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Original Article

Different preoperative approaches for acute lumber spinal fractures

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Abstract: To compare the long and short term effectiveness of different preoperative approaches for lumber spinal fractures and finds a better surgical method for the disease. Follow up records of 144 patients received hyperbaric oxygen therapy or methylprednisolone infusion within 8 hours after the lubmer spinal injury were analyzed. Postoperative outcome immediately and 3, 6, 12, 36 months after the surgery were compared to evaluate the effectiveness two different approaches. The results indicated that there are no significant differences regarding age, sexual proportion, body mass index (BMI), visual analogue scale of pain (VAS) score as well as Frankel scores before the surgery, and significant differences VAS score as well as Frankel scores immediately after the surgery. In conclusion, hyperbaric oxygen therapy within 8 hours after the injury can be more effective than methylprednisolone infusion in patients with lumber spinal injury.

Keywords: Lumber spinal injury, hyperbaric oxygen therapy, methylprednisolone

Introduction

Experimental studies and clinical observations showed that spinal cord lesions are greatly enlarged by secondary injury [1]. In human disease or damage to the spinal cord, the greatest neurological loss is initially and the deficit may improve with time. The pathological picture is the reverse. Even in the face of improved neurological function, the gross pathological picture shows evolution or progression for 5-7 days from central to peripheral microscopic and gross pathological involvement [2]. Anatomical [3], bio-chemical [4, 5] and physiological [6] studies have been demonstrated that spinal cord microvascular potency and blood flow decrease (namely ischemia) just after severe contusion or compression injury. Available evidence suggested that oxygen radical formation and cell membrane lipid peroxidation have important roles in progressing secondary injury [7, 8].

Wound healing is a complex process involving inflammatory proliferative and remodeling phase. Molecular oxygen is one of the critical nutrients of the wound, and it plays a central role in the reparative process [9, 10]. This requirement for oxygen in wound healing is the rationale for hyperbaric oxygen (HBO) therapy. It results in an increase in tissue oxygen tension and improves collagen synthesis, angiogenesis, epithelization and resistance to bacteria in problem wounds [11, 12].

Materials and methods

Subjects

All the patients used continuous epidural anesthesia. Bend hip and knee to the operating table, put the abdomen on overhanging position as much as possible. Choose the posterior median line of lumber vertebrae, use tomographic photo of C arm to localize the articular process of the surgery. Decide the surgical incision according to the position of free intervertebral disk after precise localization. In both groups, a 3-6cm incision was taken at posterior median incision site, following by blunt dissection of spinous process. Laminectomy tractor was used to expose the vertebral plate interval. Transection, minimal incisional fenestration laminectomy or traditional laminectomy was

Table 1. Basic characteristics of patients in two groups

	Hyperbaric oxygen (n=66)	Methylprednisolone (n=78)	*P*
Age	34.1±5.3	33.6±6.1	0.32
Female (%)	21 (31.8)	25 (32.1)	0.21
BMI	27.4	27.6	0.15
VAS	6.9	6.7	0.36
ODI	15.4	15.7	0.81
Frankel score	2.1	2.0	0.27

Table 2. Comparison of time of surgery total blood loss ODI and VAS scores between two groups

		Methylprednisolone (n=78)	Hyperbaric oxygen (n=66)	*P*
Time of surgery		120.6±20.1	45.2±6.4	<0.01
Total blood loss		500.7±150.4	150.4±13.5	<0.01
Stay in the hospital		12.1±3.1	5.4±1.7	0.02
ODI index	Post op	14.2	10.4	0.04
	3 months	3.8	3.4	0..7
	6 months	3.1	3.2	0.14
	12 months	2.5	2.6	0.21
	36 months	2.4	2.7	0.17
VAS scores	Post op	5.8	4.1	0.05
	3 months	1.5	1.6	0.37
	6 months	1.4	1.2	0.62
	12 months	1.2	0.8	0.34
	36 months	0.7	0.7	0.51

performed on both sides of the vertebral plate. Drains were placed after complete hemostasis and washing.

Frankel scoring

Frankel score grading: patients were graded for four grades according to the pain, numbness, mobility of the lower limbs and functionality of the sphincter.

Frankel grade 0: with complete numbness and loss of mobility; Frankel grade 1: with hypoesthesia of the lower limbs, has muscle strength of 0-2 degrees and with significant functional disability of sphincter; Frankel grade 2: with have significant loss of sensation, muscle strength of 3 degrees, functional disability of sphincter; Frankel grade 3: with slight loss of sensation, muscle strength of 4-5 degrees, have no functional disability of sphincter; Frankel grade 4: with normal pain, sensation, mobility as well as function of sphincter.

