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Clinical features, patterns of referral and out of hospital transport events for patients with suspected isolated spinal injury

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Abstract

Background: Prehospital diagnostic accuracy and risks of transportation associated neurological deterioration for patients with spinal injury remain imprecise.

Methods: Retrospective review of medical records for patients with suspected spinal injury assessed and escorted by medically staffed team.

Results: One hundred and ninety six patients had follow up for spinal injury, 61% with actual injury. Of the 196 patients, 93% involved helicopter transport, 3.5% road vehicle and 3.5% fixed wing transports. Fifty one percent were interhospital transfers. Medical team's scene diagnostic accuracy of spinal injury was 31%. Scene medical interventions were those consistent with current paramedical skills. Of interhospital transferred patients, 19% had no injury. Cervical injuries as part of mixed injuries were the most often missed injuries. Abnormal neurological findings occurred equally amongst patients with and without spinal injury. Transport related incidents were documented for 15%. Interhospital transport patient related incidents occurred for 12% helicopter and 36% road vehicle transports ($P = 0.094$). No transport related neurological injury or other morbidity was documented.

Conclusion: Prehospital diagnosis of spinal injury, even by medical teams remains imprecise. Choice of helicopter transport, based purely upon the suspected presence of spinal injury could not be supported.

1. Introduction

The principal concern for patients with suspected spinal injuries during out of hospital transportation is deterioration of neurological function as a result of patient movement. Major neurological deterioration from time of injury to time of admission to a spinal unit has been documented for 10–26% of such patients [1,2]. The socioeconomic impact of this is significant as the typical patient is single, employed and 19–32 years of age [3]. For this reason, a great degree of emphasis is placed upon early application of spinal immobilization techniques and the subsequent mode of transportation.

Regionalization of trauma services has impacted upon the destination decision for patients with suspected spinal injuries. Regionalization may necessitate a secondary transport from a peripheral hospital for the exclusion and/or subsequent management of otherwise complex spinal injuries or inappropriate bypass decision from the scene. Applying specific triage tools in the prehospital setting may minimize inappropriate follow on interhospital transfers. However, past clinical practice was highly variable [4] and despite the strength of the evidence to support specific clinical criteria for exclusion of spinal injuries [5], the sole reliance upon them may not eventuate [6].

The impact of out of hospital transportation on patients with spinal injuries remains incompletely defined. The forces of transportation sustained by such patients are unique to the transport environment and can result in significant physiological effects [7–11]. In clinical practice, however, patient transportation has not been shown to impact adversely on neurological function, nor has the choice of transport vehicle [12].

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The aim of this study was to describe the pattern of utilization of a medically staffed patient transportation service by patients with suspected isolated spinal injuries who undergo transportation from a hospital or a scene. It also sought to document the impact of a medically staffed emergency response service upon the scene management of patients with spinal injury and the clinical consequences of different modes of transportation.

2. Methods

Medical transport records of patients aged 14 years or older, with isolated spinal injury who were transported by CareFlight, New South Wales Medical Retrieval Service, were retrospectively reviewed. CareFlight is a medical/paramedical staffed retrieval service based at Westmead, a western suburb of Sydney, Australia. Patients with multiple trauma, that is spinal plus one or more other body regions, were excluded.

The medical retrieval service is tasked based upon a need, that for scene responses, is determined by the most senior scene ambulance officer. For interhospital transfers, tasking is determined in consultation with referring, receiving and retrieval team doctors.

Patient demographics, mechanism of injury, preretrieval team patient preparation, clinical features at the accident scene or referral hospital, retrieval team medical management, mode of transportation, transport incidents and follow up from the receiving hospital were sought from the medical record. A transport incident was considered to be a clearly documented transport related event that caused or had the potential to cause patient harm. These were voluntarily reported by the retrieval doctor.

Patient demographics, type and mode of transport and transport incidents were available and analysed for all patients. Scene, prereferral, and outcome clinical data could not be retrieved for all patients and only patients for whom such information was available were analysed.

