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ORIGINAL ARTICLE

The effects of early or direct admission to a specialised spinal injury unit on outcomes after acute traumatic spinal cord injury

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Study design: Prospective cohort study.
Objectives: For acute traumatic spinal cord injury (ATSCI), this study aimed to determine differences in outcomes between patient groups stratified by admission time (⩽24 vs >24 h) to the Spinal Injury Unit (SIU) and by the nature of the admission (direct admission to the SIU vs indirect admission via another hospital). We also aimed to measure the effect on time to admission of a 'non-refusal' policy that triggered immediate acceptance of ATSCI cases to the SIU.
Setting: New South Wales, Australia.
Methods: Study population was all adult SCI patients admitted to the Prince of Wales SIU from 1 January 2001 to 31 December 2012. Patients admitted with chronic-stage SCI or with incomplete data for the duration of their stay were excluded. Comparison of outcomes was made between groups according to the setting of admission. Time to admission before and after initiation (2009) of the 'non-refusal' policy was compared. The prevalence of complications, lengths of stay (LOSs) and time to admission were compared by Mann–Whitney non-parametric methods. Count modelling was used to control for confounders of age and gender.
Results: A total of 460 cases were identified and 76 were excluded. The early group had fewer pressure areas (41.8% vs 63.2%; $P<0.001$) and shorter LOS (136 vs 172 days; $P<0.001$) than the late group. The direct group had fewer pressure areas (35.2% vs 54.9%, $P<0.001$), deep vein thrombosis (9.9% vs 24.6%, $P=0.003$) and shorter LOS (124 vs 158 days, $P=0.007$) than those admitted indirectly. Time to admission was reduced after introduction of the 'non-refusal' policy (1.53 vs 0.63 days; $P=0.001$).
Conclusions: Early and direct admission to SIU reduced complication rates and LOS. A non-refusal policy reduced time to admission.
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INTRODUCTION

Acute traumatic spinal cord injury (ATSCI) is a rare condition with catastrophic consequences for the patient, their family and carers. The global annual incidence of ATSCI was estimated to be 23 cases per million in 2007, equating to approximately 1 80 000 cases annually worldwide using the Fitzharris point model estimation derived from the International Perspectives on Spinal Cord Injury data set.[1,2] Australia has a lower annual incidence (15 per million) than the global average, in contrast with North America (40 per million) but similar to Europe (16 per million).[1] In Australia, more males are injured than females (5.3:1); the 15–24-year-old age group has the highest rate of injury; the most common mechanisms of injury are transport (46%) and falls (28%) and the in-hospital death rate is 2%.[3] In economically developed countries, the rate of injury by transport is stable or declining, but with aging populations the rate of ATSCI in the elderly caused by low falls is rising.[1] The economic burden carried by the community and medical systems is high. The total annual cost of ATSCI in Australia during 2008 was estimated at AU$2 billion (medical costs, community costs and loss of productivity) and the estimated lifetime cost for each case of paraplegia was AU$5 million and for tetraplegia AU$ 9.5 million.[4]

In New South Wales (NSW) Australia, Ministry of Health policy for ATSCI recommends that patients to be referred as soon as possible to a Spinal Injury Unit (SIU) following initial patient assessment and early treatment (Critical Care Tertiary Referral Networks & Transfer of Care (Adults) PD2010_021).[5] Two SIUs serve the population of NSW, one at the Royal North Shore Hospital (RNSH) and the other at Prince of Wales Hospital (POWH), both located in Sydney, NSW, Australia. The two units have clearly defined geographical referral areas and the prehospital protocols reliably direct ATSCI patients to the appropriate centre. The NSW spinal cord injury database (NSW SCID) collects data prospectively on all SCIs admitted to the two SIUs. The NSW SCID is maintained by a full-time data manager and data entry is cross-checked. Complete electronic data are available from 2000 onward, and it is compatible with the International Spinal Cord Society minimum data set.[6] The NSW SCID represents a high-quality data set that is suitable for performing cohort studies.

