

Clinical research on postoperative efficacy and related factors of early simulation hyperbaric oxygen therapy for severe craniocerebral injury

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Abstract: In order to discuss the clinical efficacy of simulation hyperbaric oxygen therapy (HBOT) for severe craniocerebral injury and analyze the related factors of it, 108 patients who transferred to our department during December 2010 - December 2014 for ventilator treatment after operation of severe craniocerebral injury were taken as the subjects of the study. These patients were divided into conventional treatment group and simulation hyperbaric oxygen therapy group to contrast the curative effects. At the meantime, GOS score and length of stay in intensive care unit (ICU) of two groups 6 months after treatment, as well as changes in the indexes of the HBO group during treatment were performed statistical analysis. Then factors affecting prognosis of simulation HBOT were performed regression analysis and principal component analysis. The results showed that when compared to the control group, differences in cases with four GOS score and one GOS score in the treatment group were significant ($p < 0.05$). Jugular venous oxygen saturation (SjvO₂), jugular bulb oxygen partial pressure (PjO₂), arterial partial pressure of oxygen (PaO₂) and arterial oxygen saturation (SaO₂) of the simulation HBO group before the first time treatment on the first day and after the first time treatment on the third day were significantly increased, with statistical significance ($p < 0.05$); serum lactic acid (Lac) and blood glucose (Glu) decreased significantly ($p < 0.05$). Prior to and during the first treatment on the first day, jugular bulb pressure (Pj) and central venous pressure (CVP) had no significant difference ($p > 0.05$). Regression analysis indicated that factors affecting prognosis included cerebral contusion, coronary heart disease, hydrocephalus and tracheotomy. Principal component analysis found the factors were hydrocephalus, coronary heart disease, tracheotomy, cerebral contusion, cerebral infarction and glasgow coma scale (GCS) before treatment. Therefore, stimulation HBOT can significantly improve the prognosis of patients with severe craniocerebral injury. Paying attention to risk factors in clinics and giving timely interventional treatment can reduce morbidity and mortality in patients.

Keywords: Simulation hyperbaric oxygen; severe craniocerebral injury; curative effect; influencing factors.

INTRODUCTION

Severe craniocerebral injuries are often caused by serious traffic accidents. Compared to common brain injuries, the conditions are more serious. Multidisciplinary joint surgery is an effective treatment for early life-saving (Katz *et al.* 2009). Brain injury can lead to cell rupture and necrosis, which reduces the blood flow, causes brain edema, increases intracranial pressure and even induces life-threatening brain herniation. Studies have shown that the most important two reasons for the high mortality and fatality of these patients are the secondary cerebral ischemia and hypoxia after injuries. Hyperbaric oxygen (HBO), as a means used in animal experiments and clinical studies in the treatment of severe craniocerebral injury, has been decades of years (Vlodavsky *et al.* 2006). Hyperbaric oxygen therapy (HBOT) can eliminate cerebral edema, reduce intracranial pressure, improve brain hypoxia, ischemia and nervous system function and promote patients' recovery (Sahni *et al.*, 2012). Additionally, it is better to perform HBO as early as possible. Rogatsky (Rogatsky *et al.* 2005) found that performing HBOT to severe craniocerebral injury patients within 2 hours can significantly lower intracranial

pressure and mortality rate. Although HBOT has an obvious effect on the prognosis of patients with severe brain injury, its use in early treatment of severe craniocerebral injury is limited, because of their need for special equipment (hyperbaric oxygen chamber) and the potential side effects (Auer *et al.* 2001). High pressure oxygen can be replaced by atmospheric pressure oxygen with high concentrations which has good tolerability and produces fewer side effects (Matalon 1982; Royston 1990; Carvalho 1998; Brock 2006). For patients with cerebral infarction, atmospheric oxygen with high concentrations therapy can reduce the infarct size (Flynn 2002; Singhal 2002a; Singhal 2002b; Kim 2005), but the experiments are limited. Study found atmospheric oxygen with high concentrations therapy might improve the prognosis of patients with severe craniocerebral injury (Shin 2007; Mcleod 2003). However, high concentration oxygen therapy is controversial, because it may increase the production of free radicals, damage blood-brain barrier, cause inflammation and bleeding and thus induce infection. Studies have reported that high concentrations of atmospheric oxygen therapy can improve brain blood flow and oxidation and partially inhibit depolarization around the focus of infarct necrosis (PDIs) (Shin *et al.* 2007). Studies have found that patients with severe craniocerebral injury craniotomy adopt positive end

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expiratory pressure (PEEP) in the early stage can significantly improve brain-injury patients' arterial pressure and intracranial pressure (Zhang *et al.* 2011). Currently, there is no simulation HBOT by the joint use of the ventilator, PEEP and high concentrations of oxygen.