The relevant data was collated onto a study specific database. Descriptive statistics were used to analyse continuous variables and comparison of nominal data was performed using Chi square analysis. Level of significance was taken as 0.05. Statistical analysis was performed using Minitab vs 12 (Minitab Inc.) statistical software.

3. Results

The transport records of 318 patients, from 1991 to 1999, with isolated acute spinal injuries were identified. Patients without documented follow up from the receiving hospital were excluding, leaving 196 (62%) patients (54% of all interhospital, 50% of all scene) with documented follow up for analysis. Mean age was 31 ($+/-$ 16) years, 68% were males, 51% were interhospital transports and 49% were a scene response. Patients transported directly from the scene were younger, mean age of 26 ($+/14$) years compared to interhospital transferred patients, mean age of 33 ($+/-18$), $P = 0.004$. Motor vehicle/other accidents and sporting incidents each contributed to 42%, hanging to 1.5%, other causes to 3% and not recorded in 11.5% of cases.

Injury sites were 41% cervical, 10% lumbar, 8% thoracic, 2% mixed and 39% were normal. There was no significant difference in the site of injury amongst different modes of transportation.

The majority of transports, 93%, were by helicopter, 3.5% by fixed wing aircraft and 3.5% by road vehicle. All scene transports were by helicopter. Duration of interhospital helicopter transport was longer ($42 +/-$ 28 min) than scene transfers ($19 +/- 12$ min), $P < 0.001$, but similar to road vehicle transfers ($45 +/- 26$ min), $P = 0.84$. Rural hospitals were the referral source for 55% of interhospital transfers.

Fig. 1 illustrates the type of spinal injury for interhospital transferred patients, both at the time of referral and as determined at the receiving hospital. Of all referred cervical lesions, 16% were subsequently documented to be normal. All referred lumbar and thoracic injuries were accurately identified. Mixed lesions were the most often missed referral injury, with the cervical spine being the missed 'other' site. Of all interhospital referrals, 18% were to exclude a spinal injury that could not be otherwise excluded at the referral hospital. Of these, 34% were later documented as normal.

Motor vehicle/other accidents injuries were more often associated with a spinal injury (81%) compared to sporting accidents (42%), $P < 0.001$. Fig. 2 shows the site and incidence of spinal lesions for scene and interhospital sporting and accident related mechanisms of injury.

Scene transports were more often associated with sporting incidents (64%) whilst interhospital transfers were more often associated with motor vehicle/other accidents (61%), $P < 0.001$.

Scene winch extrication was required for 8 (5%) patients. Two had cervical, one a lumbar, three had no spinal injury and two did not have receiving hospital outcome information documented.

The retrieval team doctor assessed 84% of scene patients to have been adequately prepared and 15% to have had no preparation by scene ambulance officers prior to the team's arrival. The significance of patient access and/or other environmental factors upon patient preparation, prior to the arrival of the retrieval team, could not be delineated from the transport records. The

retrieval doctor deemed that a doctor was not required for 57% of scene responses, required for their diagnostic skills for 37% and for 7% because the treatment required was beyond the protocols of the treating scene ambulance officers, all of whom were recorded to be non-paramedic trained. Specific medical treatment given for this latter group of patients was analgesics, antiemetics and intravenous fluids. Whether these diagnostic skills were of benefit in excluding spinal or other injuries or another clinical reason was not clearly differentiated from the transport patient record. Of patients for whom the doctor's diagnostic skills were considered necessary, 30% had a confirmed spinal injury.

