurgery 72:35–39, 2013

DOI: 10.1227/NEU.0b013e318276edc5

www.neurosurgery-online.com

RECOMMENDATIONS

Level III:

- Expeditious and careful transport of patients with acute cervical spine or spinal cord injuries is recommended from the site of injury by the most appropriate mode of transportation available to the nearest capable definitive care medical facility.
- Whenever possible, the transport of patients with acute cervical spine or spinal cord injuries to specialized acute spinal cord injury treatment centers is recommended.

RATIONALE

Complete and accurate care of the patient with an acute traumatic cervical spinal injury cannot be provided at the accident scene. Proper care for patients with spinal injuries includes immobilization, extrication, initial resuscitation, and early transport of the patient to a medical center with the capability for diagnosis and treatment.¹⁻⁵ Less favorable outcome, longer hospitalizations, and increased costs are associated with delayed transportation of spinal injury patients to a definitive treatment center.⁵⁻⁷

Selecting the most appropriate mode of transportation from the site of injury to a definitive treatment facility for an individual patient depends on the patient's clinical circumstances, distance, geography, and availability. Land (ambulance) and air (helicopter or fixed-wing plane) are the primary modes available to trans-

port the spinal injury patient. The goal is to expedite safe and effective transportation without an unfavorable impact on patient outcome. These factors provide the rationale to establish medical evidence-based guidelines for the transportation of patients with acute traumatic cervical spine and spinal cord injuries (SCIs). The guidelines author group of the Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons have previously produced a medical evidence-based guideline on this topic.⁸ The current review is undertaken to update the medical evidence on the transport of acute SCI patients since that 2002 publication.

SEARCH CRITERIA

A National Library of Medicine (PubMed) computerized literature search from 1966 to 2011 was completed using Medical Subject Headings in combination with “spinal injury” and “transport.” The search was limited to the English language and yielded 10 008 citations for the first search term and 71 323 articles for the second. A search combining both search terms provided 259 articles. All 259 abstracts were reviewed. Additional references were culled from the reference lists of the remaining articles. Finally, members of the author group were asked to contribute articles known to them on the subject matter that were not found by other search means. A total of 16 articles directly relevant to the subject of transportation of spine-injured patients were identified. All provided Class III medical evidence. The 11 most pertinent publications are summarized in Evidentiary Table format (Table).

ABBREVIATIONS: ASCIU, Acute Spinal Cord Injury Unit; SCI, spinal cord injury

SCIENTIFIC FOUNDATION

Safe, rapid, and careful transport of the spinal injured patient to a medical facility for definitive care has long been a fundamental concept of emergency medical service care delivery. No reported Class I medical evidence clinical studies have established the requirement or effectiveness of this strategy. A search of the literature has provided only Class III medical evidence in support of this practice.

One of the basic principles of prehospital spinal care is the early transfer of the injured patient to a center with the resources and expertise to manage acute cervical spine injuries or SCIs.¹⁻⁵ Better neurological outcomes with fewer complications have been reported when early transfer to a specialized SCI center is accomplished.^{3,5} Limiting untoward spinal motion during transportation of patients with cervical spine injuries is considered essential to preserve neurological function and to limit further injury from spinal instability.⁹ The transport of injured patients to the closest definitive care facility can be provided with a variety of transportation methods. Choosing the mode of transportation depends on the patient's overall medical status, the distance to the nearest capable facility, and the availability of resources.

In 1974, Hachen³ described the creation of a nationwide emergency transportation protocol for spinal injury patients implemented in Switzerland in 1968. All SCI patients in Switzerland were immediately transported to The National Spinal Injuries Centre in Geneva by the Swiss Air Rescue Organization. In the 10-year follow-up of this protocol published in 1977, Hachen reported that early transport from the site of the accident to the SCI center under close medical supervision was associated with no patient death during transport. Before 1968, multiple deaths occurred during transport secondary to acute respiratory failure before definitive care could be provided. After 1968, patients were transported rapidly with an onboard anesthesiologist who provided respiratory, cardiac, and hemodynamic monitoring, resuscitation, and nasotracheal intubation as necessary. The average time for the rescue operation was reduced from 4.5 hours to 50 minutes. There was a significant reduction in cardiovascular and respiratory morbidity and mortality. The mortality rate for complete quadriplegic patients dropped from 32.5% in 1966 to 6.8% in 1976 and that for incomplete cervical cord injury patients from 9.9% to 1.4% during the same time period. Hachen concluded that survival and outcome of patients with acute SCIs were enhanced by a well-organized medical system and rapid medically supervised transfer by helicopter to a specialized center, followed by definitive care in a SCI facility for aggressive management in the intensive care unit setting.^{3,10}

