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ORIGINAL ARTICLE

Several time indicators and Barthel index relationships at different spinal cord injury levels

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Study Design: Retrospective chart review.

Objectives: To compare different injury levels in spinal cord injury (SCI) patients with respect to operation intervention time (OIT), rehabilitation intervention time (RIT), average length of hospital stay (ALOS) and Barthel Index (BI) on admission and discharge.

Setting: China.

Methods: We retrospectively analyzed data from 95 SCI cases who received treatment in our rehabilitation center from 2010–2013.

Results: SCI resulted from high falls (55.79%), traffic accidents (28.42%), diseases (8.42%) and low falls (7.37%). We found no correlations between OIT, RIT, ALOS and discharge BI for all spinal segments ($P>0.05$). The OIT of thoracic SCI and lumbar SCI correlated negatively with RIT ($P<0.01$). The OIT of lumbar SCI correlated negatively with ALOS ($P<0.05$).

Conclusion: BI had no correlation with OIT, RIT or ALOS for all spinal segments; the OIT of thoracic and lumbar SCI correlated negatively with RIT; and the OIT of lumbar SCI correlated negatively with ALOS.

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INTRODUCTION

The incidence of spinal cord injury (SCI) is high, especially in developing countries, and in Western countries the incidence appears to be stable and shifting in cause from traumatic to nontraumatic. A higher number of people suffer SCI in Australia, especially older people suffering high falls; whereas in young people, SCI results more often from traffic accidents. Overall prevention strategies depend on the needs of the population and different mechanisms of injury.[1] In 2007, 179 312 SCI cases occurred worldwide, with 23 cases per million SCI patients resulting from trauma, and 40 cases per million SCI patients resulting from trauma in North America.[2] In developing countries, traffic accidents cause traumatic SCI most often in young patients, and falls from trees, balconies and roofs most often in older patients.[2] From 1998 to 2008, the annual incidence of SCI was 2.46/10 000 in Taiwan, with 61.2% because of trauma. The cervical SCI (CSCI) rate was 1.28/10 000, lumbar SCI (LSCI) 0.56/10 000 and thoracic SCI (TSCI) 0.30/10 000. Men were more likely than women to suffer SCI, with a ratio of 1.52:1, respectively, rural areas more commonly than urban and those with low income more often than in those with high income.[3] There are no large-scale epidemiological studies in mainland China, but despite a population of 1.3 billion and a rapidly growing economy, the number of SCI patients appears to be similar.

SCI therapy at American rehabilitation medicine centers cost US $785 per patient per day in the 1980s and reached $1125 in the 1990s.[4] Costs are expected to rise in the 21st century, potentially reaching £ 2169.4 in the UK. Shorter average length of hospital stay (ALOS) and improved patients' activities of daily life ability are key to reducing these costs and also key to reducing social and family burdens.

We retrospectively analyzed data from SCI cases to evaluate the relationships between operation intervention time (OIT), rehabilitation intervention time (RIT), ALOS and Barthel Index (BI) on admission (admission BI, ABI) and discharge (discharge BI, DBI).

MATERIALS AND METHODS

General information

This retrospective study was conducted at the Anhui Provincial Hospital and was approved by the Medical Ethics Committee of the hospital, authorization number: 2014018. We collected OIT, RIT, ALOS, ABI and DBI data for 95 SCI cases who received treatment in our Center from 2010 to 2013. To avoid interference and bias during the data collection process, both patients and staff were blinded to the purpose of the study. The results were verified three times by the staff to ensure no errors occurred during data collection.

Statistical analysis

We used SPSS 13.0 software (SPSS Inc., Chicago, IL, USA) to analyze the data. For ABI, DBI, OIT, RIT and ALOS, we used the independent samples *t*-test for normally-distributed data for between-group analysis and the bivariate correlation (Spearman) test to analyze correlations in each group. $P<0.05$ was considered statistically significant.