Fig. 3 illustrates the correlation of the clinical neurological findings prior to and at time of transportation for patients with confirmed spinal injury. Of scene patients, 58% were medically assessed to have no abnormal neurology. Of scene patients with a cervical spine injury, 52% had sensory and motor signs and/or symptoms, 16% sensory only and 32% no abnormal neurology. The incidence of abnormal neurological signs and/or symptoms was similar amongst patients with (50%) and without (46%) a confirmed spinal injury. Patients with a spinal injury had a higher incidence of sensory and motor (42%) signs and/or symptoms, compared to patients without a spinal injury

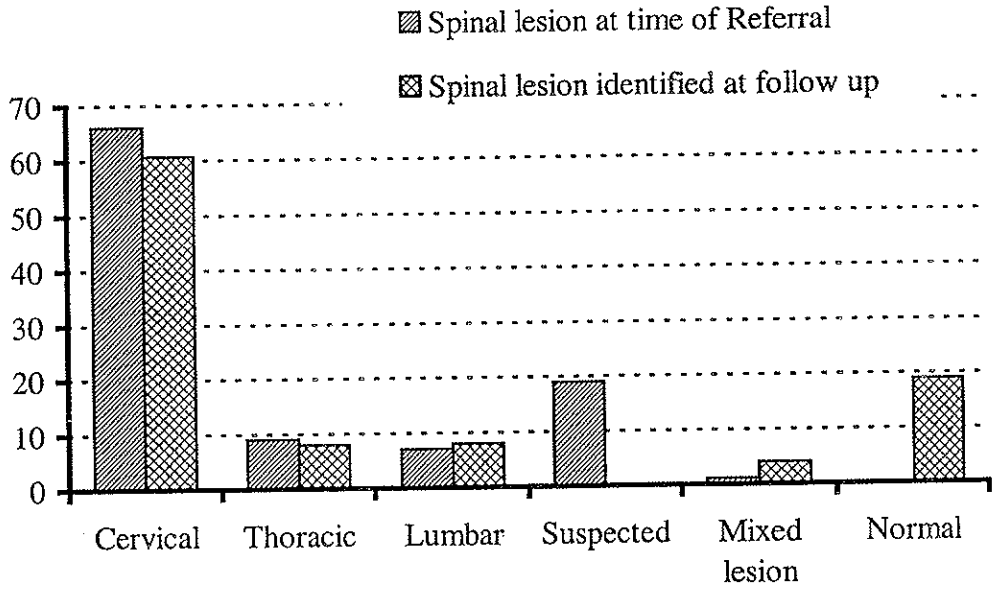

Fig. 1. Site of spinal injury at time of referral and as identified subsequently at the receiving hospital.

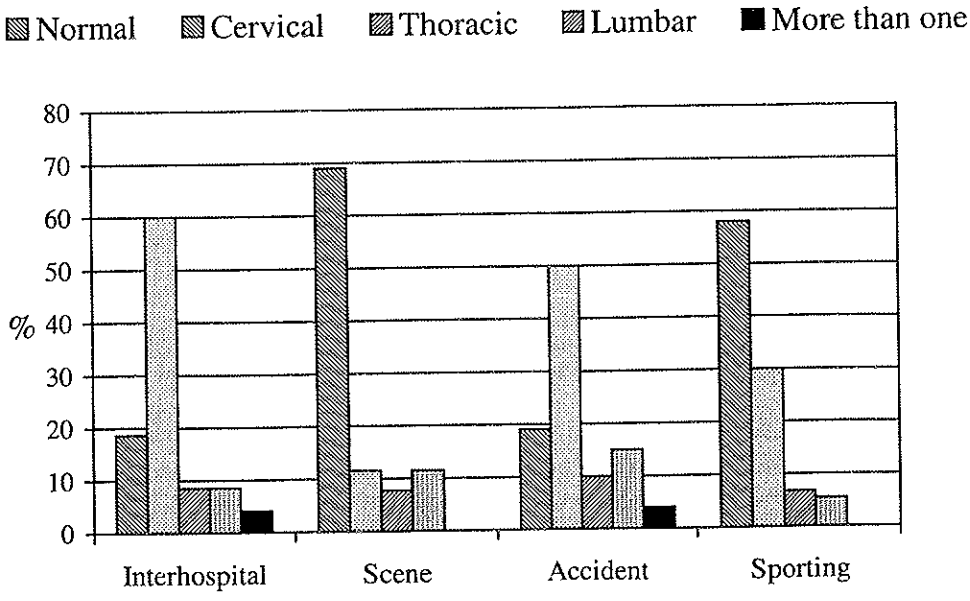

Fig. 2. Site of spinal lesion for scene and interhospital transports, sporting and accident events.