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ATSCI patients are at risk of developing many possible complications of which the following are considered important: pressure areas, pneumonia, urinary tract infections, deep venous thrombosis, and pulmonary emboli. These complications can lead to delayed rehabilitation and increased hospital length of stay (LOS).[7] In Australia, like in the United States and the United Kingdom, SIUs have been developed as a means of reducing complications in ATSCI patients through multidisciplinary care. Middleton *et al.*[8] have shown that, in NSW, Australia, a delay in admission to a SIU from time of injury of >24 h is associated with a 2.5 times increase in the likelihood of developing a complication. A review of the role of SIUs published in the Cochrane Library in 2009 failed to find conclusive evidence of benefit;[9] however, a more recent review in 2011 recommended early (<24 to 48 h) admission to a SIU in order to reduce the overall LOS, mortality and the number of complications.[10]

It has been shown that a principal reason for delayed admission to a SIU is lack of bed availability at the SIU hospital.[11] This raises the question of enhancing service provision by the SIU by removing barriers to admission for ATSCI. The SIU at the POWH introduced a non-refusal policy[12] in May 2009 to facilitate referrals made according to Critical Care Tertiary Referral Networks & Transfer of Care (Adults) PD2010_021.[5] The policy is designed primarily to streamline logistical care of ATSCI patients by removing barriers to admission. The policy states that POWH will accept all referrals of ATSCI (except in those individuals moribund as a result of severe trauma or medical comorbidities) and provide appropriate resources for management of those patients from their time of arrival. In extremis of having no available resources at POWH, cross-referral to the SIU at the RNSH will be made. In effect, all calls to the POWH regarding ATSCI may be accepted for immediate transfer rather than waiting for suitable resources to be made available first.

Thus the goals of this study were to find whether there was a difference in the prevalence rates of complications and LOS for patients admitted either earlier (⩽24 h) or later (>24 h) after injury or admitted directly from the scene of injury or indirectly via another hospital to the POWH SIU. We wished to find whether there was an effect of the 'non-refusal' policy on time to admission during the period of this study. By its nature, the 'non-refusal' policy applied to those patients referred from another hospitals and for this study it is relevant to the indirect admissions and not the direct admissions.

MATERIALS AND METHODS

All admissions to the SIU at the POWH from 1 January 2001 to 31 December 2012 were identified on the NSW SCID. The inclusion criteria were ATSCI presentation and age ⩾18 years. Exclusion criteria were admission for chronic-stage SCI, re-admission in rehabilitation phase of care, referred from overseas, and currently admitted in the SIU at the time of data retrieval and death during stay.

A direct admission was defined as a patient transported directly to the Emergency Department of the POWH from the scene of injury by ambulance. An indirect admission was defined as any patient referred to the POWH SIU from another hospital and who was the subject of interhospital transfer from the referring hospital to POWH SIU. An early admission was defined as a patient arriving at POWH within or at 24 h of their acute SCI (whether direct or indirect admission). A late admission was defined as a patient arriving later than 24 h after their injury (whether direct or indirect admission). The time of injury and hospital admission as well as the source of the admission (scene or other hospital) are recorded in the NSW SCID to the nearest 5-min period. The non-refusal policy was implemented in May 2009 and applied to all indirect admissions, whether admitted before or after 24 h from ATSCI. The policy applied to indirect (and not direct) admissions because it affected only those cases subject to a referral from another hospital that required an executive decision to be accepted for transfer to the SIU.

Demographic data collected were age, gender, time from injury to admission to the POWH SIU, direct or indirect admission type, the admission American Spinal Injury Association Impairment Scale (AIS)[13] and the Injury Severity Score (ISS).[14] The admission AIS was derived from the first full examination according to the International Standards for Neurological Classification of Spinal Cord Injury, which was performed in the first 3 days of acute admission to POWH. The ISS was calculated from the record of injuries at the time of acute admission to POWH. The following outcomes for each admission were retrieved from the NSW SCID: LOS in intensive care unit (ICU), LOS in acute spinal ward, LOS in the rehabilitation ward and the total LOS; discharge AIS and five possible medical complications (pressure area, pneumonia, urinary tract infection, deep vein thrombosis and pulmonary embolus). The discharge AIS was derived from the last examination according to the International Standards for Neurological Classification of Spinal Cord Injury performed prior to the patient being discharged to the community from the rehabilitation ward in the SIU. The outcome 'complication types' was the number (or variety) of the five different medical complication types patients encountered during their stay. One patient may suffer multiple occasions of the same complication and thus record one 'complication type'. Thus 'complication types' may range from zero to five only. However, analysis of the prevalence rates of specific complications between groups was performed on the total number of complications, counting multiple episodes of the same complication in individuals separately.