Generally, it is believed that the physiological and pathological changes in patients with craniocerebral injury are mainly: brain contusion, axonal injury, intracranial hematoma, or bleeding leading to increased intracranial pressure, secondary to cerebral hypoxia, ischemia, edema, acidosis and micro circulation disorders (Hymel *et al.* 2013). The main extent of the diseases in brain tissue includes not only the direct lesion area, but also the secondary damaged zone around the lesion area (Palzur 2004; Vlodaysky 2005). Research shows that factors that influence the prognosis efficacy of craniocerebral injury treated by HBOT include the degree of coma by HBOT for the first time, whether perform tracheotomy when receiving HBOT and the site of injury (Kretschmer 1983). Paying attention to risk factors in clinics and giving timely interventional treatment can reduce disability and fatality rates in patients.

Comparing conventional treatment with early PEEP + high concentrations of oxygen simulation HBOT for brain injury, this study observed the expected effects of two ways, aiming to investigate the influence of early simulation oxygen therapy on clinical effects and related factors of patients with severe brain injury, make the right judgments on prognosis after surgery and intervention on relevant factors to as early as possible, so that patients can get better prognosis.

MATERIALS AND METHODS

Study subjects

108 patients who transferred to our department during December 2010 - December 2014 for ventilator treatment after operation of severe craniocerebral injury were divided into conventional treatment group (A) and simulation HBOT group (B), wherein group A had 54 patients, 36 males and 18 females; and group B had 54 patients, 39 males and 15 females. Their age ranged from 22 to 78 years old, with an average age of 55.59 years old. The causes of injury included traffic accidents (76 cases), falling accidents (24 cases) and blunt force injury (8 cases). According to imageological examination, there were 28 cases with intracranial hematoma, 39 cases with subarachnoid hemorrhage, 38 cases with brain contusion, 20 cases with subdural hematoma, 7 cases with epidural hematoma, 24 cases with basal ganglia cerebral hemorrhage broken into ventricles and 30 cases with cerebral hernia. Previously, there were 27 cases with hypertension, 21 with diabetes and 23 with coronary heart disease. There were 36 with tracheotomy. Neurological complications included hypernatremia (25 cases), epilepsy (22 cases), diabetes insipidus (18 cases), cerebral

infarction (15 cases) and hydrocephalus (20 cases). Diagnostic criteria: Eligible patients all had a clear history of craniocerebral trauma; Glasgow Coma Scale (GCS) scores were three to eight in admission and they belonged to severe brain injury.

Research methods

Collection of cases

(1) Inclusion criteria: Patients who a. received definite diagnosis of craniocerebral injury; b. GCS was three to eight points; c. were clearly diagnosed by CT or MRI; (2) Exclusion criteria: patients who (whose) a. circulation was not stable or with other life-threatening illness or injury; b. were moribund (estimated death within 6h); c. had known or suspected brain death; d. were ongoing other treatment which may interfere with this study; e. were more than 80 years old; (3) Exclusion criteria: patients who a. died or discharged from hospital not more than 24h after treatment; b. were failed to adhere to systemic treatment because of their own reasons.

Therapeutic methods

All patients who met the inclusion criteria were accessed to research program after the consent form was signed by patient's family. First, we determined whether the patients had taboos like ventilator support and deep venipuncture. The conventional treatment group with indications of operation was given the emergency operation, such as minimally invasive hematoma clearance and craniotomy decompression. At the same time, patients were given dehydration, hemostasis, anti-infection, trophic nerve, hormone and consciousness-promoted drugs in accordance with their conditions. The tracheotomy operation was performed when necessary. Maintaining the respiratory tract unblocked effectively, clearing the secreta in the respiratory tract timely and performing adjuvant therapy by respirator. The parameters of respirator: 3 cm H₂O, FiO₂: 40%. After the patients recovered autonomous respiration, the respirator therapy was stopped. The simulation HBOT group was given intermittent PEEP (10 cm H₂O) + high concentration of oxygen therapy (FiO₂: 100%) on the basis of the control group.