Zäch et al¹¹ in 1976 described their experience with 117 acute SCI patients managed per prospective protocol in the Swiss Paraplegic Centre in Basel, Switzerland. All patients were treated in the intensive care unit setting with aggressive medical management and cardiac and blood pressure support. Outcome was stratified by initial injury and time of admission after injury. Sixty-two percent of cervical SCIs managed in this fashion

improved at the last follow-up. No patient with a cervical level injury worsened; 38% were unchanged. Of patients who arrived within 12 hours of injury, 67% improved compared with their initial neurological condition. Fifty-nine percent of patients admitted between 12 and 48 hours of injury showed neurological improvement. When admission occurred after 48 hours of injury, improvement was seen in only 50% of patients. The authors concluded that early transport and "immediate medical specific treatment of the spinal injury" appeared to facilitate neurological recovery.

In 1984, Tator et al⁵ reported their experience with 144 patients with acute SCIs treated between 1974 to 1979 at the Acute Spinal Cord Injury Unit (ASCIU) at Sunnybrook Medical Centre in Toronto, Ontario, Canada. They found a marked reduction in both morbidity and mortality after acute SCI for the group of patients managed from 1974 to 1979 compared with a similar group of patients managed from 1947 to 1973, before the creation of a dedicated, regional spinal cord injury unit. Reasons cited for these improvements included earlier transport to the ASCIU after trauma and better definitive management on arrival.

In a subsequent 1993 publication comparing ASCIU patients managed from 1974 to 1981 with their historical population of patients managed from 1947 to 1973, Tator and colleagues¹² noted a statistically significant difference in duration of time from injury to arrival, 5 hours for ASCIU patients compared with 13 hours for the pre-ASCIU group. They found a significant decrease in the severity of SCI (65% complete cervical lesions compared with 46% for ASCIU patients) and noted fewer complications, shorter hospital stays, and lower expenses for patients managed under the new ASCIU paradigm. Their findings support the advantages of early transport to a regional, specialized SCI center for definitive comprehensive care of patients with SCIs.

Burney et al¹ reviewed the means of transport and type of stabilization used for all patients with acute SCIs transferred to the University of Michigan Medical Center from 1985 to 1988 to determine the effect of these variables on impairment and neurological improvement. Sixty-one patients were reviewed. Twenty-five patients were transported by ground ambulance (41%), 33 by helicopter (54%), and 3 by fixed-wing aircraft (5%). Forty-three patients (70.5%) had cervical spinal injuries, 11 patients (18%) had thoracic spine injuries, and 7 patients (11.5%) had lumbar spinal injuries. Fifty-one patients (84%) were transferred within 24 hours of injury. A variety of standard methods of stabilization were used during transport. No patient suffered an ascending injury as a result of early transport. Level of function improved before discharge in 26 of 61 patients (43%). Patients transported to the medical center within 24 hours of injury were more likely to show improvement (25 of 51) than those transported after 24 hours (1 of 10). There was no significant difference in the probability of improvement between ground (8 of 25 patients) and air (18 of 36 patients) transportation. The authors concluded that acute SCI patients could