During a patient stay, all complications were diagnosed and recorded according to fixed standards in an established data dictionary used by the POWH SIU. Weekly meetings on the SIU review every inpatient and record current complications. These are then verified by the data manager who cross-checks the patient record for the criteria contained in the data dictionary. At discharge, each consultant physician is required to sign off on the list of complications recorded for each patient, providing a second check on data collection. Pressure areas are defined as any of the following non-blanching areas of skin erythema, skin necrosis or skin ulceration. Pneumonia is defined as specific changes on chest X-ray in the context of appropriate clinical symptoms and signs. Urinary tract infection is defined as a positive urine culture for pathogenic organisms in the context of appropriate clinical symptoms and signs. Deep venous thrombosis is defined as positive findings on Doppler ultrasound investigation. Pulmonary embolus is defined as positive findings on computed tomography pulmonary angiogram or nuclear medicine ventilation–perfusion study. Every patient is screened for deep venous thrombosis by Doppler ultrasound at the time of admission to the acute rehabilitation ward of the SIU from ICU, other hospital ward or other hospital. Further screening is performed in response to clinical symptoms and sign suggestive of deep venous thrombosis or pulmonary embolus. The data dictionary did not change during the years of admission for this study.

Descriptive statistics were calculated for all variables. T-test statistic was used to compare normally distributed variables. The non-parametric Mann–Whitney rank test was used to compare variables with non-normal distributions and the Chi-squared test for categorical variables. Multivariate count models, including Poisson, negative binomial, zero-inflated Poisson and zero-inflated binomial, were employed to predict the number of events for each clinical outcome and for all outcomes. Model selection was based on goodness of fit using the Akaike Index Criterion, a transformation of the maximum value of the likelihood model adjusted by the number of covariates. The lowest value of the Akaike Index Criterion indicates the preferred model, that is the one with the fewest parameters that still provides an adequate fit to the data.[15] LOS was modelled using linear regression of the log-transformed LOS. Different count models were employed based on the distributions of different complications, with zero-inflated models used for the analyses of pressure areas and urinary tract infections. In all tests, the level of statistical significance was set at $P<0.05$. Statistical analysis was performed using SPSS Statistics v21 (SPSS Inc., Chicago, IL, USA) and STATA SE v12 (StataCorp LP, College Station, TX, USA).

Statement of ethics

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. Human Research Ethics approval (09/113) was obtained prior to conducting the study.

RESULTS

Table 1 shows the characteristics of those included and excluded from the study. All admitted patients were recorded on the NSW SCID (no missing data). A total population of 460 patients were identified and 76 were excluded, leaving 384 ATSCI patients to be included in the analysis. Of the 76 excluded patients, 30 were admitted for rehabilitation with chronic-stage SCI, 19 came from an international facility, 14 were aged <18 years, 10 died during their stay and 3 were still admitted in the SIU. Although not significantly different, the excluded group has a much longer median time to admission (102 h) than the included group (15 h) because a small number of patients referred from overseas typically had prolonged time to admission. Ten (of 460 patients, or 2.2%) patients died during acute hospitalisation (2 deaths occurred in the POWH SIU and the remaining in the ICU). For all study patients, the mean age at injury was 41 years (s.d. 18 years) and the median age was 39 years (range 18–91 years). C4 was the most common level of injury ($n=112$), followed by C5 ($n=47$) and then L1 ($n=39$). The distribution of injury by neurological level is shown in Figure 1. The admission mean ISS was 25. The median time from injury to admission to the POWH was 15 h (interquartile range 6–138 h) (range 0.5 h–148 days), respectively. A total of 232 patients (60.4%) were admitted within or at 24 h of injury and 152 (39.6%) after 24 h. Ninety-one patients (23.6%) were admitted directly from the scene of injury and 293 (76.4%) were admitted indirectly from another hospital.

