Effects of Propofol on Intracranial Pressure and Prognosis in Severe Neuropathy Patients Undergoing Endotracheal Suctioning

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Abstract

Background To investigate whether intravenous propofol before endotracheal suctioning (ES) in severe neuropathy patients can reduce the sputum suction response, improve the prognosis, and accelerate recovery.

Methods A total of 208 severe neuropathy patients after craniocerebral surgery were enrolled in the study. The subjects were randomly divided into the experimental group (n=104) and the control group (n=104). The experimental group was given intravenous propofol, 0.5-1 mg/kg, before ES, while the control group was subjected to ES only. Changes in vital signs, sputum suction effect, the fluctuation range of intracranial pressure (ICP) before and after ES, choking cough response, short-term complications, and length of stay and hospitalization cost were evaluated. Additionally, the Glasgow Outcome Scale (GOS) prognosis score was obtained at six months after the operation.

Results At the baseline, the characteristics of the two groups were comparable (P>0.05). The increase of systolic blood pressure after ES was higher in the control group than in the experimental group (P < 0.05). The average peak value of ICP in the experimental group during the suctioning (15.57 ± 12.31 mmHg) was lower than in the control group (18.24 ± 8.99 mmHg; P < 0.05). The percentage of patients experiencing cough reaction and pain during suctioning in the experimental group was lower than in the control group (P < 0.05), and the fluctuation range of ICP was increased (P < 0.0001). The effect of ES was achieved in both groups. The incidence of short-term complications in the two groups was comparable (P > 0.05). The difference at 6 months after the surgery, the GOS scores were significantly higher in the experimental than in the control group (4-5 points, 51.54% vs. 32.64%; 1-3 points, 48.46% vs. 67.36%; P<0.05). There was no significant difference in the length of stay and hospitalization cost between the two groups.

Conclusions Propofol sedation before ES can reduce the choking cough response, the pain experience of patients, and the intracranial hypertension response. The use of propofol is safe and improves long-term prognosis.

The study was registered on May 16, 2015 at Chinese Clinical Trail Registry (ChiCTR-IOR-15006441).

Background

Severe neuropathy is often accompanied by disorders of consciousness, weak sputum discharge ability in spontaneous cough, airway obstruction, and hypoxia, which aggravate secondary damage to brain cells [1, 4, 5]. To maintain airway patency and avoid airway obstruction and pulmonary infection in patients affected by severe neuropathy, artificial airways should be established, and endotracheal suctioning (ES) should be performed in time [1–3].

ES stimulates airway mucosa, triggers the cough reflex, induces bronchospasm, decreases blood oxygen saturation, and increases intracranial pressure. Severe airway stimulation may lead to adverse consequences [1], such as severe cough, increased chest pressure, a sudden rise in blood pressure, increased cerebral perfusion, increased intracranial pressure (ICP) caused by cerebral vasospasm, and increased risk of vascular rupture [12–16]. The stimulation of airway caused by different suction modes and duration, the amount of negative pressure applied, and the depth of suction tube insertion leads to reflexive ICP changes [4–11, 16, 17].

Propofol, a short-term acting sedative, can reduce cerebral blood flow, ICP, and cerebral metabolic rate of oxygen (CMRO2). The action of propofol is characterized by a fast onset time of approximately 30–60 seconds, a short half-life of 10–15 minutes, and a fast wake-up time after drug withdrawal, which facilitates the evaluation of the nervous

system [18–26]. During ES, propofol can directly dilate the bronchial smooth muscle, inhibit the pharyngeal reflex, and reduce the airway hyperresponsiveness [18–20, 25]. In addition, it exerts amnesic and anticonvulsant effects, increasing patients' comfort [21–22, 28, 29]. Moderate or slow infusion (respectively, 40 mg/10 s or 20–50 mg/min in generally healthy adults) has no significant effect on vital signs of patients [18, 19, 24–29].

