Pretest of the clinical application of a management model for comprehensive treatments of acute spinal cord injury

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Abstract: Objective: To explore the effects of a new management model of comprehensive treatments of acute spinal cord injury (SCI) on clinical application. Methods: From January 2010 to January 2011, there were 89 patients with acute SCI over the same admission period, including 32 cases divided into the management model group and the other 57 into the control group. Respectively, at the 1, 3 and 6 months after treatment, the score standardization, developed by the American Association of spinal cord injury (ASIA), was used to assess the motor and sensory function during the admission period. At the same time, a follow-up survey was made to investigate the satisfaction of patients and their families. Results: At 1 and 3 months after treatment, the motor and feeling function scores of patients in the experimental group both improved significantly compared with the control group, and the differences were statistically significant (P<0.05). In addition, six months after treatment, the motor and sensory function scores of patients in the control group were not significantly improved any longer; while those scores in the experimental group still significantly recovered, and the difference between experimental and control groups was also statistically significant (P<0.05). According to the follow-up, patients and their families in the experimental group were of greater satisfaction than the control group (P<0.05). Conclusions: The management model of acute SCI treatment performed perfect clinical effects, and was worth promoting.

Keywords: SCI, comprehensive treatment, management

Introduction

The spinal cord, as a portion of the central nervous system (CNS), is the low-level center which is dominant for limb movement, sensation and visceral activities. It is the key structure linking to higher nervous center and peripheral nervous system, which has dense nerve conduction bundle up and down stream [1]. Therefore, even partial damage may also bring about serious consequences. Incomplete quadriplegia is the most frequent neurologic category of SCI (30.1%), followed by complete paraplegia (25.6%), complete quadriplegia (20.4%), and incomplete paraplegia (18.5%). The paralyzed parts lose sensory function, or are accompanied by pain, motor and autonomic symptoms such as enhanced reflection [2]. Every year, an estimated 12,000 Americans sustain and survive a SCI. Approximately 259,000 Americans currently live with a SCI [3]. SCI is traditionally thought to mainly affect young males, but currently the age of SCI patients is increasing, with an average age of 40.2 years. Of the injuries reported since the year 2005, most have occurred in males and Caucasians (80.9% and 66.1%, respectively) [4]. The non-renewable character of SCI takes life-long injuries into patients [5]. SCI also brings heavy economic burden to society and families. According to the statistics in America, the average cost of paralyzed patients for lifetime treatments is about $1000000 [6]. With regard to SCI, many scientific studies have been carried out, but found no recognized, effective treatment methods. How to treat SCI effectively has been a hotspot and difficult problem. SCI mainly contains primary injury and secondary injury, and the dysfunction is mainly caused by uplink and downlink nerve fiber conduction interruption. Current research-
Table 1. Clinical data of 89 patients with SCI

<table>
<thead>
<tr>
<th>Groups</th>
<th>Gender</th>
<th>The average age</th>
<th>Hospitalized time after injury (h)</th>
<th>Site of injury</th>
<th>Motor function scores</th>
<th>Sensory function scores</th>
<th>Surgical cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Cervical vertebrae</td>
<td>Thoracic vertebrae</td>
<td>Lumbar vertebrae</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental</td>
<td>20</td>
<td>12</td>
<td>39.8±10.1</td>
<td>4.6±2.6</td>
<td>7</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Control</td>
<td>38</td>
<td>19</td>
<td>40.4±10.5</td>
<td>5.3±2.5</td>
<td>16</td>
<td>28</td>
<td>13</td>
</tr>
</tbody>
</table>

Note: Patients in each group, in terms of age, course of disease, and degree of injury, were comparable through statistical tests (P>0.05).
es focus on how to prevent and reduce secondary injury of SCI, and how to restore the spinal cord nerve fiber connection up and down [7].

In the 1990s, the refinement of spinal stabilization led to changes in the management of acute spinal trauma. Research efforts in the search for a pharmacologic intervention to limit secondary injury are ongoing [8].

While, great care must be taken when providing medical care to an acutely injured patient prior to arrival at hospital. About 2% of all blunt trauma patients suffer a SCI, and the rate is higher in the setting of severe closed head injury. Patients with acute SCI are at risk of neurologic deterioration due to secondary injury to the spinal cord. A potential cause of secondary injury is the inadvertent manipulation of the spinal cord in the setting of an unstable spinal column injury. Minimizing the chances of secondary injury can be challenging in the pre-hospital setting due to the local and transport environment, a lack of resources, and heterogeneity in health care providers and their skill sets. Furthermore, treatments initiated prior to arrival in the hospital can lead to significant morbidity in other body regions, such as sacral and occipital ulcers. There is tremendous variation in how care is administered prior to arrival at the hospital and during transport from one hospital to another. Some care models and treatments may provide patients with improved safety and reduced morbidity, and thus improve efficiency of care delivery. These variations of practice serve as the impetus to perform a systematic review, in conjunction with a series of other systematic reviews related to SCI care. The purpose of this study was to provide evidence-based guidelines agreed upon by a multidisciplinary expert panel to identify optimal care in key areas in the pre-hospital setting for patients with potential SCI [9].