For all cases, the median ICU LOS was 3 days and the median acute spinal ward LOS was 23 days. Following acute spinal ward stay, 317 of 384 patients (82.6%) were transferred to the spinal rehabilitation ward, 28 (7.3%) were transferred to other hospitals and 39 (10.2%) were discharged home. For all cases, the median total LOS was 150 days.

Table 2 summarises neurological changes. The AIS was recorded at admission for all patients and 352 patients (91.7%) had their AIS recorded at discharge. The median duration from last determination of AIS prior to discharge was 1 day (range 0–55 days). At admission, the median AIS grade was C, whereas the most common was AIS grade A. Of the patients who had their AIS recorded at discharge, 237 (67.3%) remained the same and 112 (31.8%) improved, whereas 3 (0.9%) deteriorated.

Major medical complications in all patients were recorded as follows: pressure areas 197 (51%), pneumonia 83 (22%), urinary tract infection 218 (57%), deep venous thrombosis 86 (22%), and pulmonary embolus 48 (13%). The median number of complication types suffered was 2. Patients had between 0 and 5 complication types in the following distribution: 26.8% had 0; 22.4% had 1; 24.2% had 2; 20.1% had 3; and 6.5% had 4 or 5.

Differences in outcomes between different admission groups

The median time to admission was significantly shorter for the direct group compared with the indirect group (2 vs 25 h; $P<0.01$). Table 3 shows the numerical and statistical differences in outcomes between groups according to admission type: early vs late and direct vs indirect. The results of statistical modelling are shown in Table 4.

Effect of age

During the 11 years that the data have been collected, the mean age of ATSCI within POWH SIU increased by 18 years (31 ± 14 vs 50 ± 21 years). Our modelling (Table 4) showed that increased age was associated with significantly increased risk of deep vein thrombosis, pneumonia, pulmonary embolus, total complications and overall LOS.

Table 1 Comparison of included and excluded populations

Variable	*Included (n = 384)*	*Excluded (n = 76)*	P-*value*
Mean age (s.d.) (years)	41 (18)	42 (21)	0.90
Median age (range) (years)	39 (18–91)	41 (15–82)	
Number of males	328 (85%)	55 (72%)	<0.01
Number of motor complete SCI	231 (60%)	46 (61%)	0.95
AIS at admission			0.86
Number with grade A	153 (40%)	30 (40%)	
Number with grade B	34 (9%)	9 (12%)	
Number with grade C	100 (26%)	18 (24%)	
Number with grade D	97 (25)	19 (25%)	
Number with tetraplegia	230 (60%)	39 (51%)	0.17
Number with paraplegia	154 (40%)	37 (49%)	
Number of direct admissions	91 (24%)	18 (24%)	0.10
Median time to admission (IQR) (h)	15 (6–138)	102 (5–949)	0.09
Median LOS (IQR) (days)	172 (111–243)	150 (83–218)	0.09
Prevalence of pressure areas	51.3%	40.7%	0.09
Prevalence of pneumonia	21.6%	10.5%	0.03
Prevalence of urinary tract infections	54.4%	46.1%	0.28
Prevalence of deep venous thrombosis	21.1%	15.8%	0.20
Prevalence of pulmonary emboli	12.5%	9.2%	0.42

Abbreviations: AIS, ASIA Impairment Scale; IQR, interquartile range; LOS, length of stay; SCI, spinal cord injury.
T-test for normally distributed variables. Mann–Whitney rank test for non-parametric variables. Chi-square test for categorical variables.

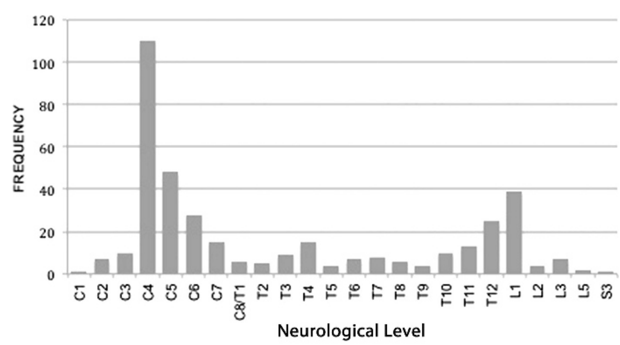

Figure 1 Frequency distribution of neurological level of SCI.