Outcome identification

The clinical outcomes identification was performed according to Nakano N standard 1: *Excellent:* have no pain and numbness, normal sphincter function, have no difficulty in normal life and work. *Fine:* no pain and numbness, significant recovery of sphincter function, and basically normal life and work. *OK:* significant release of pain and numbness, partial recovery of sphincter and lower limb function, still difficulty in walking and gait abnormality, and taking care of oneself. *Worse:* symptoms not changed even worsened as compared to pre-operation.

Statistical analysis

All of the data are treated with SPSS 19.0. Measurement data was using mean $x \pm s$. *t* test was used to compare the characteristics of patients in two groups. X^2 test was used to compare the clinical results, ODI scores and VAS scores of patients. $P<0.05$ stands for the significance difference.

Results

Basic characteristics of patients

Clinical manifestations: among 154 patients, 86 were male, 58 were female, has an average age of 34 (16-45), 122 patients complained of severe back pain, 78 reported pain on a lower limb, 46 reported pain on both lower limbs. 96 reported numbness in saddle area, 16 reported functional disability of sphincter, decrease in sensation and muscle strength of both lower limbs in 74 patients, decrease in sensation and muscle strength of one lower limb in 28 patients.

Tomographic examination showed obvious hernia of intervertebral disk in all 144 patients,

Table 3. Clinical results of patients in two group

	Evaluation after surgery				
	Excellent	Fine	OK	Unsatisfactory	*P*
Methylprednisolone (n=78)	54	16	8	7	>0.05
Hyperbaric oxygen (n=66)	60	21	12	8	

including hernia of L4-5 disk in 7 patients, L4-5 in 52 patients, L_5S_1 in 85 patients. Central type in 121 patients and partial central type in 33 patients. Sixty-six patients underwent hyperbaric oxygen therapy and 78 underwent methylprednisolone infusion within 8 hours after the surgery. There is no significant difference between two groups regarding age, sexual proportion and body mass index (BMI) (**Table 1**). Among all the patients, there are 5 patients of Frankel grade 0, 97 patients with Frankel grade 1-2, 57 patients with Frankel grade 3-4. There is also no significant difference between two groups regarding visual analogue scale of pain (VAS) and Frankel scores (**Table 1**).

Assessment of VAS, Frankel scores and ODI scores

There are significant differences between the two groups regarding time of surgery, total blood loss during the surgery, total time for stay in the hospital (**Table 2**, $P<0.05$). Significant differences were demonstrated regarding VAS score, ODI scores immediately after the surgery (**Table 2**, $P<0.05$). However, there were no significant differences for the VAS scores and ODI scores at 3, 6, 12, 36 months postoperatively (**Table 2**, $P>0.05$).

Clinical outcomes

According to the Nakano N evaluation system, after the surgery, we found that 54 patients gained excellent in methylprednisolone group, and 60 patients in hyperbaric oxygen group (**Table 3**). There were 16 patients gained fine in methylprednisolone group, and 21 patients in hyperbaric oxygen group (**Table 3**). The statistical analysis results indicated that there were no significant differences between the two groups for the clinical outcomes (**Table 3**, $P>0.05$).

Discussion

Traumatic injuries to the spinal cord cause tissue damage through both primary and secondary mechanisms [13]. Primary damage results in mechanical damage to neuronal and vascular tissue. Secondary damage due to disruption of cell membranes [14] and alterations in both spinal cord blood flow and metabolism exacerbate the effects of initial mechanical trauma. Neurological dysfunction results more often from secondary changes than from primary neuronal damage [15]. Although there is no medical or surgical treatment for primary damage, it seems theoretically possible to uncover the mechanisms of secondary changes, and prevent them from taking place.

The central nervous system consists largely of lipids and is damaged easily by free-radical-induced lipid peroxidation [16]. Membrane lipid changes contribute significantly to the secondary injury process and free radicals induced lipid peroxidation and also are considered important in the second auto-destruction of the injured spinal cord. The ultimate outcome of this process would be tissue necrosis and loss of function.

Hyperbaric oxygen (HBO) therapy is delivered by a procedure in which 100% pure oxygen is administered at greater than atmospheric pressure. HBO therapy chambers were developed at the turn of the 19th century for the purpose of administering HBO to caisson workers and deep-sea divers with decompression sickness. Treatment is administered within a monoplace chamber that houses 1 patient placed in the supine position, or it may be given in a multiplace chamber that accommodates 2 or more patients. The procedure is safe and is associated with few adverse effects. Central nervous system and pulmonary toxic effects are rare but include seizures, visual changes, sweating, muscle twitching, cough, pulmonary fibrosis, and shortness of breath. The most common and easily managed complication is barotitis, which can lead to episodes of barotrauma, such as rupture of the tympanic membrane or middle ear and sinus injury.