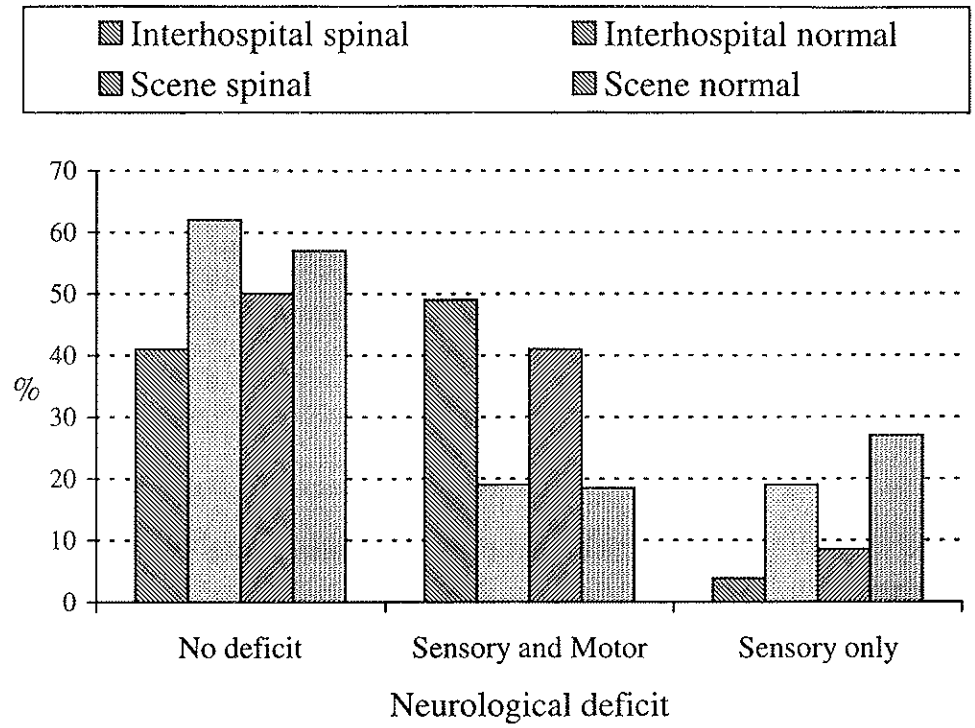

Fig. 3. Correlation of the neurological findings prior to and at the time of transportation with the eventual spinal diagnosis for both scene and interhospital transfers.

Table 1
List of transport incidents for each mode of transportation

Helicopter ($N = 295$ transports)		Road vehicle ($N = 11$ transports)		Fixed wing aircraft ($N = 11$ transports)	
Incident	No.	Incident	No.	Incident	No.
Equipment related	11	Equipment related	1	Equipment related	2
Pain/irritable	14	Pain/irritable	2		
Nausea/vomiting	4	'Bumpy' trip	1		
Hypotension	3	Request for helicopter	1		
Hypertension	1				
Tachycardia	1				
Bradycardia	1				
Respiratory discomfort	2				
Mechanical ventilation related	2				
Turbulence	1				
Total	37	Total	5	Total	2
(% of all transports)	13%	(% of all transports)	45%	(% of all transports)	18%
More than one incident	3	More than one incident	2	More than one incident	0

(17%) and less likely to have sensory only (8%) signs and/or symptoms than patients without a spinal injury (27%), $P = 0.035$.

Although patients may not have been routinely assessed for in transit neurological deterioration, no such deterioration was documented for any patient. At the receiving hospital, 20% of scene patients with documented prehospital abnormal neurology had complete resolution of those abnormal findings.