TABLE. Evidentiary Table: Transportation^a

Citation	Description of Study	Evidence Class	Conclusions
Crandall et al, ¹⁸ <i>Archives of Surgery</i> , 2010	Retrospective review trauma patients who underwent interfacility transfer and those who did not	III	Although the majority of transfers occur at greater than the mandated 2-h interval, the most seriously injured patients are reaching definitive care within 2 h. Markers of acuity for patients transferred at > 2 h parallel those of the general trauma patient population. These data suggest that, in this system, provider-determined transfer time that exceeds 2 h has no adverse effect on patient outcome.
Bagnal, ¹⁷ <i>Cochrane Database System Review</i> , 2008	To answer the question: Does immediate referral to a spinal injury center result in a better outcome than delayed referral?	III	The current evidence does not enable conclusions to be drawn about the benefits or disadvantages of immediate referral vs late referral to spinal injury centers. Well-designed, prospective, experimental studies with appropriately matched controls are needed.
Bernhard et al, ¹⁹ <i>Resuscitation</i> , 2005,	Review of prehospital management on spinal cord injury	III	Careful movement and the use of appropriate extrication techniques are crucial in all trauma patients with cervical column injury or in mechanisms of injury with the potential to cause spinal injury.
Tator et al, ¹² <i>Surgical Neurology</i> , 1993	201 ASCI patients, ICU care, hemodynamic support compared with 351 prior patients	III	Less severe cord injuries resulted from immobilization, resuscitation, and early transfer to and ICU setting.
Armitage et al, ¹⁴ <i>BMJ</i> , 1990	Case reports of 4 patients who developed respiratory problems during airplane transport	III	Airplane air is less humid, and measures to optimize humidity and pulmonary function travel in patients with high cervical injury may be required.
Boyd et al, ¹³ <i>Journal of Trauma</i> , 1989	A prospective cohort study to determine the effectiveness of air transport for major trauma patients when transferred to a trauma center from a rural emergency room	III	Patients with severe multiple injury from rural areas fare better with helicopter emergency medical service than ground emergency medical service.
Burney et al, ¹ <i>Journal of Trauma</i> , 1989	Retrospective review of the means of transport and type of stabilization used for all patients with ASCIs	III	ASCI patients can be safely transported by air or ground when standard precautions are used.
			Distance and extent of associated injury are the best determinants of the mode of transport.
Tator et al, ⁵ <i>Canadian Journal of Surgery</i> , 1984	Retrospective review of results of innovations between 1974 and 1979 at Sunnybrook Medical Centre in Toronto; the unit achieved a marked reduction in both mortality and morbidity	III	Patients were transferred to the SCI unit earlier, with a consequent marked reduction in complications and cost of care.
Hachen, ¹⁰ <i>Journal of Trauma</i> , 1977	188 patients with ASCI managed in the ICU; aggressive treatment of hypotension and respiratory insufficiency	III	Morbidity and mortality were reduced with early transfer, attentive ICU care and monitoring, and aggressive treatment of hypotension and respiratory failure.
Zäch et al, ¹¹ <i>Paraplegia</i> , 1976	117 patients with ASCI at a Swiss center, ICU setting; aggressive blood pressure and volume therapy	III	Neurological outcome was improved with aggressive medical treatment. Outcome was better for early referrals.
	Rheomacrodex for 5 d Dexamethasone for 10 d		
Hachen, ³ <i>Paraplegia</i> , 1974	Retrospective review of effectiveness of emergency transportation of spinal injury patients in Switzerland. Between 1965 and 1974, all SCI patients were immediately transported by air to SCI center. Mortality reduced to zero during transport. Average time for the rescue operation reduced from 4.5 h to 50 min. Significant reduction in cardiovascular and respiratory morbidity.	III	Mortality and morbidity of patients with acute spinal injury is reduced by a well-organized medical response with smooth and rapid transfer by helicopter to a specialized SCI center.

^aASCI, acute spinal cord injury; ICU, intensive care unit.

be safely transported by air or ground when standard precautions are used. They found that distance and the extent of the patient's associated injuries were the best determinants of the mode of transport.

