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Full Length Research Paper

Intracranial pressure and cerebral perfusion pressure monitoring in the preventive nursing care of severe traumatic brain injury

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The present study evaluated the roles of intracranial pressure (ICP) and cerebral perfusion pressure (CPP) in preventive nursing care of severe traumatic brain injury (STBI).Totally 100 STBI patients with 3 to 8 Glasgow Coma Score (GCS) score at admission were enrolled in this study, and they were randomly divided into monitoring group (n=50) and control group (n=50). STBI patients were nursed with conventional monitoring in the control group, and STBI patients were nursed with combination of conventional monitoring and ICP and CPP monitoring in the monitoring group, and early treatment and nursing intervention were given according to the monitoring results. Compared with the control group, there was a lower incidence of complications and better curative effects in the monitoring group. The proportion of patients with good curative effects in the monitoring and control group was 64 and 40%, and their mortality rates were 12 and 24%, respectively. Dynamic monitoring of ICP and CPP in the early stage of STBI is conducive to judge the changes of pathogenetic condition and give optimal treatment and early nursing intervention, so it's an effective measure to reduce disability and mortality rates.

Key words: Severe craniocerebral injury, intracranial pressure and cerebral perfusion pressure, monitoring, preventive nursing care.

INTRODUCTION

Cerebral edema is usually accompanied with the patients in the department of neurosurgery, especially in patient with severe traumatic brain injury (STBI) (Spiotta et al., 2010). Recently, how to relieve cerebral edema, decrease intracranial pressure (ICP), and maintain sufficient cerebral perfusion pressure (CPP) have been crucial treatment methods in intracranial hypertension (Rosner et al., 1995; Nordström et al., 2003). From September 2006 to January 2009, 50 STBI patients with 3 to 8 GCS scores were dynamically monitored with ICP and CPP, and accordingly optimal clinical treatments and nursing intervention were provided.

PATIENTS AND METHODS

Clinical data

A total of 100 selected STBI patients with 3 to 8 Glasgow Coma Score(GCS) score were hospitalized within 24 h following injury, and they were randomly divided into monitoring group (n=50) and control group (n=50). In the monitoring group, there were 34 males and 16 females, with a mean age of 36.4 years (6 to 73 years), and they were cerebral contusion accompanied with acute subdural hematoma in 15 cases, intracerebral hematoma in 10 cases, epidural hematoma in 11 cases, and primary brain stem injury in 14 cases. Of these 50 STBI patients, 32 and 18 patients received surgical and conservative treatments, respectively.

In the control group, there were 37 males and 13 females, with a mean age of 33.2 years (4 to 68 years), and there was cerebral contusion accompanied with acute subdural hematoma in 12 cases, intracerebral hematoma in 13 cases, epidural hematoma in 8 cases, and primary brain stem injury in 17 cases. Of these 50 STBI patients, 21 and 29 patients received surgical and conservative treatments, respectively. There were no significant differences in the age, gender ratio and GCS scores of STBI patients between both groups (P>0.05).

Methods

At present, there are three ICP monitoring methods including cerebral intraventricular pressure, extradural pressure and cerebral tissue pressure, but the cerebral intraventricular pressure was monitored in this study. In the monitoring group, the paracentesis of

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Table 1. ICP and CPP (mmHg) values and prognosis of 50 STBI patients in the monitoring group

ICP	CPP	Cases	Prognosis				
			Well	Severe disability	Moderate disability	Vegetative patients	Death
<15	>90	6	5	1	0	0	0
~ 20	~80	23	17	3	1	1	1
~40	~70	14	10	1	2	0	1
>40	<60	7	0	0	1	2	4
Total		50	32	5	4	3	6

Table 2. Complication and prognosis of STBI patients between the monitoring and control groups

Complication (n)$^{\mu}$							Prognosis (n)$^{\mu\mu}$				
Group	Cerebral hernia	Moderate disability	Pulmonary infection	Electrolyte disturbances	Alimentary hemorrhage tract	Renal failure	High glucose	Well	Severe disability	Vegetative patients	Death
Monitoring group	1	1	6	2	2	2	32	5	4	3	6
Control group	7	3	12	4	7	5	20	4	8	6	12

$^{\mu}P<0.05$, $^{\mu\mu}P<0.01$.

anterior horn of lateral ventricle was performed within 2 h after admission, and then a sensor connecting an Codman ICP monitor (JohnsonJohnson company, USA) was inserted for ICP dynamical monitoring, and meanwhile mean arterial blood pressure (MABP) was monitored with a multi-function monitor (Hewlett-Packard Company, USA), and then CCP was calculated with a formula of CPP=MABP-ICP. ICP and CPP dynamical monitoring was discontinued until ICP and CPP had remained stable or patients died. These 50 STBI patients were monitored with a mean time of 4.2 days (3 to10 days).