The acute management of SCI requires a multidisciplinary and multisystem approach. Appropriate treatment begins in the field with immobilization of the spine by emergency response personnel. Spinal precautions, including external immobilization and log rolling, are then used to prevent further SCI, especially in the unstable spine. The initial hospital evaluation of the SCI patients should include diagnosis and treatment of the spinal pathology as well as any other acute or life-threatening injuries. Medical management is of utmost importance during the acute post injury period [10].

SCI patients admitted often need to take emergency spine CT three-dimensional reconstruction and spinal MRI to identify injuries [11]. Some patients need emergency canal decompression fixation [12] combined with autologous bone marrow mesenchymal stem cell transplantation, which provides a new way for the rehabilitation of neurological function [13]. SCI patients with acute onset and severe illness, are difficult to have surgery, and have complicated treatment procedures, long cycle of rehabilitation. As involved in more than 10 sections like spinal neurosurgery, the operating room, the stem cell laboratory, the department of rehabilitation, it is essential to establish a standardized management model of comprehensive treatment of acute SCI [14]. Our department, based on the experience in the treatment of acute SCI in recent years, has developed a type of management model of comprehensive treatment of acute SCI, which has been clinically implemented on 32 cases from January 2010 to January 2011, and got good effects. Now we will report it as follows.

Materials and methods

Materials

Thirty-two patients with acute SCI in our department from January 2010 to January 2011 got the access to the comprehensive treatment management model. The other 57 cases admitted in our department at the same time with the former ones were obtained as controls. Clinical information of patients in the two groups, such as age, gender, site of injury, injury severity, and treatment, showed no significant difference and was summarized in Table 1.

Methods

The treatment of the experimental group and control group

The control group got only the general treatment. Neck-collar-brake should be taken if cervical SCI suspected to prevent secondary damage during the process of transfer. Then the patients were checked with CT and nuclear magnetic resonance scanning and a further therapy plan for patients was drawn up. The data including age, cause of disease, the
Management model of comprehensive treatment of acute spinal cord injury

injured segments, neurological status, the necessity of surgical, the methods of surgical, whether agree with autologous bone marrow stem cell transplantation, complication, and so on were evaluated. After the examination, the surgery was taken and then the guardianship was performed. The experimental group underwent the management model of comprehensive treatments of acute SCI. The procedure of this method was shown in Figure 1.

**Features of treatment management**

**First aid green channel:** A green channel was open after 120 telephone calls. At first aid scene, if cervical SCI suspected, a instantly cervical collar brake protection must be given to the patients based on their symptoms. Gentle movement was needed to protect the neck marrow and avoid secondary injury [15]. During transfer, car video intercom system was used for the emergency neurosurgeons to observe the condition, give symptomatic treatment in time, and therefore inform the spinal nerve surgeon, CT room and MRI room at the same time. Patients, as soon as they arrived at the hospital, must be immediately given cervical CT and MRI scans to determine the specific injury, and decide the following treatment plan [16].

**Multidisciplinary involvement:** With vertebral fracture, the SCI patients should immediately start the management model and be ware-housed. The involved departments included the departments of the spine neurosurgery, stem cells laboratory, orthopedics, imaging, clinical laboratory, operating room, rehabilitation, psychological counseling division, information section and others relevant. All the members of the management team participated in the case discussion, analysis and evaluation of the follow information: age, gender, cause of injury, the injured segment, injury severity score [17], pre-hospital treatment, neurological function status when admitted and whether emergency surgery was needed, modus operandi, agreement for the stem cell transplantation, risks of the postoperative complications, patients and their families’ aware-
ness level of the disease, expectations of the prognosis, the mental state of the patients [18], status of the family support system and so on, to make an objectively evaluation and record it. Then an individualized emergency treatment plan and a long-term treatment plan were developed for each patient. We must start a multidisciplinary cooperation actively and open a multidisciplinary green channel to gain time for the following treatments. Warehousing patients were clearly marked in department management computers through the information processing system, prompting the department to focus on them and designate special messenger for management, and they have their own plans of handling flowsheet to ensure safety.