HBO stimulates angiogenesis and neovascularization, optimizes cellular oxygen levels, promotes osteoblast and fibroblast proliferation and collagen formation, and supports the growth of new blood vessels. HBO is often administered to promote proliferation of fibroblasts, epithelial cells, and blood vessels in nonhealing wounds. It can also enhance the

killing ability of leukocytes and may inhibit toxin production by certain anaerobes, while exerting direct bactericidal effects. This therapy is administered to increase the flexibility of red cells, reduce tissue edema, preserve intracellular adenosine triphosphate, and maintain tissue oxygenation in the absence of hemoglobin.

Therapy with HBO has been reported to improve neurologic recovery after spinal cord injury and to extend the prime therapeutic period for acute spinal cord injury to 6 hours after injury. In such cases, multiple HBO treatments are more effective than single sessions [17, 18]. In an animal model of motor neuron disease, HBO treatment significantly ameliorated mitochondrial dysfunction in the motor cortex and spinal cord and delayed the onset of disease [19]. HBO therapy has also been used success-fully to treat patients with type 2 decompression sickness involving the spinal cord [20].

In neural transplantation, a lack of oxygen supply to the graft during the acute stage is a significant problem. Clearly, the reduced edema associated with HBO therapy prevents displacement of the graft from the gap and contributes to the integration between graft and host [21]. The administration of HBO shortly after ischemic insult in rabbits produced protective effects against ischemic spinal cord damage, but delayed treatment with HBO did not change the prognosis [22]. In a study of sheep that sustained a controlled contusion to the thoracic spinal cord, HBO treatment improved the rate and strength of motor recovery and reduced the severity of cord degeneration-a finding that suggests that ischemia plays a significant role in contusion injury to the spinal cord [23]. In another study of sheep with spinal cord injury, HBO treatment was administered to delay the onset of paraplegia after injury. Results of this preliminary report suggest that early treatment provided within 2 hours of injury can enhance motor recovery [24].

In a study of patients with various spinal cord injuries (e.g., trauma, discogenic ischemic myelopathy, sequelae associated with tumor removal), HBO therapy frequently led to pronounced regression of neurologic symptoms [25]. In these patients, pelvic and motor functions and reflexes returned to normal, and pain syndromes were alleviated. In a retrospective study of patients with acute traumatic cervical spinal cord injury treated with and without HBO therapy in Tokyo Metropolitan Ebara Hospital, Tokyo, Japan, those who received HBO therapy demonstrated a faster rate of recovery than did those who did not [26]. In a study of patients with cervical compression myelopathy who received HBO therapy after surgery, the effect of HBO was more highly correlated with recovery rate after surgery than were other investigated parameters [27].

Hyperbaric oxygen can serve as a diagnostic tool for evaluating the functional integrity of the spinal cord and for assessing the success of recovery of spinal cord function after surgical decompression. In a study of patients with radiation myelopathy and micturitional symptoms who underwent a combination of steroid pulse therapy and HBO, 2 of 3 patients demonstrated a decrease in micturitional disturbance and other neurologic deficits [28].

In a rat model, magnetic resonance imaging was used to assess the efficacy of HBO treatment in spinal cord injury [29]. During a treatment period of 72 hours, HBO treatment led to improved neurologic recovery (based on the Tarlov scale) and appeared to arrest the spread of hemorrhage and resolve edema. In lateral amyotrophic sclerosis, HBO therapy produces only a minimal and short-lived positive effect in some patients. In most cases, therapy fails to control or stabilize neurologic disorders. In light of these results, HBO can be recommended as adjunctive therapy in the treatment of patients with vascular damage to the spinal cord [30].

Hyperbaric oxygen therapy can mediate the preservation of marginally injured neuronal elements of long tracts of the spinal cord during the early phases of traumatic spinal cord injury. This protective effect may be related to the reversal of focal tissue hypoxia or to reduction of tissue edema [31]. Among 13 patients with compressive spinal cord lesions treated with HBO, 6 demonstrated marked improvement, particularly in motor function. The other patients showed only little change in neurologic status. Moreover, arterial and cerebrospinal fluid PO_2 levels measured in 8 patients during the HBO sessions increased considerably during treatment. Increased cerebral spinal fluid PO_2 may be indicative of improved oxygenation

of spinal cord tissue during peroxide treatment [32].

In a study of 25 patients who underwent HBO or conventional therapy for approximately 7.5 hours after acute spinal cord injury [33], those who received HBO therapy appeared to recover more quickly, although their final motor scores were about the same as those of patients who received conventional therapy. In an animal study in which experimental allergic encephalomyelitis was induced in guinea pigs, those animals that received HBO treatment 5 to 19 days after induction demonstrated clinical signs of the disorder 4 to 6 days later than did animals that did not receive treatment, and they survived 4 to 5 days longer [34]. Results of a 10-patient study show that support of injured spinal cord tissue with oxygen under pressure may improve nerve function without loss of motor power or sensation [35, 36].

Disclosure of conflict of interest

None.

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