Documentation of critical transport related incidents was sought from the 318 patient records and documented for 15%, of which 2% had more than one documented incident. These occurred in 20% of interhospital transfers and 8% of scene transfers, $P < 0.001$. Table 1 lists the type and number of documented incidents for each transport vehicle. Table 2 compares patient only (excludes equipment related incidents) and interhospital patient only related incidents, as no scene transport was performed by road vehicle. Although patient only related incidents occurred more often with

road vehicle transports, this difference was not significant when all modes of interhospital only transportation were compared.

Interventions such as the administration of antiemetics, analgesia, intravenous fluid bolus and reassurance were initiated in response to patient related incidents. No reported incident was documented to have resulted in patient morbidity or mortality.

4. Discussion

Patients with suspected isolated spinal injuries who undergo out of hospital assessment and transportation by a medical/paramedical staffed retrieval service are least likely to have a spinal lesion if, they are a scene response, injured as a result of a sporting accident and have solely sensory signs or symptoms. These features, however, were not unique to patients without a spinal injury. Of medically assessed scene patients, 31% had a subsequently confirmed injury, 58% of which had a documented normal clinical neurological scene assessment. Patient related incidents occurred in 15% of all transports, and were mostly associated with interhospital transfers. For interhospital transfers, the documented occurrence of patient only related incidents was similar for helicopter and road vehicle transportation. Although not routinely sought, no in transit neurological deterioration was documented. Complete resolution of scene documented abnormal prehospital neurology at the receiving hospital was noted for 20% of scene patients.

The diagnosis of cervical spine injury within the confines of a hospital environment remains unreliable [13,14] unless specific criteria can be met [5]. Previous studies have shown no neurological signs in 26% of patients with cervical spine injury [15]. Some patients require higher-level radiological investigations, not often available at smaller or rural hospitals to confirm the presence or absence of injury.

In this study, of patients referred with a spinal injury only, undergoing interhospital transfer, $\approx 20\%$ had confirmation of no injury. A cervical injury in patients with more than one spinal injury site was the most often missed injury. Cervical injuries were most likely to be over diagnosed and 18% of referrals were to exclude a suspected spinal injury, of which 34% were normal. It could not be determined retrospectively what resources were available to the referring hospital at the time of transfer so as to exclude a spinal injury. It would not be uncommon for such referrals to arise from the need of more specialized, regionally located clinical and diagnostic medical resources.

Poorly reliable clinical indicators for excluding a spinal injury are even less efficacious at a 'hostile' environment common to most retrieval scene responses. The physical nature of such an environment and the need to expedite patient extrication for both operational and medical reasons precludes the opportunity for a detailed patient assessment and monitoring [16,17]. Similarly, the number of patients documented to have complete resolution of their prehospital abnormal neurology and confirmed absence of spinal injury at the destination hospital are factors that would make the likelihood of reliably excluding a spinal injury at the time of the scene response very unlikely. It is also highly probably that in consideration of these factors, the retrieval team would have based their suspicions of a spinal injury more on the mechanism of injury. An explanation for the resolution of scene abnormal neurology, and for some of the subsequent transport related adverse events, may be the pain, discomfort and physiological consequences of in transit spinal immobilization techniques [18–20].

The incidence of prehospital neurological deterioration has been suggested to be 10–26% [1,2]. There have been no direct comparisons as to the ideal transport vehicle for such patients. In a group of 61 patients (25 by road vehicle, 33 by helicopter and 3 by fixed wing aircraft), no patient was observed to have suffered an ascending level of injury [12]. It may be that neurological deterioration is mostly related to the initial high energy forces necessary to cause a spinal injury [21], rather than the significantly lesser forces encountered during transportation. Even the benefits of spinal immobilization, as compared to no immobilization, have been brought into question [22]. It thus appears that the likelihood of in transit neurological deterioration remains a very uncommon event. For any out of hospital patient transport, operational and environmental factors specific to the immediate task also need to be taken into consideration when choosing mode of transportation. Such considerations could not be ascertained from the available records.