The objective of the present study was to explore whether the administration of propofol prior to the ES procedure in severe neuropathy patients helps to maintain the respiratory and circulatory stability, reduce the increase of ICP, and suppress the high-pressure response caused by strong stimulation.

Methods

1.1 Study participants

This study has been approved by the Clinical Trial and Biomedical Ethics Committee of the West China Hospital of Sichuan University (approval number 2014 (238). All patients signed informed consent. A total of 208 severe neuropathy patients who underwent craniocerebral surgery at the West China Hospital of Sichuan University from May 2015 to October 2018 were included (clinical trial registration number: ChiCTR-IOR-15006441). They were equally divided into the experimental group and the control group according to the random number table method. The inclusion criteria were: patients (1) aged 18–75 years; (2) with cerebrovascular disease and undergoing craniocerebral surgery; (3) with artificial airway and ventilator-assisted respiration; (4) equipped with intracranial pressure monitor; and (5) with the initial ICP of $\leq$ 25 mmHg. Exclusion criteria: patients with (1) insufficient blood volume or unstable circulation; (2) hypotension; (3) shock; or (4) maternal patients.

1.2 Research methods

Patients in both groups were treated by the same team of doctors and nurses. After the operation, both groups were treated with anti-inflammatory medications, ICP-reducing drugs, and nutritional support. All patients were subjected to continuous ECG monitoring, oxygen inhalation, and intracranial pressure monitoring. The control group was given ES directly. The experimental group was sedated with propofol prior to ES. The dose of propofol was 0.5-1 mg/kg, and the injection was performed slowly. To perform the ES procedure, patients were placed in a supine position, and the head of the bed was raised 15–30°. During the operation, No. 12 sputum suction tubes were used, the interval between consecutive ES was more than 30 minutes, and the negative pressure was set to 200 mmHg; the deep ES was performed [4–6, 32–33]. Each patient had ES at least 5 times.

1.3 Outcome measures

The changes in vital signs, ES effect, the fluctuation range of ICP before and after ES, choking and coughing reaction, recent complications, prognosis score of Glasgow Outcome Scale (GOS) six months after the procedure, the duration of in-hospital stay, and hospitalization expenses were compared between the two groups.

1.3.1 ES indications

ES was considered necessary in the following cases: rapid breathing, high blood pressure, high airway pressure, cough, decreased SPO_2, presence of secretions in the airway, and wheezy phlegm on auscultation [4–6, 31, 32].

1.3.2 Vital signs and SPO $_2$

Vital signs and SPO_2 were observed within 5 minutes after ES [6, 27–29].

1.3.3 Measurement of ICP fluctuation range

The ICP fluctuation range was evaluated by the peak value of ICP during ES, the time to reach the peak value (seconds), the value of ICP after the recovery to a stable state, and the time to recover to a stable state (seconds).

1.3.4 Assessment of choking cough response

The choking cough response was graded as follows: grade 1, no choking cough; grade 2, slight cough, 1–2 times, without apparent physical movement; grade 3, strong cough, 3–4 times, with neck and chest movement; grade 4, more than 4 times of cough, accompanied by general movement and retching and causing extreme pain [34, 35].

1.3.5 Auscultation evaluation of the ES effect

Three degrees of reduction of the wheeze phlegm were assigned: 1, complete disappearance; 2, significant decrease; and 3, partial decrease [6].

1.3.6 GOS

Six months after the procedure, the patients were evaluated using the GOS prognosis score [41–42]. The GOS scores of 4 and 5 indicated a good prognosis, and scores of 1–3 indicated poor prognosis [41–45].

1.4 Statistical analysis

The baseline measurement data were analyzed using the SPSS 22.0 software and represented as the mean and standard deviation ($x \pm s$). The Student's t-test was used for comparisons between the two groups. The enumeration data were represented as the composition ratio or percentage, and the chi-square test or Fisher's exact probability method was used for inter-group comparison. The rank data comparison was performed using the rank-sum test. The significant level was set at $\alpha = 0.05$ (two-tailed), and $P < 0.05$ was considered statistically significant. SAS software was used for repeated measurement of quantitative data. The mixed program performed data analysis. The random intercept-slope model that included grouping variables and measurement times was established.