Benchmarking the flow of hospital transferring: Patients admitted into the emergency department may need the spine CT and MRI, operation, and entering ICU, transferring out to the ward when stable. To reduce cardiopulmonary arrest, secondary injury and other risks on the way of transfer, we had standardized the transfer process. The process was like this: assessment—processing—appointment—escorting. Before transferring, certain parameters were carefully evaluated, including the patient’s breathing, blood pressure, heart rate, transcutaneous oxygen saturation, drainage tubes, dressing fixed, symptoms of neurological function, sputum in respiratory tract [19]. If indicators above were normal, we should assist patients to wear cervical collar and connect to the spare oxygen device. Besides, we should carry the first aid kit for transfer, make an appointment in advance with the inspection department and the targeted department, and provide various services such as priority check and priority reception. Patients were escorted by primary nurses and the physicians in charge and the strict handover processes were adopted to assure the transfer safety, reduce the risk in the transport process, and avoid accidents.

Psychological adjustment: Patients with SCI are mostly young adults, who are pillars of the society and families. In addition, SCI often occurs suddenly with different degrees of neurological dysfunction, and severely affects eating, sleeping and others. Besides, spine surgery would make a big trauma because of its special position. Patients always have great hope for treatments as well as misgivings and fear. With mental stress and lack of confidence in the prognosis, they may undergo restless, negative and pessimistic mood. Aiming directly at different psychological characteristics, patients were given early intervention, assessments of anxiety states and follow-up by psychologists in the hospital [20]. Beside, psychological intervention based on the assessment results and psychological decompression combined with nurses of the treatment management team, such as the introduction of disease-related knowledge, announcements needed in peroperative period, surgical approaches, successful surgical cases and so on, were also provided for the patients. We should seriously answer the questions raised by patients to eliminate their doubts and fears and enhance their treatment confidence [21].

Primming self-efficacy management: The self-efficacy management takes full use of the patient’s knowledge and experience to educe their subjective motility to improve their compliance with treatment. Sometimes patients are more aware of their condition, so they can not only accept treatments and cares, but also act as the decision-makers and participants of the treatments, which can greatly increase their self-confidence and initiative. Practising self-management is based on health education, such as oral mission, literal picture, hospital network video. The contents include disease signs and symptoms, causes, drug effects, announcements, positive impacts on prognosis of self-efficacy management [22].

Statistical analysis

All data were presented with median ± SD and the statistical analysis was conducted with SPSS 13.0 software. The differences of neuro-

<table>
<thead>
<tr>
<th>Groups</th>
<th>Before treatment</th>
<th>1 month after treatment</th>
<th>3 month after treatment</th>
<th>6 month after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>The experimental group</td>
<td>Motor scores</td>
<td>38.6±13.8 a</td>
<td>57.4±17.7 a</td>
<td>63.8±23.6 a</td>
</tr>
<tr>
<td>The control group</td>
<td>Sensory scores</td>
<td>92.4±30.5</td>
<td>129.4±34.4 a</td>
<td>141.9±41.6 a</td>
</tr>
</tbody>
</table>

Note: compared with the control group, P<0.05.
logical scoring between experimental group and control group were analyzed by One-way ANOVA analysis. The difference was considered to be significant when \( P < 0.05 \).

**Results**

The difference of neurological function scoring between the experimental group and control group

As shown in Table 2 and Figure 2, the score of experimental group was better than the control group overall. Moreover, as the extension of time after comprehensive treatment of acute SCI, the motor scores and sensory scores were both higher and higher. And the range of this increase was far larger for sensory scores compared with motor scores both in two groups. Besides, the motor scores and sensory scores both changed more obviously in experimental group than in control group. This indicated that it was effective to manage the comprehensive treatment of acute SCI, and can obviously improve the prognosis of patients.

**The satisfaction survey of two treatment methods**

To analyze the popularity degree of the general treatment and the management model of comprehensive treatment of acute SCI, we conducted a satisfaction survey. The result demonstrated that the management model of comprehensive treatment of acute SCI was more popular among the patients and their families than the general treatment (Table 3). Based on this survey, the management model of comprehensive treatment of acute SCI was superior to the traditional treatment and might be worth clinical promotion vigorously.