Meanwhile, the heart rate, blood pressure, breath rate, body temperature, pulse, oxygen saturation, central venous pressure, blood glucose, electrolytes, blood gas analysis and other routine monitoring parameters were also monitored, and then standardized nursing care was provided according to the monitoring results. Except ICP and CPP monitoring, the conventional monitoring and nursing care in the control group was the same as that in the monitoring group.

Statistical analyses

In the monitoring group, the ICP and CPP of 50 STBI patients were compared. The prognosis of STBI patients was judged with GCS prognostic scoring (Zhi et al., 2002), and the complication and prognosis of STBI patients between two groups were compared with X^2 test. A value of $P<0.05$ was considered statistically significant.

RESULTS

Of 50 STBI patients in the monitoring group, the duration of intracranial hypertension was <6 h in 9 cases, 6 to 12 h in 11 cases, 12 to 24 h in 12 cases, 24 to 48 h in 7 cases, 48 to 72 h in 7 cases, and >72 h in 4 cases. Within 72 h, there were 6 cases with ICP<15 mmHg and CPP>90 mmHg, 23 cases with 15 mmHg <ICP<20 mmHg and 70 mmHg < CPP <80 mmHg, 14 cases with 20 mmHg <ICP<40 mmHg and 60 mmHg < CPP <70 mmHg, and 7 cases with ICP>40 mmHg and CPP <60 mmHg. The CT scanning of intracranial hypertension patients revealed secondary intracranial hematoma in 10 cases and brain swelling in 6 cases Table 1.

In the monitoring group, the ICP and CPP was normal in 6 cases, after comprehensive treatments and nursing intervention for 1 to 3 m, good curative effects were obtained in the remaining 44 STBI patients with increased ICP and decreased CPP judging by GCS scoring. The proportion of patients with good curative effects in the monitoring and control groups was 64 and 40%, and the mortality rate in the monitoring and control group was 12 and 24%, respectively. There were significant differences in complications and curative effects between two groups (Table 2).

Nursing care

The following measures must be carried out to ensure that ICP and CPP monitoring data were accurate: 1) Monitored patients should be in supine position or high head position for 10 to15°. 2) In order to obtain accurate monitoring data, all sensors and monitors must receive zero setting before working, and the zero reference point of monitor was usually at external auditory canal. 3) It

must be ensured that there was no mechanical failure in the monitoring system, without air or liquid leakage. 4) All extracranial interference factors should be excluded as soon as possible, such as respiratory tract obstruction, fever, hypoxia, urinary retention, the obstruction or defluxion of drainage tube, inappropriate tightness of blood pressure cuff was excessive operation and stimulation.

The exclusion of all confounding factors was essential to accurately record ICP and CPP.

Protective nursing care

In the monitoring group, the STBI patients were nursed as follows: 1) 24 h continuous monitoring of vital signs, observation of consciousness, pupils and limb activities. 2) The treatment targets of ICP were: < 10 to 15 mmHg in patients with craniotomy and < 20 mmHg in patients without craniotomy. The treatment targets of CPP were 60 to 90 mmHg, but 70 to 80 mmHg was better (Zhi et al., 2002). If ICP and CPP was above the above-mentioned limits, the following treatment and nursing measures must be immediately given, such as to raise bed head, to keep respiratory tract was unobstructed, to inspire high-flow oxygen, to maintain normal body temperature, to give sedation treatment, to raise blood pressure, to intravenously transfuse sufficient liquid, to intravenously transfuse mannitol, to drain cerebrospinal fluid, to orally take nimodipine.

If these measures could not decrease ICP and increase CPP, emergency CT examination must be performed and corresponding treatments were timely given; 3) Body temperature was maintained between 35 to 38 μ, and was severely restricted below 38.5 μ. The temperature control measures included alcohol, ice bags, ice caps, ice blanket, and drug administration; 4) Systolic blood pressure was maintained between 90 to 160 mmHg, and CVP was between 5 to 12 mmHg, heart rate was 50 to 120 beats/min, respiratory rate was between 8 to 24 times/min; 5) PaO_2 should be above 75 mmHg or higher, and the lowest was not less than 60 mmHg. SPO_2 should be more than 95%.

Treatment and nursing measures included: to maintain the correct body position, to avoid the twist of neck, to timely spray and discard spit. If SPO_2 was less than 90% and PaO_2 was less than 60 mmHg, tracheotomy should be performed, and mechanical ventilation in the mode of pressure support was given, and the parameters are set within the base ranges. 6) Blood glucose was maintained between 6 to 8 mmol/L, and insulin was subcutaneously injected if necessarily. Hypertonic sugar liquid was used as less as possible in the early stage of STBI. 7) Effective circulating blood volume should be sufficient. Blood should be transfused if Hb was <8g/dl, and coagulation function was monitored, and abnormal INR, PT and KPTT should be corrected by transfusing prothrombin complex and fresh frozen plasma.