2 Results

2.1 Comparison of baseline conditions between the two groups

A total of 206 patients were included in the analysis (2 patients in the control group withdrew from the study). The average age of the 104 patients in the experimental group was 52.45 ± 15.05 years, and the average age of the 102 patients in the control group was 52.68 ± 14.06 years. There was no significant difference in age, gender, condition (pupil size, consciousness, tracheal situation), disease classification, surgical method, and GOS between the two groups (all $P > 0.05$) (Table 1).

Table 1
Comparison of general conditions between the two groups

Clinical data		Experimental group (n = 104)	Control group (n = 102)	*P*
Gender	Male	48	55	0.2649
	Female	56	47	
Age		52.45 ± 15.05	52.68 ± 14.06	0.9120
Weight		60.82 ± 11.26	64.24 ± 11.31	0.0315
Pupil	Diameter	Left: 2.3204 Right: 2.4412	Left: 2.3235 Right: 2.4412	0.9872
	Light reflection			0.6264
Consciousness	Sober	3	5	0.3273
	Drowsiness	16	15	
	Lethargy	28	21	
	Light coma	29	30	
	Coma	27	31	
	Deep coma	0	0	
Trachea condition	Endotracheal intubation	104	102	0.4976
	Tracheotomy	34/104 (33.01%)	32/102 (31.37%)	0.8019
Disease classification / cases (%)	Cerebrovascular diseases	74 (71.15%)	68 (66.67%)	0.3914
	Intracranial tumors	22 (21.15%)	19 (18.63%)	
	Severe brain injury	7 (6.73%)	14 (13.73%)	
	Other	1 (0.96%)	1 (0.98%)	
Surgical method / cases (%)	Decompressive osteotomy	2 (1.93%)	4 (6.86%)	0.1237
	Hematoma removal + decompressive osteotomy	28 (25.96%)	42 (35.29%)	
	Aneurysm clipping or vascular malformation resection	49 (47.12%)	39 (38.24%)	
	Tumor resection	25 (25.00%)	17 (16.67%)	
APACH score				0.9679

2.2 Effect of propofol on vital signs

Before the administration of propofol and ES, the vital signs were comparable between the two groups ($P > 0.05$). After ES, the systolic pressure in the control group was higher than in the experimental group ($P < 0.05$), while the values of HR, P, SpO2, and diastolic pressure were similar in both groups (all $P > 0.05$ (Table 2).

Table 2
Comparison of vital signs between the two groups before and after ES

Before After										
	HR	P	SpO2	Systolic pressure (mmHg)	Diastolic pressure (mmHg)	HR	P	SpO2	Systolic pressure (mmHg)	Diastolic pressure (mmHg)
Experimental group	78.75	14	100	134.71	72.56	89.5	21	100	139.24	75.85
Control group	77.75	15	100	136.44	71.53	93.5	24	100	144.93	76.30
t	-0.32	1.75	0.15	-0.51	-1.89	0.68	0.9	1.43	2.68	0.49
P	0.75	0.081	0.88	0.61	0.06	0.49	0.37	0.15	0.008	0.62

2.3 Effect of propofol on ICP

Before and after ES, the differences in ICP between the two groups were not significant (P > 0.05). The average peak value of ICP during ES in the experimental group (15.57 ± 12.31 mmHg) was lower than in the control group (18.24 ± 8.99 mmHg, P < 0.05) (Table 3).