Specific implementation methods

We evaluated the patients coma degree (GCS score), oxygen partial pressure, oxygen saturation, jugular bulb oxygen partial pressure, jugular bulb oxygen saturation, central venous pressure, jugular vein ball pressure and glucose and lactic acid content in the blood after 6h of the surgery. The simulation HBO treatment group, on the basis of the conventional treatment group, received PEEP (10cm H₂O) + high concentration of oxygen (FiO₂: 100%) treatment every 8h, each lasted for 60 min and the treatment time was 3d. The indicators above were measured during the course of treatment and after treatment.

Table 1: Comparison of patients' general information in two groups

Group	Case number	Gender		Age	GCS before entering department	Tracheotomy
		Male	Female			
HBO group	54	39	15	54.39±15.15	5.11±0.94	20
Control group	54	36	18	56.78±11.08	5.17±1.07	12
χ^2/t		0.552		-0.803	-0.251	0.129
<i>p</i>		0.583		0.424	0.803	0.719

Table 2: GOS score and ICU stay of patients after treatment

Group	Case number	GOS (%)					ICU (days)
		1	2	3	4	5	
Simulation HBO group	54	2(3.7%)	14(25.9%)	23(42.6%)	15(27.8%)	0	4.52±0.52
Control group	54	11(20.37%)	21(38.9%)	18(33.3%)	3(7.4%)	0	4.51±0.47
χ^2/t		5.939	1.677	0.779	5.104	1.677	0.064
<i>p</i>		0.015	0.196	0.377	0.024	0.196	0.949

Table 3: Changes in the indicator of the simulation HBO patients before and after treatment

Indicator	Group	Before the first treatment on the first day	After the last treatment on the third day	<i>p</i>
SjvO ₂	Treatment group	55.21±5.83	65.39±5.80	0.00
	Control group	47.05±3.61	61.86±4.29 ^a	0.00
paO ₂	Treatment group	106.57±27.83	382.46±129.9	0.00
	Control group	62.58±6.44	210.49±46.70 ^a	0.00
SaO ₂	Treatment group	97.62±1.80	99.23±0.68	0.00
	Control group	93.15±0.82	94.59±1.39 ^a	0.00
PjO ₂	Treatment group	37.16±4.72	42.09±4.99	0.00
	Control group	34.04±3.27	38.55±2.62 ^a	0.00
Lac	Treatment group	1.86±1.09	0.91±0.45	0.00
	Control group	2.32±1.25	1.61±0.57 ^a	0.01
Glu	Treatment group	11.27±2.83	8.43±1.39	0.00
	Control group	15.20±3.86	9.67±2.22 ^a	0.00

Note: Two groups were compared after the last treatment on the third day: ^a *p*<0.05. SjvO₂=jugular venous oxygen saturation, PjO₂=jugular bulb oxygen partial pressure, PaO₂= arterial partial pressure of oxygen, SaO₂= arterial oxygen saturation, Lac= serum lactic acid.

Table 4: Pressure changes of the simulation HBO patients during treatment

Indicator	Group	Before the first treatment on the first day	During the first treatment on the first day	<i>p</i>
Pj	Treatment group	9.22±3.39	9.26±2.27	0.767
	Control group	9.15±1.36	9.36±2.34 ^a	0.724
CVP	Treatment group	7.89±2.42	7.84±1.87	0.895
	Control group	7.28±3.19	7.49±2.58 ^a	0.638

Note: Compared to the controls, ^a *p*>0.05.

Department assessment

GCS score including eye opening reaction, language reaction and movement response. The patient's response was expressed by the sum of the number of each indicator: mild 13-15 points, moderate 9-12 points and severe 3-8 points (Middleton. 2012).

Prognostic rating

The patients were performed prognosis rating after 6 months of the onset by GOS scores. The GOS based on evaluation criteria were divided into five levels 1 point:

death; 2 points: vegetative state; 3 points: severely disabled; 4 points: moderate disability; 5 points: good recovery (Lingsma *et al.*, 2010), 1-2 points belonged to poor prognosis group, and 3-5 was good prognosis group. Prognostic evaluation was carried out by the authors themselves.