Table 2 Change in the ASIA Impairment Scale (AIS) from admission to discharge

Admission AIS	*Discharge AIS*					*Total*
	A	*B*	*C*	*D*	*E*	
A	112	11	14	6	0	143
B	1	12	8	9	0	30
C	1	0	39	50	1	91
D	0	0	1	74	13	88
Total	101	23	55	112	6	352

Table 3 Comparisons of early vs late admission and direct vs indirect admission

	Timing of admission			*Type of admission*		
	⩽24 h	*>24 h*	P-*value*	*Direct*	*Indirect*	P-*value*
Number of admissions	232	152		91	293	
Mean age (s.d.) (years)	38 (16)	47 (19)	<0.01	36 (17)	43 (18)	<0.01
Median age (range) (years)	33 (18–82)	46 (18–91)		31 (18–89)	41 (18–91)	
Male gender	207 (89%)	121 (80%)	<0.01	82 (90%)	246 (84%)	0.15
Number with tetraplegia	138 (59%)	87 (57%)	0.39	57 (63%)	168 (57%)	0.37
Number with paraplegia	94 (41%)	65 (43%)		34 (37%)	125 (43%)	
AIS at admission			0.27			0.23
Number with grade A	93 (40%)	60 (39%)		35 (38%)	118 (40%)	
Number with grade B	23 (10%)	11 (7%)		7 (8%)	27 (9%)	
Number with grade C	53 (24%)	47 (31%)		19 (20%)	81 (28%)	
Number with grade D	63 (27%)	34 (22%)		30 (33%)	67 (23%)	
Median Injury Severity Score	25	25	0.05	25	25	0.11
Prevalence of pressure areas	41.8%	63.2%	<0.01	35.2%	54.9%	<0.01
Prevalence of pneumonia	21.1%	20.3%	0.99	23.1%	20.1%	0.58
Prevalence of urinary tract infections	53.0%	56.6%	0.31	52.7%	54.9%	0.61
Prevalence of deep venous thrombosis	18.1%	25.6%	0.07	9.9%	24.6%	<0.01
Prevalence of pulmonary emboli	10.8%	15.1%	0.22	13.1%	12.3%	0.82
Median number of complication types (range)	1 (0-5)	1 (0-5)	<0.01	1 (0-5)	2 (0-5)	0.03
Median ICU+acute spinal ward LOS (IQR) (days)	32 (16–48)	33 (19–57)	0.82	29 (11–47)	32 (22–42)	0.61
Median total LOS (IQR) (days)	136 (51–221)	172 (102–242)	<0.01	124 (40–208)	158 (79–237)	0.01

Abbreviations: AIS, ASIA Impairment Scale; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay.
T-test for normally distributed variables. Mann–Whitney rank test for non-parametric variables. Chi-square test for categorical variables.

Effect of gender

Male gender was associated with an increase in the prevalence of deep vein thrombosis (odds ratio 3.1, $P<0.01$). There were no other significant differences between the genders (Table 4).

Effect of completeness of SCI

There was a significantly higher prevalence of all complications in those with motor complete SCI in comparison with motor incomplete injury. The motor complete patients also had a longer LOS (odds ratio 2.5, $P<0.05$; Table 4).

Effect of non-refusal policy

The non-refusal policy was introduced in May 2009. The time to admission to the POWH SIU was compared for the cohorts admitted indirectly before May 2009 and after that date. The time to admission by year is shown in Figure 2. The median time to admission reduced from 33 h prior to May 2009 to 14 h following May 2009 ($P<0.01$). After May 2009, there was a significant rise in the prevalence of deep venous thrombosis, unadjusted for age, by almost 10% compared with before May 2009 ($P=0.05$); however, the average age of admitted patients did not change significantly. Multivariate count model analyses also demonstrated an independent effect of increased deep vein thrombosis prevalence since May 2009 ($P=0.01$).