Table 3
Comparison of ICP fluctuation between the two groups

Group	ICP before ES (mmHg)	ICP during ES (mmHg)	ICP after ES (mmHg)
Experimental group	8.88 ± 8.57	15.57 ± 12.31	8.91 ± 8.70
Control group	8.68 ± 8.23	18.24 ± 8.99	9.00 ± 8.53
t	0.19	4.80	1.86
P	0.848	< 0.0001	0.065

2.4 Effect of propofol on choking cough response and ICP fluctuation

The beneficial effect of ES was observed in both groups of patients (P > 0.05) (Table 4). However, the proportion of patients suffering from pain in the experimental group was lower than in the control group (grade 3: 27.39% vs. 36.72%; grade 4: 0.12% vs. 2.15%. The grade of choking cough reaction was directly related to the fluctuation range of ICP (P < 0.0001) (Table 4).

Table 4
Comparison of ES effect and choking cough reaction between the two groups (case)

Group	ES effect, n (%)			Choking cough response, n (%)				ICP fluctuation range (mmHg)
	1	2	3	1	2	3	4	
Experimental group	8 (0.93%)	625 (72.76%)	226 (26.34%)	82 (9.56%)	540 (62.94%)	235 (27.39%)	1 (0.12%)	6.68 ± 7.02
Control group	1 (0.11%)	656 (74.12%)	228 (25.76%)	34 (3.84%)	507 (57.29%)	325 (36.72%)	19 (2.15%)	9.56 ± 5.09
P	0.99			< 0.01				< 0.0001

2.5 Effect of propofol of complications and prognosis

2.5.1 Comparison of the incidence of complications between the two groups

The number of complications in the two groups is listed in Table 5. There were no significant differences in the number of cases of cerebral hemorrhage, brain hernia, and pulmonary infection (all P > 0.05).

Table 5 Comparison of complications between the two groups (% (n)/ X±s)

Note: patients can have two or more complications at the same time.

Group	Cerebral hemorrhage	Brain hernia	Pulmonary infection
Experimental group	0	3	38
Control group	4	10	48
Statistical quantity	104	101	2.34
P	1.00	0.99	0.12

2.5.2 Comparison Of Gos Scores Between Two Groups

Six months after the procedure, 51.54% of the patients in the experimental group and 32.64% in the control group had the GOS score of 4 or 5, while 48.46% in the experimental group and 67.36% in the control group had the GOS score of 1–3. The cases of 4–5 and 1–3 points in the experimental group were both significantly less than the control group (both P < 0.05) (Table 6).

Table 6
Comparison of GOS scores between the two groups, n (%)

Group	1 point	2 points	3 points	4 points	5 points	P
Experimental group	8 (8.25%)	7 (7.22%)	32 (32.99%)	21 (21.65%)	29 (29.90%)	0.037
Control group	17 (17.89%)	5 (5.26%)	42 (44.21%)	18 (18.95%)	13 (13.68%)	

2.6 Effect of propofol on hospital length of stay and cost

There was no statistically significant difference between the two groups in total hospital expenses and the length of in-hospital stay (both $P > 0.05$).

3. Discussion

The results of the present investigation documented that propofol reduces the irritation associated with sputum suction, the fluctuation of ICP, the cough response, and short-term complications, and improves the prognosis of the GOS score. These findings indicate that propofol should be used before ES to relieve the stress response of the patients undergoing the procedure.

3.1 Propofol sedation before ES helps to stabilize intracranial pressure

ES is an effective method for keeping the artificial airway unobstructed in patients with severe neurologic diseases, and is, therefore, the most common procedure in neurology ICU. However, ES can increase ICP by stimulating the airway mucosa, triggering the cough reflex, elevating chest pressure, increasing blood flow into the brain, and decreasing venous return. The variations in the stimulation of the airway caused by the differences in suction methods, suction duration, negative pressure applied, and suction tube insertion depth, are reflected in ICP changes [4–11, 16, 17]. It has been previously demonstrated that ES is an important factor affecting ICP [12–16]. The results of the current work showed that the average peak value of ICP in the experimental group was 15.57 ± 12.31 mmHg, while that in the control group was 18.24 ± 8.99 mmHg. This finding indicates that propofol sedation before ES can effectively reduce the mean peak of ICP. This beneficial action of propofol depends on its ability to activate the GABA receptor chloride complex and reducing the stress response of the body caused by ES. Moreover, propofol can reduce cerebral blood flow, ICP, and $CMRO_2$ [18–26].