**Discussion**

The management model can improve the treatment effect of SCI

Acute SCI is a common severe trauma of neurosurgery with the general national incidence of approximately 20~40/10^6, which is much higher in our country. The pathological mechanisms of SCI are serious and widespread spinal cord contusion, edema, hemorrhage, accompanied by the release of large numbers of inflammatory cytokines and immune factors [23]. Mechanical forces at the primary site of injury directly shear the cell membrane of nerve cells and endothelial cells. Hemorrhagic necrosis firstly formed at the gray matter regions is soft and rich in blood vessels. However, uneven movement of injury organization can also lead to hemorrhage at the central area of the spinal cord, and the shear damage of nerve cell membranes and connective tissue [24]. With the continuous spinal cord compression, specific molecular and cellular mechanisms will occur and further evolve to secondary injury which can lead to nerve cell necrosis, apoptosis eventually. Therefore patients will get severe neurological dysfunction. During the early stage of SCI, it manifests as a gradually worsened pathophysiological process. Therefore, it is essential to get the timely and effective treatments, which will critically affect the degree of neurological rehabilitation. The management model can significantly save time for effective treatments. A green channel will open after the 120 telephone calls. At first aid scene, if cervi-
cal SCI suspected, we must immediately give the patients a cervical collar brake protection based on their symptom signs. Gentle movement is needed to protect the neck marrow, and to avoid secondary injury. During transferring, the emergency neurosurgeons use the car video intercom system to communicate with others and observe the condition as well as give symptomatic treatment in time, and at the same time inform the spinal nerve surgeon, CT room and MRI room. Patients are given cervical CT and MRI scans to determine the specific injury and decide the following treatment plans as soon as they arrive at the hospital. It can greatly shorten the time spent on admission, examination, treatments, and provide a guarantee to maximize the recovery.

The management model uses multidisciplinary participation, synthesis of various treatment factors and integration of the best medical resources of the hospital to form a concerted effort to provide a safest and most effective treatment option. As for vertebral fracture, the involved departments include the spine neurosurgery, stem cells laboratory, orthopedics, imaging, clinical laboratory, operating room, rehabilitation, psychological counseling division, information section, and others relevant. An objective evaluation of the following parameters: age, gender, cause of injury, the injured segment, injury severity score, treatments before admission, neurological functional status at admission and need for emergency surgery, modus operandi, agreement for the stem cell transplantation, risks of the postoperative complications, patients and their families’ awareness level of the disease, expectations of the prognosis, the mental state of the patients, situation of the family support system is and so forth, is performed and recorded by all members of the management team participate through the case discussion and analysis. Then we develop an individualized emergency treatment plan and a long-term treatment plan for each patient to make them achieve the best situation as possible as they can.

If inappropriate measures are taken in first aid, handling or even the treatment process, SCI may be aggravated, which is called secondary injury and even several times more severe than the primary one, bringing patients more serious consequences, and further aggravating the burden on families and society. In an earlier literature of five-year’s review of SCIs in Beijing, 70 cases (22.6%) of 310 patients, were recorded as secondary injury. Our management model emphasized the specification of transfer process at all aspects, from the emergency scene to check after admission, avoiding secondary injury to the maximum extent. Patients admitted into the emergency department need the spine CT and MRI, operation, entering ICU and transferred to the ward when stable. The transferring process has been standardized in order to reduce secondary injury, cardiopulmonary arrest and other risks for transferring. With convoy of primary nurses and the physicians in charge and strict handover process, we can transfer the patients safely with reduced risks and therefore better prevent the accidents.

Most SCI patients are young adults, and the injuries mostly occur suddenly and lead to a severe condition. Patients hope a lot for the treatments, however, there is still misgiving and fear among them. A negative mood with restlessness and pessimism could happen to the patients because of the mental stress and lack of confidence in prognosis. In allusion to different psychological characteristics, psychologists offer the patients early intervention, anxiety states assessment and follow-up assessment in the hospital, then psychological intervention based on the assessment results, psychological decompression combined with nurses of the treatment management team, such as the introduction of disease-related knowledge, announcements needed in peroperative period, surgical approach, successful surgical cases and so on. Questions raised by the patients should be answered seriously so that they are of great treatment confidence with fewer doubts and fears. Studies have demonstrated that self-efficacy management can improve the health status of patients with chronic disease. By taking full use of the patient’s knowledge and experience and educating patient’s subjective motility, we can improve their compliance with treatment. Thus they can no longer just accept treatment and care, but act as the decision-makers and participants of the treatment, which can greatly increase their self-confidence and initiative. The self-management is conducted on the basis of health education, such as oral mission, literal picture, hospital network video and so on. Besides, its contents consist of various aspects, including disease signs and symptoms, causes, drug
Management model of comprehensive treatment of acute spinal cord injury’s effects, announcements, positive impacts on its prognosis.

The management model of comprehensive treatment of acute SCI can improve the satisfaction of patients and their families.

This management model can significantly save the examinational time and provide effective treatments for patients. Our management model which combines a variety of therapeutic factors and integrates the best medical resources perfectly provides the safest and most effective treatment options for patients with acute SCI, and forms individualized plans for emergency treatments and long-term treatments to make patients rehabilitate with the greatest degree. The management model emphasizes standardizing hospital transferring process to avoid secondary injury in SCI and provide the possibility of rehabilitation to the maximum extent. It even highlights the role of psychological adjustment and self-efficacy management. In short, with all the patients-centered procedures, the sake of patients’ recovery, and experience of the whole process, the relationship between medical staff and the patients is much closer, greatly improving the treatment satisfaction of patients and their families.

Disclosure of conflict of interest
None.

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References
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