Statement of ethics

This retrospective study was conducted at the Anhui Provincial Hospital, and was approved by the Medical Ethics Committee of the hospital, authorization number: 2014018. We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

RESULTS

Baseline data

The patients included 77 males (81.05%) and 18 females (18.95%) with an average age of 39.76 years. There were 48 patients (50.49%)

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Table 1 Baseline data

	Age	*ALOS*	*OIT*	*RIT*	*ABI*
Male	40.44 ± 14.98	37.09 ± 28.40	15.38 ± 27.57	55.43 ± 81.04	22.96 ± 23.57
Female	36.83 ± 13.08	47.94 ± 35.15	10.11 ± 19.79	38.78 ± 31.96	26.39 ± 23.94
Total	39.76 ± 14.65	39.15 ± 29.90	14.38 ± 26.26	52.27 ± 74.41	23.62 ± 23.55

Abbreviations: ABI, admission Barthel index; ALOS, average length of hospital stay; OIT, operation intervention time; RIT, rehabilitation intervention time.

Table 2 Different SCI segments number ratio (*N*)

	Male	*Female*	*Total*
CSCI	43 (45.23%)	5 (5.26%)	48 (50.49%)
TSCI	15 (15.79%)	8 (8.43%)	23 (24.22%)
LSCI	19 (20.03%)	5 (5.26%)	24 (25.29%)
Total	77 (81.05%)	18 (18.95%)	95 (100%)

Abbreviations: CSCI, cervical spinal cord injury; LSCI, lumbar spinal cord injury; TSCI, thoracic spinal cord injury.

with CSCI, 23 (24.22%) with TSCI, and 24 (25.29%) with LSCI. We found no differences between males and females regarding ALOS, ABI, OIT, and RIT ($P > 0.05$, Tables 1 and 2). SCI resulted from high falls (55.79%), traffic accidents (28.42%), disease (8.42%), and low falls (7.37%) (Tables 1 and 2).

Comparison of OIT, RIT, ALOS, ABI and DBI for different spinal segments

We found no significant difference in ALOS, ABI and DBI for all spinal segments ($P > 0.05$); however, the OIT of CSCI was significantly longer than that for TSCI, and the RIT of CSCI was significantly longer than that for TSCI and LSCI ($P < 0.05$). We found no difference between TSCI and LSCI for RIT ($P > 0.05$, Table 3).

Correlation between DBI, OIT, RIT and ALOS for different spinal segments

We found no correlation between DBI, OIT, RIT and ALOS for all segments ($P > 0.05$); however, OIT correlated negatively with RIT in the TSCI and LSCI groups ($P = 0.00$, $r = 0.63$; $P = 0.00$, $r = 0.64$, respectively) and OIT for LSCI correlated negatively with ALOS ($P = 0.01$, $r = 0.52$; Table 3).

DISCUSSION

SCI is an important cause of disability and male patients are injured more often than females, likely because more males perform heavy labor, military operations, bridge and house construction and drive for a living. Approximately 180 000 new cases occur each year[5] and in developing countries, the incidence is 25.5 per million per year with males accounting for 82.8%, with an average age of 32.4 years. The two primary causes overall are traffic accidents and high falls, and the proportion of complete injury is higher than incomplete injury (56.5 vs 43.0%, respectively).[6] In developed countries, traffic accidents are the most common cause of SCI; however, in developing countries, high falls are the main cause. In the US state of Alabama, 31.5% of SCIs were caused by traffic accidents, 25.3% resulted from high falls and 10.4% resulted from gunshot wounds.[7] We found that high falls were the most common cause in our study, followed by traffic accidents, disease and low falls.

We found that the incidence was different in different spinal segments; the CSCI ratio was higher than for LSCI and TSCI. We also found that the proportion of males was higher than females, and the vast majority of patients were injured during falls at construction sites.

In the past 10 years in American SCI rehabilitation institutions, the ALOS was 26.2 ± 23.2 days with a downward trend: in 2002, ALOS was 29.7 ± 25.4 days and in 2009, ALOS was 22.9 ± 18.9 days. Seventy percent of SCI patients transferred from hospital to community for further rehabilitation.[8] Our study found that ALOS for all spinal segments was > 30 days, with unchanged BI despite increasing ALOS. Also, ALOS for CSCI was longer than that for TSCI and LSCI. The reason may be because of greater challenges for CSCI patients.

The majority of patients suffering SCI at work worry that their employer or insurance company will refuse to pay additional medical fees when they leave the hospital and transfer to other medical institutions. Because of unbalanced medical care, patients also worry about reduced level of care at other medical institutions; therefore, most do not wish to transfer for further rehabilitation, resulting in SCI patients concentrated in large hospitals, increasing the ALOS.