DISCUSSION

Age, gender and distribution of levels of injury are similar to previously published reports by the Australian Spinal Cord Injury Register.[16] The distribution of admission and discharge AIS is also similar to international published experience.[17–19] At POWH, the acute spinal injury unit and the spinal rehabilitation unit are colocated (providing integrated as well as multidisciplinary care), and hence the total LOS refers to admission to the same institution for the entire patient journey from injury to re-establishment in the community.

In NSW, there is a state-wide ambulance service (road and air transport) operating to standard trauma protocols administered by a central health ministry. There are stable referral areas for the SIUs at POWH and RNSH, which means that there is unlikely to be bias of patient injury pattern received at POWH SIU. In fact, the administrative structure of NSW Health provides a sound, uniform framework in which to conduct this kind of cohort study.

We found that both the early and direct admission groups were younger by approximately 10 years, which may bias the rate of complications. There was also a greater proportion of males in the early admission group. The injury characteristics of the different groups are otherwise similar with regard to neurological levels of SCI, AIS and ISS between the comparison groups, which mitigates potential bias for the early or direct admissions to be less severely injured and therefore less likely to suffer complications. We found that early or direct admissions have fewer pressure areas and fewer medical complications in total. This effect may reflect either the younger age of patients in the early and direct groups, the effect of males in the early group or that more immediate multidisciplinary care at POWH has a beneficial impact on outcomes. On further analysis, multivariate count modelling of our data confirms a significant association between age and the risk of deep venous thrombosis, pulmonary embolus and pneumonia but not pressure area development. In other studies, increased age has been linked with a greater risk of pneumonia but not with other major medical complications in the initial phase of care.[20–22] Our modelling also showed an independent reduced risk of pressure area development in the direct admission group. Therefore, it is reasonable to claim that the reduction in prevalence of pressure areas with early or direct admission to the SIU in our study is a real effect. Pressure areas are known to be initiated during the first

Table 4 Count model analyses

Outcomes		*PA*	*DVT*	*UTI*	*Pn*	*PE*	*All*	*LOS*
Model of best fit		ZI, NB	NB	ZI, P	NB	P	ZI, NB	MLR
Factors for model	Age (increased)	1.005	1.015[a]	0.997	1.024[a]	1.017[a]	1.007[a]	1.005
	Male (vs female)	0.814	3.075[a]	1.078	0.998	1.834	1.036	0.863
	Motor complete (vs incomplete)	1.977[a]	1.854[a]	1.610[a]	3.016[a]	1.877[a]	1.911[a]	2.513[a]
	Indirect (vs direct) admission	1.512[a]	2.142[a]	1.118	0.809	0.744	1.237	1.108
	Late (vs early) admission	0.908	1.149	1.115	1.236	1.315	1.033	1.494[a]
Zero inflated	Age (increased)	—	—	−0.024	—	—	—	—
	Motor complete (vs incomplete)	−2.061	—	−1.362[a]	—	—	−1.756[a]	—
	Late (vs early) admission	−2.439	—		—	—	−1.287[a]	—

Abbreviations: All, all complications; DVT, deep venous thrombosis; LOS, log total length of stay; MLR, multivariate Linear regression; NB, negative binomial; *P*, Poisson; PA, pressure area; PE, pulmonary embolus; Pn, pneumonia; UTI, urinary tract infection; ZI, zero inflated.
All values shown represent the odds ratio for the factors analysed.
[a]Results where $P<0.05$.

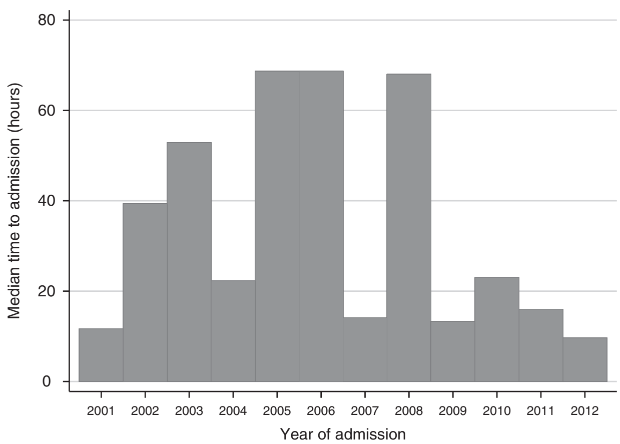

Figure 2 Median time to admission by year of admission.

