A Clinical Study of Treatment for Delayed Neuropsychoneural Sequela Caused by Acute CO Poisoning with ClearMate™ Gas Poisoning First Aid Ventilator

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Abstract

Objective: A clinical study for observation of treatment for delayed neuropsychoneural sequela caused by acute CO poisoning with ClearMate gas poisoning first aid ventilator.

Method: Acute CO poisoning patients were divided into two therapy groups and both groups received same routine treatment. Treatment group (319 patients) received ClearMate treatment immediately after admission besides the routine treatment used in control group. Therapeutic effect was observed in both groups.

Result: The total effective rates were 99.05% and 77.81% in treatment group and control group respectively, and the incident numbers of delayed neuropsychoneural sequela were 3 and 71 in treatment group and control group respectively, all results demonstrated statistic significance (P<0.05).

Conclusion: Application of ClearMate treatment in early stage of clinical intervention can significantly decrease incidence of delayed neuropsychoneural sequela caused by acute CO poisoning, increase cure rate, reduce sequela and complications, shorten time for consciousness recovery, recover brain electric activity in early stage, improve BI score of assessment for activities of daily living, and ClearMate is safe, quick and easy to use, can be operated and controlled by bedside, affordable and well acceptable for patients.

Key words ClearMate treatment, hyperbaric oxygen, acute CO poisoning, delayed neuropsychoneural sequelae

Material and Method:

From October 2012 – January 2014, 320 patients with acute CO poisoning were treated with routine therapy, and these patients were the control group in the study. From February 2014 – May 2015, 319 patients with acute CO poisoning were treated with ClearMate in the early stage on basis of routine therapy, and these patients were the treatment group in the study. All patients had obvious CO contact history, and presented acute CO poisoning symptoms such as vomiting and confusion. Positive carboxyhemoglobin (HbCO) is used as reference index. Conditions such as cerebrovascular accident, concussion, meningitis, diabetic ketoacidosis, hypoglycemia and confusion caused by other poisonings were excluded. Data were applied to statistic analysis. The result showed that there was significant difference (P<0.05) and comparability between two groups.
Intervention: Both groups received same routine therapy which was consist of hyperbaric oxygen treatment (HBO), mannitol, glucocorticoid and medication that promoted metabolism of brain cells. The treatment group received in the early stage ClearMate treatment on basis of conventional treatment that the control group received.

Control group: HBO treatment. 0.22MPa, oxygen treatment for 60 minutes, 1-2 times/day, for 10 days as a therapeutic course.

Treatment group: ClearMate treatment. On site or after arrival in emergency centres, ClearMate treatment was immediately administrated to patients once or twice (30 minutes to 1 hour earlier than first HBO treatment in control group), HBO and other treatment were followed afterwards, and a therapeutic course lasted for 10 days.

The therapeutic effect was observed in each group in recovery of EEG (the observational cycle of EEG was 10 days) and in onset of delayed neuropsychoneural sequela (by follow-up visits after discharge).

Assessment criteria for treatment effect: Cure: patient has clear consciousness, signs of CO poisoning disappear, EEG returns to normal, and BI score > 60 (total is 100). Effective: Patient has clear consciousness, continence, major signs of CO poisoning disappear, EEG shows minor abnormalities, and BI score is 40 - 60. Noneffective: no improvement in consciousness and signs, exacerbation or death, moderate or serious abnormalities on EEG, and BI score < 40. Statistic method: results were presented in standard deviation of mean (X±S), X² test was applied to count data, and t-test to measurement data.

Result:

Two patients in control group discontinued HBO treatment due to fever, and in treatment group no patient had shown specific discomforts. Comparison between ClearMate treatment group and control group demonstrated significant difference (P<0.05). Table 1 indicates that complete recovery of EEG has been observed in 316 patients in treatment group, and 3 patients developed delayed neuropsychoneural sequela during follow-ups after discharge. Complete recovery of EEG has been observed in 249 patients in control group, and 71 patients developed delayed neuropsychoneural sequela during follow-ups after discharge. Statistic significance (P<0.05) existed in time for consciousness recovery and for EEG recovery, and in incidence of delayed neuropsychoneural sequela as well. Please refer to table 2.