Platelets should be transfused if platelets were too low. 8) The measures of nutritional support included: enteral nutrition as early as possible, low-dose feeding with a drip tube was given within 24 to 48 h, and then the feeding dose was gradually increased up to the dose of physiological needs by 5 to 7 d. If there was obvious gastric retention, total parenteral nutrition (TPN) should be administrated. 9) Hyperbaric oxygen therapy should be carried out as soon as possible. In the control group, except ICP and CPP monitoring, various nursing interventions according to doctor's orders were performed.

DISCUSSION

Head injuries can be classified into mild, moderate, and severe categories. GCS, the most commonly used system for classifying TBI severity, grades a person's level of consciousness on a scale of 3 to 15 based on verbal, motor, and eye-opening reactions to stimuli. It is generally agreed that a TBI with a GCS of 13 or above is mild, 9 to 12 is moderate, and 8 or below is severe (Parikh et al., 2007). At present, it is advocated that STBI patients (GCS ≤ 8) shall be monitored with ICP and CPP (Narotam et al., 2009; Olivecrona et al., 2009). Continuous monitoring of ICP and CPP may play key roles in the prognostic evaluation of STBI patients, and the appropriate therapeutic measures and nursing intervention on intracranial hypertension were conducive to decrease the severe disability and mortality rates, and to improve the quality of life of patients (Huang et al., 2006). Monitoring data revealed that ICP<15 mmHg and CPP>60 mmHg were in the majority of patients, but not all patients had increased ICP and decreased CPP, especially in the postoperative stage. The occurrence time points and duration of ICP increase and CPP decrease was different, and the treatments were also different (Pillai et al., 2004).

Our experience of treatment and nursing intervention on STBI were as follows: 1) If ICP and CPP were > 10 to 15 mmHg in patients with craniotomy or > 20 mmHg in patients without craniotomy, intracranial depressurization nursing such as raising bed head for 20 to 30°, keeping unobstructed respiratory tract, catheter and ventricular drainage tube, decreasing body temperature, sedation, inspiring high-flow oxygen. Low-dose dehydrating agent was administrated to decrease ICP and ensure sufficient blood supply for brain tissues if necessary. CPP was maintained between 60 to 90 mmHg. Of 23 patients in this group, ICP and CPP resorted to normal limits in 17 patients after conventional intracranial depressurization nursing, with good prognosis. 2) If conventional treatments could not significantly decrease ICP, the dosage and frequency of dehydrating agents should be appropriately increased, and cerebrospinal fluid was

intermittently drained. Meanwhile, the blood gas, electrolyte, central venous pressure, blood glucose and other parameters were monitored, and then a comprehensive analysis based on the monitoring results on ICP increase was performed, and then symptomatic treatments were given.

The treatment period of these patients was relatively longer, but comprehensive basic nursing could effectively prevent and reduce complications, modulate ICP and CPP, and significantly improve the prognosis (Huang et al., 2006). Of 14 STBI patients, there was good recovery in 10 patients, severe disability in 2 patients, and death in 1 patient. 3) After a series of intracranial depressurization and brain blood perfusion improving treatments, progressive increase of ICP following a temporary decrease indicated secondary intracranial hematoma or acute cerebral edema, and thus an emergency head CT scanning should be performed. Of 16 patients with ICP>30 mmHg and CPP <60 mmHg for a long term in the monitoring group, CT scanning revealed intracranial hematoma in 13 patients and cerebral edema in 6 patients. After timely surgical treatments, there was a good recovery in 13 patients, severe disability in 2 patients, and death in 1 patient. Of 6 patients with intracranial hematoma in the control group, operation was performed when cerebral hernia appeared, and poor prognosis was obtained.

4) If ICP>40 mmHg and CPP<50 mmHg last a long term after intracranial depressurization and brain blood perfusion improving treatments, and there were no indications of surgical treatments in CT scanning, and the intracranial pressure of these patients was difficult to control, and their prognosis was poor. For these patients, comprehensive basic nursing, hypothermic brain protection, symptomatic and supportive treatments, prevention of multiple organ failure and other treatments could minimize the disability and mortality rates. Of 7 patients in this group, 4 patients died, 1 patient had severe disability, and 2 patients became vegetative men.

Ventricular access for ICP and CPP monitoring can be safely and accurately achieved. ICP and CPP monitoring via ventriculostomy may facilitate an early and accurate intervention for severely brain-injured patients (Zeng and Gao, 2010). The intraventricular ICP and CPP monitoring is a low-risk procedure and can yield great benefits for management of patients with STBI.

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