STATISTICAL ANALYSIS

SPSS 16.0 software package was used for data analysis. Factors influencing patients' prognosis were performed

Table 5: Univariate analysis of factors influencing the prognosis of patients with severe craniocerebral injury

Influencing factor		Case number	Good prognosis group (n=38)	Bad prognosis group (n=16)	χ^2	P
Gender	Male	39	26	13	0.971	0.325
	Female	15	12	3		
Age	<45 years old	20	18	2	5.87	0.015
	≥45 years old	34	20	14		
	Tracheotomy	20	10	10	6.322	0.012
Site of injury	Intracranial hematoma	15	11	4	0.089	0.766
	Subarachnoid hemorrhage	21	14	7	0.226	0.634
	Brain contusion	21	10	11	8.531	0.003
	Subdural hematoma	9	7	2	0.297	0.586
	Epidural hematoma	3	2	1	0.02	0.886
	Basal ganglia cerebral hemorrhage broken into ventricle	12	8	4	0.1	0.752
	Cerebral hernia	18	5	13	23.492	0
Underlying diseases	Diabetes	12	7	5	1.027	0.311
	Hypertension	15	9	6	1.038	0.308
	Coronary heart disease	12	5	7	5.686	0.017
Nervous system complications	Hypernatronemia	15	8	7	2.767	0.096
	Epilepsia	12	4	8	9.454	0.002
	Diabetes insipidus	9	6	3	0.07	0.792
	Cerebral infarction	10	3	7	8.829	0.006
	Hydrocephalus	12	3	9	14.288	0
GCS score	3-5 points	36	22	14	4.441	0.035
	6-8 points	18	16	2		

Table 6: Stepwise logistic regression analysis results

Factor	B	S.E	Wals	Df	Sig.	Exp (B)
Brain contusion	-2.917	1.28	5.198	1	0.023	0.054
Coronary heart disease	-3.681	1.581	5.424	1	0.02	0.025
hydrocephalus	-5.063	1.711	8.757	1	0.003	0.006
Tracheotomy	-3.383	1.349	6.289	1	0.012	0.034
Constant	5.868	1.575	13.878	1	0	353.593

single factor analysis of variance, and then variables with statistical significance were performed stepwise Logistic regression analysis and principal component analysis using forward method. The measurement data were expressed by ($\bar{X} \pm s$) and performed t-test. The enumeration data were expressed by χ^2 test. $p < 0.05$ was considered statistically significant.

RESULTS

Comparison of patients' general information in two groups

The gender, age, GCS score before entering the department and the number of patients with tracheotomy in two groups were not statistically significant ($p > 0.05$), so they are comparable (table 1).

Efficacy evaluation of patients after treatment

Comparing the GOS of the simulation HBO group and the control group after treatment, we found that the cases with 1 point after HBOT were significantly lower than the control group; cases with 4 points were significantly higher than the controls ($p < 0.05$), and cases with 2 and 3 points were not significant ($p > 0.05$, table 2). The difference in intensive care unit (ICU) days after treatment was not significant in two groups, suggesting that simulation HBOT had a long-term and significant efficacy for patients with severe craniocerebral injury, and would not extend the length of ICU stay.

Analysis of each index in the simulation HBO group

When comparing the changes in jugular venous oxygen saturation ($SjvO_2$), jugular bulb oxygen partial pressure (PjO_2), arterial partial pressure of oxygen (PaO_2) and

Table 7: Total variance decomposition

component	Initial eigenvalue			Extract quadratic sum load		
	Sum	Variance %	Total %	Sum	Variance %	Total %
1	1.515	16.837	16.837	1.515	16.837	16.837
2	1.441	16.012	32.849	1.441	16.012	32.849
3	1.287	14.300	47.150	1.287	14.300	47.150
4	1.165	12.940	60.090	1.165	12.940	60.090
5	0.988	10.983	71.072			
6	0.862	9.573	80.646			
7	0.716	7.955	88.601			
8	0.663	7.362	95.963			
9	0.363	4.037	100.000			

Table 8: Factor loading matrix

	Component			
	1	2	3	4
Age	0.299	-0.406	0.530	0.050
Cerebral contusion	0.642	-0.214	-0.413	0.038
Cerebral hernia	0.387	-0.314	-0.225	0.482
Coronary heart disease	-0.691	0.062	-0.456	-0.042
Epilepsia	0.344	0.440	0.072	-0.482
Cerebral infarction	-0.182	0.021	0.614	0.439
Hydrocephalus	-0.142	-0.389	0.378	-0.589
GCS	0.457	0.592	0.078	-0.142
Tracheotomy	-0.077	0.657	0.214	0.366

arterial oxygen saturation (SaO₂), blood lactate (Lac) and glucose (Glu) in the simulation HBO group before the first treatment on the first day with those after the last treatment on the third day, we found SjvO₂, PaO₂, SaO₂ and PjO₂ after treatment were significantly increased, with statistical significance (p<0.05), while Lac and Glu were significantly decreased (p<0.05). Differences in SjvO₂, PaO₂, SaO₂, PjO₂, Lac and Glu between two groups after treatment in the third day were statistically significant (p<0.05, table 3). Comparing the changes in jugular bulb pressure (Pj) and central venous pressure (CVP) before and during the first treatment on the first day in the simulation HBOT group, we found no significant difference (table 4), indicating that HBOT can improve cerebral oxygen metabolism in patients without increasing intracranial pressure.