6 h of injury,[23] and hence early multidisciplinary care at a SIU would be expected to reduce the risk.

Modelling shows that indirect admission is independently associated with increased prevalence of deep venous thrombosis. Similarly, modelling shows that admission >24 h after injury is independently associated with greater number of medical complications and longer LOS than early admission. Thus the better outcomes associated with early or direct admission shown by comparative statistics are supported by modelling. It should be noted that the nature of model selection under the Akaike Index Criterion implies that the objective criterion will asymptotically select the best-fitted model and does not assess the absolute quality of the model. However, the independence of the order in which models are computed allows robust and precise estimation of effects. The limitation of this method is that it does not specifically test against a null hypothesis, instead it is an estimation of the true effects of tested data.

The results show a possible effect of the 'non-refusal' policy on reducing time to admission to the SIU. The policy was implemented to remove barriers to admission of patients with ATSCI so that they may access the most appropriate multidisciplinary care for their needs at the earliest time possible. The median admission time from injury to SIU was reduced by $>50\%$ from 1.53 days to 0.63 days in the cohorts admitted before and after implementing the policy. Factors other than the 'non-refusal' policy that may have influenced this change could only be influences external to POWH. The principal influence would have been the prehospital and interhospital transfer guidelines administered by the NSW Ministry of Health: Critical Care Tertiary Referral Networks & Transfer of Care (Adults) PD2010_021.[5] This publication embodies continuing and unchanged principles of care and transfer for ATSCI in NSW as had been used in previous years and represents only an administrative revision without substantive change to policy.[24,25] Therefore, the provision of acute ambulance transport by road and air for ATSCI was unchanging for the period of this study. Thus we feel that the policy of 'non-refusal' towards ATSCI at POWH is likely to have been a principal explanation for reduction in time to admission for such injuries.

Internal management guidelines for ATSCI at POWH may evolve over time and influence the reporting of complications before and after May 2009. However, data on complications before and after the date of implementation of the 'non-refusal' policy show that there is no change, except for a raw increase in the prevalence of deep venous thrombosis of nearly 10%. In 2001, we introduced new policies regarding detection and treatment of complications using a standard data dictionary of definitions to allow good quality data collection for the new electronic database that was set up at that time. These procedures were stable during the period of the study and we believe that changes in complication rates are likely to be real. This belief is supported by the overall unchanged prevalence of complications before and after 2009. With respect to the increased prevalence of deep venous thrombosis, we know from our comparative statistics and modelling that indirect admission (transfer from another hospital) is associated with higher prevalence of deep venous thrombosis (24.6% vs 9.9%), and it would seem that the efficiency of the 'non-refusal' policy in bringing patients in earlier from other hospitals also 'buys in' greater risk of deep venous thrombosis as it primarily applies to cases of indirect admission. It is possible that failure to adequately protect against deep venous thrombosis at the referring hospital may explain the higher prevalence subsequently found at POWH.

The prevalence rates of complications reported in our study are relatively high compared with other published figures. However, such comparison is difficult because of the varied conditions under which data are collected in different studies. The period of observation in some is acute phase only,[20,26] in others it is during rehabilitation only[21,22] or a mixture of cases.[9] In our hospital, the SIU rehabilitation physicians are involved in care from the time of admission in conjunction with surgeons, and hence data are collected from day 1 through to discharge to the community. This captures all time points of possible occurrence of deep venous thrombosis, pulmonary embolus and pneumonia during the acute phase of care. Then the extended stay owing to integrated rehabilitation captures late complications as well. Multiple occurrences of the same complication are separately recorded for each case in the SCID of NSW. In particular, our prevalence of deep venous thrombosis is 22%, but it is reported as <5% in three studies[7,21,26] but was 14.5% during acute hospital stay in another.[27] It is not clear what particular policies these other units have regarding detection of deep venous thrombosis, but our SIU has a policy of screening for deep venous thrombosis at 1 week after injury if the patient's admission has been delayed for ⩾24 h or was transferred from another hospital because of the uncertainty of adequate prophylaxis, which is the majority of cases. This means that many asymptomatic deep venous thrombosis are detected and treated. There is also a low threshold for performing pulmonary angiogram for possible pulmonary embolus, including unexplained fever. In our study, pulmonary embolus prevalence is 13%, but it is <5% in all the aforementioned studies.[7,21,26,27]