Table 1: Comparison of Therapeutic Effect between Two Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Patient Number (Case)</th>
<th>Cure (Case)</th>
<th>Effective (Case)</th>
<th>Ineffective (Case)</th>
<th>Total Effective Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>319</td>
<td>296</td>
<td>20</td>
<td>3</td>
<td>99.05</td>
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<tr>
<td>Control Group</td>
<td>320</td>
<td>187</td>
<td>62</td>
<td>71</td>
<td>77.81</td>
</tr>
</tbody>
</table>

Remark: compared with control group, P<0.05

Table 2:
Comparison of Time for EEG Recovery and Incidents of Delayed Neuropsychoneural Sequela between Two Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Patient Number (Case)</th>
<th>Time for Consciousness Recovery (Hours)</th>
<th>Time for EEG Recovery (Days)</th>
<th>Incident Number of Delayed Neuropsychoneural Sequela</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Group</td>
<td>319</td>
<td>12.6 ± 1.2</td>
<td>10.3 ± 1.3</td>
<td>3</td>
</tr>
<tr>
<td>Control Group</td>
<td>320</td>
<td>30.2 ± 9.8</td>
<td>22.1 ± 7.6</td>
<td>71</td>
</tr>
</tbody>
</table>

Remark: compared with control group, P<0.05

Discussion

Acute carbon monoxide poisoning (ACOP) is one of common poisonings. Carbon monoxide (CO) replaces oxygen (O₂) in hemoglobin and forms carboxyhemoglobin (COHb), reduces oxygen delivery into tissue, and therefore patients develop a series of symptoms and signs due to oxygen deficit, which may cause serious harm and is also the most common cause of death in gas poisonings. Normally if patients are not treated in time, there is high chance to develop serious complications, and disability rate is quite high, among other complications delayed neuropsychoneural sequela followed carbon monoxide poisoning, (DNS) is a main common complication, and it is one of the most serious complications. According to reports from aboard, incidence of DNS during the recent 10 years is 20 - 60%; reports in China have reported an approximate incidence of 0.2% - 47.3%, and for severe ACOP patients, it reaches up to 10% - 40%.

Acute CO poisoning is an acute hypoxic disease of the brain caused by inspiration of high concentrated CO, and a small number of patients may develop delayed neuropsychoneural symptoms, i.e. after consciousness has recovered from acute CO poisoning, following a pseudo-recovery period of 2 -60 days, mental and conscious disorders and neurologic system impairs may appear again, which is termed as delayed neuropsychoneural sequela followed carbon monoxide poisoning (DNS). Because DNS patients usually suffer from cognitive and memory disorders and conditions caused by extrapyramidal system impairs, their life quality is seriously compromised, and the problems become enormous burden for both family and society.

Therapeutic mechanics of HBO in treatment for CO poisoning include: HBO decreases COHb level rapidly, while the half-life period for COHb elimination is 80 minutes, when 100 % oxygen is inspired under normal pressure, under HBO of 30 am, the half-life period of COHb elimination is only 23 minutes; in the meantime, HBO accelerates disassociation of CO from cytochrome oxidase, but the accurate change of the half-life period is still unclear; besides, HBO inhibits white blood cells adhesion mediated by adhesion and aggregation factors, thereby reduces injury of vascular endothelium, and helps ameliorate pathophysiologic reactions related with impairs of central nervous system induced by CO. Study of animal model about effect of HBO on CO poisoning indicated that HBO can better improve microcirculation, decrease mortality of poisoned animals and neurological sequelae. Clinical research revealed that HBO alone has though significant therapeutic effect, the incidence of delayed neuropsychoneural sequela as complication in severe CO poisoning cases can still reach as high as 25.2%. (1)