Rural areas reportedly account for 70% of fatal accidents, and rural mortality rates for victims of motor vehicle accidents are 4 to 5 times greater than those in urban areas. A prospective cohort study by Boyd et al¹³ examined the effectiveness of air transport of major trauma patients when transferred to a trauma center from a rural emergency room. The study consisted of 872 consecutive trauma patients admitted after long-distance transfer. The authors found a 25.4% reduction in predicted mortality ($Z = 3.95$; $P < .001$). The benefit of helicopter emergency medical service transport was realized only in major trauma victims with a probability of survival of $< 90\%$. Thus, the benefits identified with early helicopter emergency medical service transport were directly related to injury severity. It is unclear whether these findings can be extrapolated to spine-injured and/or SCI patients because the authors did not stratify injuries by body systems in their report.

Neither land nor air transport has been reported in the literature to negatively affect the outcome of spine-injured patients when properly executed. One note of caution was offered by Armitage et al.¹⁴ They described 4 spine-injured patients who developed respiratory distress or failure during airplane transport. They noted that because patients with cervical SCIs may have severely reduced pulmonary performance, measures to optimize oxygenation, humidification, and pulmonary function in cervical SCI patients should be undertaken.

The role that specialized centers play in the care of patients with SCIs has long been a topic of debate. In 1990, DeVivo et al¹⁵ compared patients admitted to their multidisciplinary SCI center at the University of Alabama within 1 day of injury with a group of similar SCI patients who received their acute care outside of their facility and were transferred later, solely for rehabilitation. The demographics of the 2 SCI patient groups were similar. The authors reported statistically significant reductions in length of care in acute care and total length of hospitalization, coupled with a highly significant reduction in the incidence of pressure ulcers among patients admitted within 1 day of injury.

Further support for the transport of SCI patients to specialized SCI centers for acute care was offered by Swain and Grundy¹⁶ in 1994. They compared the outcomes of 420 SCI patients who underwent spinal surgery after acute SCI with a cohort of similar patients operated on at other facilities and later transferred to their center. They noted that "complications were more frequent in patients undergoing spinal surgery before transfer to the center. Furthermore, the longer the delay in transfer, the higher the incidence of pressure sores."

Since the publication of the previous medical evidence-based guidelines on this issue in 2002,⁸ 2 contemporary articles germane to the issue of transportation/transfer of seriously injured patients have been published. In 2004, Jones and Bagnall¹⁷ addressed the issue of to which type of facility should acute SCI patients be

transferred. In contrast to prior studies that suggest that SCI patients have better outcomes when treated at specialized centers, their Cochrane Review concluded that there is not sufficient evidence to support either the immediate or delayed transfer of SCI patients to a specialized facility. Their summary is predictable given that there is no Class I or Class II medical evidence on this topic.

In 2010, Crandall et al¹⁸ reported the timing of transfer data from a state-wide trauma registry in Illinois from 1999 to 2003. During that period, there were 22 447 interfacility transfers. The overall transfer rate was 10.4%. Only 20% of the transfers occurred within the arbitrary yet mandated 2-hour transfer interval. Measured outcomes included the Injury Severity Score, mortality, and the time interval to the operating room at the receiving facility. They found that even though most transfers exceeded the recommended 2-hour window limit, there were no adverse effects on patient outcome. The authors concluded that the most seriously ill patients were being transferred expeditiously and that there was no need for a mandated 2-hour transfer interval.

SUMMARY

The patient with an acute cervical spinal injury or SCI should be expeditiously and carefully transported from the site of injury to the nearest capable definitive care medical facility. The mode of transportation chosen should be based on the patient's clinical circumstances, distance from target facility, and geography to be traveled and should be the most rapid means available. Immobilization of patients with acute cervical spinal cord and/or spinal column injuries is recommended. Cervical SCIs have a high incidence of airway compromise and pulmonary dysfunction; therefore, respiratory support measures should be available during transport. Several studies cited suggest improved morbidity and mortality of spinal cord-injured patients after the advent of sophisticated transport systems to dedicated SCI treatment centers. These studies all provide Class III medical evidence on this issue.

KEY ISSUES FOR FUTURE INVESTIGATION

Development and refinement of transportation protocols for patients with cervical spine and SCI should be undertaken and could be accomplished with a large prospectively collected data set. From these data, additional case-control or comparative cohort studies could be structured to generate Class II evidence.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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