Univariate analysis of factors affecting the prognosis of severe craniocerebral injury patients by HBOT

Differences in age (over 45 years old), tracheotomy, the site of injury (cerebral contusion, cerebral hernia), underlying disease (coronary heart disease), neurological complications (epilepsy, cerebral infarction, hydrocephalus) and GCS score before treatment had statistical significance between the bad prognosis group and good prognosis group (p<0.05), which can be explained as these nine factors were associated with the prognosis of severe craniocerebral injury (table 5).

Multivariate analysis of factors affecting the prognosis of severe craniocerebral injury patients by HBOT

Variables with statistical significance in univariate analysis were performed stepwise Logistic regression analysis using forward method: brain contusion, coronary heart disease, hydrocephalus, tracheotomy can significantly affect the prognosis of severe craniocerebral injury (table 6).

Principle component analysis of factors affecting the prognosis of severe craniocerebral injury patients by HBOT

Variables with statistical significance in univariate analysis were performed principal component analysis. Factors with eigen values greater than 1 were obtained by the method. The sum of the first four principal components variance accounted for 60.090% of all the variances, which was in line with statistical requirements and could reflect the level of the entire factors, so we can choose the first four principal components for analysis. Meanwhile, factor loading matrix was obtained from the index data using factor extraction method (tables 7 and 8).

As can be learned from table 8, the variable coefficient of the first principal component on two original indexes coronary heart disease and cerebral contusion was larger, accounting for 16.837% in the amount of information. The variable coefficient of the second principal

component on tracheotomy and GCS was larger, accounting for 16.012% of the total information. The variable coefficient of third principal component on cerebral infarction was larger, accounting for 14.300% of the total information. The variable coefficient of the fourth principal component on hydrocephalus was larger, accounting for 12.940% of the total information.

DISCUSSION

Brain tissue is the most vigorous metabolism and highest oxygen consumption tissue in the body. After severe brain injury, brain cells rupture and necrosis, blood-brain barrier damage, local microcirculation disturbance, cerebral ischemia and hypoxia, increased production of oxygen free radicals and central toxic cytokine release result in swelling of the brain tissue. Additionally, brain edema will aggravate brain tissue hypoxia, form a vicious cycle and aggravate brain injury. The central link is hypoxia (Shahrokhi 2010; Huh 2008). Currently, HBO is an important method in the treatment of severe brain injury, which can increase the physical dissolved oxygen in the blood to improve body's uptake and utilization of oxygen, increase oxygen content of blood and oxygen partial pressure, and enhance the capacity of oxygen diffusion into the tissue, thus improving microcirculation and aerobic metabolism of the tissue and making the tissue get a lot of oxygen. However, since its requirement for special equipment (hyperbaric chamber) and the potential side effects (Auer 2001), its application in the early treatment of severe craniocerebral injury patients is limited. In this study, an early simulation HBOT (PEEP + high concentration oxygen) was used. The results showed that the degree of prognosis recovery of simulation HBOT was significantly better than the control group, which may be because simulation HBO treatment can improve brain tissue hypoxia, reverse the pathological process and promote the recovery of neurological function of patients. Craniocerebral injury can affect nerve cell function by the exceptional oxygen metabolism. Thus, by detecting the condition on oxygen metabolism of brain tissue, we can master the function of brain cells indirectly, in order to timely and accurately determine the patient's condition and carry out treatment. Cerebral oxygen metabolism index reflects the matching relationship between cerebral oxygen supply and oxygen consumption. It can better reflect cerebral circulation and brain injury statuses than the cerebral blood flow (CBF), cerebral perfusion pressure (CPP) and other cerebral hemodynamics. If it can meet patient needs for oxygen metabolism under the pathology, it can be considered cerebral hemodynamic at this time can meet the needs of cerebral circulation in this case (Chieregato *et al.* 2007). For patients with severe craniocerebral injury, monitoring cerebral oxygen metabolism through the content of $SjvO_2$, Glu and Lac in serum (Fischer 2008; Toet 2009; Asgari 2011), will help evaluate the prognosis of patients. The normal value of $SjvO_2$ is 55% to 77% and the threshold of cerebral