Table 2
Comparison of the number and frequency of transport related incidents for helicopter and road vehicle

	Helicopter	Road vehicle	*P* value
Interhospital and scene associated incidents	37 (13%)	5 (45%)	0.016
Interhospital and scene patient only incidents (excludes equipment incidents)	28 (9.5%)	4 (36%)	0.024
Interhospital transport and patient only incidents	17 (12%)	4 (36%)	0.094

For patients with isolated spinal injuries, loading difficulties, hypoxia and temperature at altitude, turbulence, cabin limitations, duration of transportation are the potential patient risk factors for helicopter transports. The need for a secondary transport vehicle is an additional risk factor for fixed wing aircraft. For the road vehicle, unpredictable, low frequency, higher amplitude vibration or 'jolts' and duration of transportation are the principal patient concerns.

Although not ascertainable in this study, the exclusive use of the helicopter for all scene responses may have been due to scene related access difficulties. It was not possible, however, to account for the factors, other than clinical, for the tasking of the helicopter to the 27% of scene responses that were located within an urban area or the 45% of interhospital urban transports. This may reflect a bias towards the helicopter as the preferred mode of transportation by the referring, transporting and/or receiving medical staff.

This study found a higher overall occurrence of incidents associated with the use of a road vehicle than fixed wing or helicopter. When comparing interhospital patient transports only, there was no significant difference in patient related incidents between helicopter and road vehicles. Nausea and vomiting were solely documented for patients transported by helicopter. Pain and irritability was more often associated with the road vehicle. The majority of incidents required only minor medical intervention. No transport incident was documented to cause a neurological deterioration or persistent adverse physiological effect. The limitation of such comparisons in this study is the disproportionately greater use of the helicopter as compared to fixed wing and road vehicles for spinal patient transportations. Also, the helicopter was the only vehicle used for scene responses.

The difference in occurrence of incidents between scene and interhospital transports may be accounted for by the lesser duration of patient transportation for scene as compared to interhospital. Duration of spinal immobilization has been shown to contribute directly to pain and discomfort.

Winch extrication was required for 8% of scene patients and 15% were not prepared prior to the retrieval team arrival, reflecting the adverse scene environment at that time. All medical scene interventions documented in this study could have potentially been provided by a higher level of ambulance officer than was documented to be available in those instances. For this study's group of patients, a medical officer could only be justified in the absence of advanced trained (paramedic) ambulance officers.

The weakness of this study is it's retrospective and mostly descriptive nature, the absence of randomization, inequality of patient injury and numbers amongst the various forms of transport modes, inability to elucidate the indications for selection of mode of transportation at that time and the non-standardization of patient neurological assessment during the long study period. Many of these weaknesses would, however, be difficult to be otherwise overcome in the setting of an emergency response service operating in unpredictable circumstances and environments and the infrequency of isolated spinal injuries.

In summary, this study confirmed that the prehospital diagnostic accuracy of spinal injury remains low, even if that prehospital assessment is by medical officers. Management of such patients could be adequately performed by ambulance officers trained to the level of administering systemic analgesia and intravenous fluids, both in terms of scene management and of transport adverse events. Although limited by the number of road and fixed wing transports there appears to be no clinical advantage in terms of further neurological injury in the preferential use of the helicopter as the mode of transport. The choice of transport vehicle should thus be based upon the ambient geography, operational factors and time to receiving hospital rather than the suspected presence of a spinal injury.

There was a tendency for the helicopter to be associated with fewer patient related incidents. No such incidents, however, were associated with patient morbidity. Ideally further studies with a greater utilization of road transportation would be required to confirm this latter finding. Based upon the analysis of this series of patients, transport related deterioration of neurological injury during out of hospital transportation appears to remain an uncommon event.

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