BI includes 10 items: eating, stool control, urine control, toileting, bathing, grooming, bed-to-chair shifting, climbing and descending stairs, dressing and walking, and for SCI patients, improvement in any item is significant. We found that after active rehabilitation, although the BI change was not statistically significant, but DBI was higher than ABI. In Italy, Franceschini *et al.*[9] followed 251 SCI cases over 6 years and found that patients who were able to work and drive were younger, and their quality of life was higher. Being able to work and having intact relationships correlates positively with quality of life. For most SCI patients, good chronic disease self-management and low-intensity wheelchair operating skills improves their quality of life and health, and also improves their ability to participate in society.[10] OIT and RIT also affect patients' activities of daily life ability, and SCI patients treated surgically scored higher in sensation and motor scores than did nonsurgical patients.[11] Large numbers of SCI patients also have other injuries, such as traumatic brain injury, other fractures, chest trauma and splenic rupture. Early after injury, patients' conditions remain critical and unstable, especially in CSCI patients, making them poor surgical candidates and increasing RIT.

The presence of additional injuries is related to the SCI level, with compound injury patients' function being much worse than for solely traumatic SCI patients, also increasing the ALOS.[12] In our study, we found that the CSCI patients' OIT was longer than that for TSCI and LSCI patients and the CSCI patients' RIT was longer than that for TSCI and LSCI patients. Both the spinal cord and other body parts are injured during trauma and appropriate treatment of these injuries requires time. The ratio of CSCI patients with other injuries was much higher than for other segments; therefore, the OIT and RIT were higher than for TSCI and LSCI patients.

If the patient's condition allows, early surgical treatment shortens ALOS and RIT; however, these are increased for older SCI patients, with ALOS showing an upward trend.[13] Older SCI patients, most with SCI resulting from high falls, have relatively poor function and require more time in hospital rehabilitation;[14] however, there is reportedly no

Table 3 The comparison of OIT, RIT, ALOS, ABI, DBI and the correlation ship in different segments

	OIT	*RIT*	*ALOS*	*ABI*	*DBI*
CSCI	22.14 ± 37.65*	70.00 ± 96.52	42.37 ± 35.11	24.70 ± 29.05	52.76 ± 31.84
TSCI	12.48 ± 19.52$^{**,\sharp}$	38.43 ± 34.20$^{\Delta}$	36.57 ± 19.56	19.35 ± 14.01	56.30 ± 13.92
LSCI	5.74 ± 9.6$^{\sharp\sharp}$	34.35 ± 35.91$^{\Delta\Delta}$	34.87 ± 26.40$^{※}$	18.13 ± 21.81	67.08 ± 22.31

Abbreviations: ABI, admission Barthel index; ALOS, average length of hospital stay; DBI, discharge Barthel index; OIT, operation intervention; RIT, rehabilitation intervention time.
Note: $*P=0.008$, $**P=0.036$; $^{\Delta}P=0.009$, $^{\Delta\Delta}P=0.011$, $^{\sharp}P=0.00$, $r=0.63$; $^{\sharp\sharp}P=0.00$, $r=0.64$; $^{※}P=0.01$, $r=0.52$.

relationship between age and function.[15] Increased ALOS did not increase the activities of daily life ability, although a large study by Hammond *et al.*[16] found that when ALOS increased, the patients' chance of returning to the intensive care unit also increased. Our study found that OIT correlated negatively with RIT, and the longer the OIT, the shorter the ALOS. Dijkers and Zanca[17] found that ALOS was related to the level of injury and the complications. There are many confounding factors affecting ALOS, including the patient's psychological condition, the construction of rehabilitation hospital networks, medical expenses and others. There are also many factors affecting the ALOS and BI for SCI patients, including economic status, psychological status and whether the SCI is accompanied by other injuries. Because our original clinical data did not include all available information for the SCI patients, we collected only the ALOS, OIT, RIT, ABI and DBI.

There are two main categories of spinal cord injury, traumatic and nontraumatic, including infection, tumor, syringomyelia, spinal cord ischemia and hemorrhage. In future, we plan to systematically analyze data from traumatic and nontraumatic SCI patients, looking for more reasons for differences in BI and ALOS. Larger patient numbers from more centers in China are needed for these studies.