3.2 Propofol sedation ensures ES effect and reduces pain

Patients undergoing major neurosurgery procedures often experience consciousness disorders and reduced ability of the respiratory tract to perform self-cleaning. It is necessary to conduct timely suction of the sputum and clear

respiratory secretion to avoid the obstruction of the artificial airway and pulmonary infection [1–3]. The sputum suction tube repeatedly stimulates the respiratory mucosa, resulting in varying degrees of choking and coughing in patients. In severe cases, it causes a decrease in blood oxygen saturation and an increase in ICP, producing discomfort and even causing pain [4–17, 36–40]. Lucchini and coworkers [37] documented that patients subjected to mechanical ventilation recalled that during their stay in the ICU, ES was the most painful process, with 99% of them reporting painful experience during ES [36–39]. The current study demonstrated that the effect of ES was accomplished successfully in both the experimental and the control group, but the two groups differed in the grade of choking cough response. The number of patients with extremely painful sputum suction (grade 4) was significantly smaller in the experimental group, indicating that appropriate propofol injection prior to ES reduces the painful experience of the patients. Propofol is a short-term anesthesia drug, which is rapidly distributed in the entire organism within 40 seconds after intravenous injection. Intravenous injection of propofol before ES produces a sedative effect, inducing patients to quickly enter the sleep state. In addition, propofol can directly dilate bronchial smooth muscles, inhibit the throat reflex, and reduce the airway hyperresponsiveness during sputum suction. These properties of propofol suppress the stress response activated by ES and reduce the discomfort of patients [18, 19, 29].

3.3 Propofol sedation before ES helps to improve the prognosis of patients undergoing major neurosurgery

In the present investigation, we applied the concept of enhanced recovery after surgery (ERAS) and consulted relevant literature [24–29] to determine that an appropriate dose of sedatives was given before ES according to the weight of the patient. The results showed that propofol did not cause adverse reactions and complications. The evaluation of the GOS prognosis score sixth months after the operation revealed a high proportion of patients with 4–5 points on the GOS scale in the experimental group. This result indicates that the prognosis of patients treated with propofol was good. Together, the collected data show that propofol sedation before ES helps to improve the prognosis of patients undergoing major neurosurgery procedures by reducing the incidence of choking cough and spikes in ICP.

Some limitations of this study should be acknowledged. Only the patients admitted to the neurological ICU of the West China Hospital of Sichuan University were included. The subjects were mostly patients with cerebrovascular disease and severe brain injury. Clinical multi-center trials involving a wider range of diseases and larger sample size are needed to support the conclusions.

Conclusions

Sedation with a proper amount of propofol before ES can reduce the cough response caused by strong stimulation, reduce the patient's painful experience, suppress the increase in ICP, and improve long-term prognosis. The administration of propofol is safe and does not affect vital signs.

Abbreviations

ES: endotracheal suctioning; ICP: intracranial pressure; GOS: Glasgow Outcome Scale

Declarations

Ethics approval and consent to participate

All patients signed written informed consent. This study has been approved by the Clinical Trial and Biomedical Ethics Committee of the West China Hospital of Sichuan University (approval number 2014 (238).

Consent for publication:

Written informed consent for publication was obtained from all participants.

Availability of data and material

Ling Ye should be contacted if someone wants to request the data.

Competing interests:

There is no competing interests.

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Authors' contributions

MHW contributed to the conception and design of the study, manuscript writing and final approval of the manuscript. XRY, MJC, YL contributed to the conception and design of the study. XZ, TTL, YJL, XMW, YJL, LHP,MJZ and ZH contributed to the manuscript writing and analysis. LY contributed to the design of the study, with emphasis on the statistical analysis and sample size analyses, critical revision of the manuscript and final approval of the study. All authors have read and approved the final manuscript.

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