hypoxia threshold is 50%. When hemoglobin and arterial oxygen saturation remain unchanged, $SjvO_2 < 50\%$ indicates cerebral ischemia and anoxia, and $SjvO_2 > 75\%$ suggests cerebral blood supply is too much, which is inversely proportional to the cerebral oxygen metabolic rate and cerebral blood flow (Stippler *et al.* 2012). The results of this study showed that the serum glucose and lactic acid levels of patients were raised on admission, while the oxygen saturation was low, indicating that patients were in a hypoxic state after brain injury. After treatment, the blood glucose and lactic acid were significantly reduced and $SjvO_2$ was significantly increased (from the threshold before treatment increasing to normal value) in the simulation blood HBOT group. Pj and CVP before and during treatment on the first day showed no significant difference, indicating that the simulation HBOT can improve cerebral oxygen metabolism in patients without increasing intracranial pressure. Therefore, it can be concluded that the reason why simulation HBOT has been able to improve the mechanism of long-term prognosis of patients may be that it can rapidly increase oxygen content, improve oxygen diffusion range, increase the aerobic metabolism of brain tissue and improve cerebral microcirculation disturbance and hypoxia.

In this study, according to the quality of life, patients were divided into the good prognosis group and the poor prognosis group to study factors affecting the long-term prognosis. Logistic regression analysis found that factors influencing the prognosis of severe craniocerebral injury were hydrocephalus, coronary heart disease, tracheotomy and cerebral contusion. Principal component analysis found the factors were hydrocephalus, coronary heart disease, tracheotomy, cerebral contusion, cerebral infarction and GCS before treatment. The differences in the results of two methods may due to the different analytical theories. The same factors obtained by two methods were hydrocephalus, coronary heart disease, tracheotomy and cerebral contusion. Hydrocephalus was an important prognostic factor, which can cause persistent coma, high disability and mortality in patients after severe craniocerebral injury (Kammersgaard *et al.* 2013). When hydrocephalus occurs, the degree of expansion of the lateral ventricles is larger than the third and fourth ventricle. The forehead is most likely to expand, which will damage the frontal and side lobule. These areas are the senior center which rules the spiritual, physical exercise and urinary function. Therefore they will cause corresponding symptoms. Whether performing tracheotomy is another important factor affecting the simulation HBOT. The reasons may be as follows: (1) Patients who were performed tracheotomy mostly had a low GCS score, serious injury and long-term coma leading to critical respiratory failure. General patient (2) In the treatment of patients with tracheotomy or endotracheal intubation, ordinary pipe, simple device,

single pure oxygen cabin, cabin ventilation and other devices were adopted. Patients without tracheotomy will wear mask for oxygen uptake therapy. Compared to these two treatment methods, the first one has a low oxygen uptake concentration and decreased oxygen uptake efficiency and the safety of it during treatment also be affected. (3) Tracheotomy complications include tracheal bleeding, airway hyper responsiveness and intratracheal granulation tissue proliferation, etc., which will cause a great impact on whether the patient will be treated by simulation HBOT (Marin-Caballeros *et al.* 2005). The study found that coronary heart disease was also a factor affecting simulation HBOT. Coronary heart disease is a main psychosomatic illness which endangers the health of the elderly; it is the main cause of death in the elderly. Craniocerebral injury combined with coronary heart disease in the elderly have more postoperative complications, including pulmonary infection, brain-heart syndrome (BHS), stress ulcer, deep venous thrombosis and urinary tract infection (Long *et al.* 2011), seriously affecting the prognosis of patients. The study also found that brain contusion is also independent prognostic factors. The brain contusion is easier to cause sudden deterioration of disease. It can transform a sober consciousness into a coma in a short time. It will lead to bilateral mydriasis and make patients lose the ability of light reflex, breathing rhythm changes or sudden respiratory arrest, followed by cardiac arrest (Laccarino *et al.* 2014).

CONCLUSION

Early simulation HBO is an effective method for treating severe craniocerebral injury. Establishing rapid and effective green channel of treatment, a full assessment of the patient's injury, closely monitor changes in the disease, early and aggressive treatment of craniocerebral injury and prevention of complications help patients receive timely and effective treatment. We aim to promote patients' function recovery, the prognosis and quality of life from the perspective of improving survival rate.

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