In conclusion, BI improved after systemic treatment for SCI patients. We found no correlation between OIT, RIT, ALOS and BI for all spinal segments; the OIT of LSCI patients was shorter than for CSCI and TSCI patients and the RIT for TSCI and LSCI patients was shorter than for CSCI patients. The longer the RIT, the longer the OIT and the shorter the ALOS, for LSCI patients.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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1 Mitchell RJ, Stanford R, McVeigh C, Bell D, Close JC. Incidence, circumstances, treatment and outcome of high-level cervical spinal fracture without associated spinal cord injury in New South Wales, Australia over a 12 year period. *Injury* 2014; **45**: 217–222.
2 Lee BB, Cripps RA, Fitzharris M, Wing PC. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. *Spinal Cord* 2013; **52**: 110–116.
3 Wu JC, Chen YC, Liu L, Chen TJ, Huang WC, Cheng H *et al.* Effects of age, gender, and socio-economic status on the incidence of spinal cord injury: an assessment using the eleven-year comprehensive nationwide database of Taiwan. *J Neurotrauma* 2012; **29**: 889–897.
4 Kane T, Capen DA, Waters R, Zigler JE, Adkins R. Spinal cord injury from civilian gunshot wounds: the Rancho experience 1980–88. *J Spinal Disord* 1991; **4**: 306–311.
5 Sledge J, Graham WA, Westmoreland S, Sejdic E, Miller A, Hoggatt A *et al.* Spinal cord injury models in non human primates: are lesions created by sharp instruments relevant to human injuries? *Med Hypotheses* 2013; **81**: 747–748.
6 Rahimi-Movaghar V, Sayyah MK, Akbari H, Khorramirouz R, Rasouli MR, Moradi-Lakeh M *et al.* Epidemiology of traumatic spinal cord injury in developing countries: a systematic review. *Neuroepidemiology* 2013; **41**: 65–85.
7 Fengbin Y, Deyu C, Xinwei W, Yu C, Jinhao M, Xinyuan L *et al.* Trauma-induced spinal cord injury in cervical spondylotic myelopathy with or without lower cervical instability. *J Clin Neurosci* 2013; **20**: 419–422.
8 Granger CV, Karmarkar AM, Graham JE, Deutsch A, Niewczyk P, Divita MA *et al.* The uniform data system for medical rehabilitation: report of patients with traumatic spinal cord injury discharged from rehabilitation programs in 2002–2010. *Am J Phys Med Rehabil* 2012; **91**: 289–299.
9 Franceschini M, Di Clemente B, Rampello A, Nora M, Spizzichino L. Longitudinal outcome 6 years after spinal cord injury. *Spinal Cord* 2003; **41**: 280–285.
10 van der Woude LH, de Groot S, Postema K, Bussmann JB, Janssen TW, Allrisc *et al.* Active LifestyLe Rehabilitation interventions in aging spinal cord injury (ALLRISC): a multicentre research program. *Disabil Rehabil* 2013; **35**: 1097–1103.
11 Zhang PX, Xue F, Wang J, Zhang HB, Xu HL, Jiang BG. [The prospective study project of 62 cases spinal cord injury]. *Zhonghua Wai Ke Za Zhi* 2009; **47**: 461–464.
12 Scivoletto G, Farchi S, Laurenza L, Tamburella F, Molinari M. Impact of multiple injuries on functional and neurological outcomes of patients with spinal cord injury. *Scand J Trauma Resusc Emerg Med* 2013; **21**: 42.
13 Krause JS, Cao Y, Bozard JL. Changes in hospitalization, physician visits, and self-reported fitness after spinal cord injury: a cross-sequential analysis of age, years since injury, and age at injury onset. *Arch Phys Med Rehabil* 2013; **94**: 32–37.
14 Hsieh CH, DeJong G, Groah S, Ballard PH, Horn SD, Tian W. Comparing rehabilitation services and outcomes between older and younger people with spinal cord injury. *Arch Phys Med Rehabil* 2013; **94**: 175–186.
15 Furlan JC, Hitzig SL, Craven BC. The influence of age on functional recovery of adults with spinal cord injury or disease after inpatient rehabilitative care: a pilot study. *Aging Clin Exp Res* 2013; **25**: 463–471.
16 Hammond FM, Horn SD, Smout RJ, Chen D, DeJong G, Scelza W *et al.* Acute rehospitalizations during inpatient rehabilitation for spinal cord injury. *Arch Phys Med Rehabil* 2013; **94**: 98–105.
17 Dijkers MP, Zanca JM. Factors complicating treatment sessions in spinal cord injury rehabilitation: nature, frequency, and consequences. *Arch Phys Med Rehabil* 2013; **94**: 115–124.