ClearMate is utilised to accelerate elimination of volatile hydrocarbon (e.g. CO, anaesthetics) from blood. When blood flows through the lungs, volatile hydrocarbon can be cleared from blood quickly. The stronger respiration is, the more CO$_2$ is lost. ClearMate can automatically compensate CO$_2$ at the same speed as it is lost through a special valve. ClearMate consists of a principle machine of the size as a briefcase, and oxygen and CO$_2$ gas supply. The breathing circuit of ClearMate has automatically and manually controlled ventilation. Automatically controlled ventilation through mask or intubation can be chosen for patients with spontaneous respiration, while manually controlled ventilation for patients with no spontaneous respiration. CO$_2$ controlling valve effectively controls over proportion of the gas mixture, and automatically regulates the proper ventilation for patients. In the oxygen enhancing ventilation method of ClearMate, the asphyxia threshold is increased by 2 - 3 times, and it prevents CO$_2$ from decreasing. This kind of respiratory enhancing method can significantly increase clearance of volatile substances from blood.$^{(2)(3)}$

ClearMate supplies patients with a mixture of CO$_2$ and O$_2$ in high concentration in a constant proportion, and thereby CO can be rapidly replaced from the body, and oxygen is released into tissue, which reduces poisoning reactions and recovers normal respiratory function. ClearMate is small in size, easy to carry and easy to use with its short starting time. ClearMate is especially suitable to be used on site of poisoning, for prehospital emergency care, and for various kinds of acute CO poisoning patients such as critically ill patients, patients in coma, patients with endotracheal intubation and patients who can’t tolerate HBO treatment. HBO recovers oxygen delivery into tissue by increasing oxygen concentration in serum and replacing CO in COHb. However, HBO is not suitable for emergency treatment, mainly because HBO devices are rarely available, well trained emergency medical staff are required and starting time of the device is relatively long.

Our data showed that ClearMate treatment for acute CO poisoning can significantly increase total effective rate, shorten time for recovery of consciousness, restore brain electrical activity in early stage, increase BI assessment score of activities of daily living. Even though combined ClearMate treatment hasn’t completely prevented delayed neuropsychoneural sequela from happening, it has significantly reduced the incidence, and besides no adverse effect was observed.

References:

ClearMate 气体中毒急救呼吸机治疗
急性一氧化碳中毒致迟发性脑病临床研究

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目的：探讨 ClearMate 气体中毒急救呼吸机治疗急性一氧化碳中毒致迟发性脑病临床研究的临床价值。

方法：选择 2014 年 1月-2015 年 12 月期间在我院ICU及呼吸科住院的急性一氧化碳中毒致迟发性脑病患者 319 例，其中对照组 320 例，治疗组 319 例。

结果：治疗组的治疗总有效率为 98.4%，显著高于对照组的 87.5%（P<0.05）。

结论：ClearMate 气体中毒急救呼吸机治疗急性一氧化碳中毒致迟发性脑病临床研究的临床价值。

表 1 临床疗效比较

![Image](image_url)
本文资料表明，ClearMan 治疗慢性性 CO 中毒常能明显提高总有效率，缩短治疗时间，延长生命，减少急性死亡率。但因其对慢性性 CO 中毒的治疗效果不明显，故不宜作为首选治疗方法。

参考文献
[1] 周耀华，马彦，张俊，等。一氧化碳中毒的治疗。中国实用临床杂志，2004，4 (5)：68-69。

表

<table>
<thead>
<tr>
<th>项目</th>
<th>阳性</th>
<th>阴性</th>
<th>无效</th>
<th>有效</th>
<th>治愈率</th>
</tr>
</thead>
<tbody>
<tr>
<td>光量子</td>
<td>74</td>
<td>28</td>
<td>26</td>
<td>34</td>
<td>9.65 %</td>
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</tbody>
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