The prevalence rates of urinary tract infection and pneumonia in our study are 57% and 22%, respectively. Other reported rates vary, 9–47% for urinary tract infection and 3.5–25% for pneumonia.[7,20–22,25] For pressure areas, in our study prevalence is 51% and in the same quoted studies it varies from 3.4 to 36%. In our SIU, all grades of pressure area are rigorously recorded, including non-blanching erythema. This may relatively over record skin breakdown problems in comparison with the other studies. We also stress that our data are meticulously collected and cross-checked contemporaneously, and all complications are captured. Also, all admitted patients are included in the database, thereby avoiding selection bias.

We found a significant relationship between increased age and the following complications: pneumonia, deep vein thrombosis, pulmonary embolus, and the total number of complications. This effect seems plausible from a physiological perspective. It has been reported elsewhere that pneumonia is more common in the older person with ATSCI in the first year after injury[21] and during acute[20] and rehabilitation phases of care.[22] In one study, age was found to be associated with an increased risk of pulmonary embolus but not deep vein thrombosis.[27] In acute-phase care, the relative risk of any complication in the >65-year-old group was found to be 1.11.[7]

We have found that early (⩽24 h) or direct admission to our SIU is associated with fewer complications (particularly pressure areas) and shorter total LOS (acute plus rehabilitation phases of care) by about 5 weeks on an overall median stay of 21 weeks. It seems logical that fewer complications would be associated with shorter LOS. These findings suggest that early, specialised treatment has benefits for the individual with ATSCI and for the hospital system managing that injury. Since the Cochrane review published by Jones and Bagnall[9] in 2009, which did not find sufficient evidence to permit a statement on the value of SIUs, there has been other published evidence showing benefits of early care provided at specialist SIUs in terms of achieving a reduced prevalence of complications and shorter LOSs.[8,10,28] We feel that our study adds to this body of evidence. Therefore, we advocate for early and direct transport of ATSCI patients to a hospital with a specialised SIU in order to reduce the risk of complications and reduce total hospital stay (time from acute admission to discharge into the community). We also strongly support a policy of non-refusal at the hospital providing the spinal injury service so that time from referral to admission can be reduced.

Our study is an observational cohort study based on data collected rigorously and contemporaneously for all admissions of ATSCI to a single, specialised SCIU. The principal weakness of the study design in finding benefit in favour of specialised SCIU is in having no control arm of ATSCI patients admitted to non-specialised trauma units. Thus we are unable to make a direct comparison between specialised and non-specialised SCI care. However, our data does suggest that patients with ATSCI admitted earlier or directly to specialised care have fewer complications than otherwise.

Our study was conducted in NSW, Australia, where a uniform prehospital service and trauma hospital system are able to comply with centrally supported protocols. Whether the results of our study can be applied in regions without such uniform services is difficult to assess. However, we believe that bias in SCI referrals to our hospital is minimised by the centrally supported protocols and that recording of complication data in our unit is rigorous. The main source of bias is a potential difference in the nature of patients admitted before or after 24 h from injury, or directly from scene or indirectly from another hospital, in particular younger age for early or direct admissions. Our data suggest that such bias is not significant, and hence our results can be seen as reliable within the limitations of an observational cohort study. This kind of information is likely to be the best available in this field, as a properly controlled study would be impractical to perform.

CONCLUSIONS

For patients with ATSCI admitted to the POWH SIU, there were significantly different outcomes when comparing those admitted within the first 24 h after injury with those admitted later, or those admitted directly from the scene of injury with those admitted via another hospital. We found that there was a reduction in the prevalence of medical complications (particularly pressure areas) and shortening of total hospital LOS to discharge to the community for patients admitted early or directly to the SIU. A policy of 'non-refusal' for ATSCI removed administrative barriers to admission and significantly reduced time to admission for patients referred from another hospital.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

Dr RJM receives royalties from Stryker Spine, USA and Kasios Biomaterials, France. The other authors declare no conflict of interest.

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