Original

Safety of Prone Positioning for Patients with Severe Motor Disabilities

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Abstract

PURPOSE

The purpose of this study was to investigate the effects and safety of prone positioning for patients with severe motor disabilities.

PARTICIPANTS

We targeted ten participants (5 males, 5 females; mean age 40.8 ± 9.7 years) who suffered from quadriplegia caused by brain disease. The diagnostic names of the subjects were nine cerebral palsy (CP) and one head injury sequelae. All of the subjects with CP were gross motor function classification system V level. The level of motor function of the patient with head injury sequelae was equal to those with CP.

METHODS

The intervention period was 8 weeks. Pulse, blood pressure, oxygen concentration and respiratory rate were measured before and immediately after each implementation of the prone positioning. Muscle tone was measured on the intervention start date and the intervention end date. Adverse events were tracked throughout the intervention period as part of the safety assessment.

RESULTS

The number of times the prone position was performed on each patient was 6.3 times (range, 4–11) on average, and the average intervention time per session was 24.1 min (range, 20.2–31.1).

Oxygen concentration showed a significant increase compared to before the intervention ($p < 0.05$). Muscle tone showed a significant decrease ($p < 0.05$). No adverse events were observed during the intervention period.

CONCLUSION

Prone positioning for quadriplegic patients who present severe motor disabilities due to cerebral disease can be expected to have a certain effect even for short-term intervention, so it is possible to consider safe intervention according to the subjects.

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—Key words—

cerebral palsy, prone positioning, severe motor disabilities

Introduction

Cerebral palsy (CP) is the most common childhood neurodevelopmental disorder associated with lifelong motor impairment[1]. Compromised respiratory function, often evident in adolescents and adults with severe CP, originates with underdevelopment of the upper chest wall. This underdevelopment inhibits chest expansion and can result in rapid and paradoxical breathing patterns[2]. Pneumonia accounts for 60% of the causes of death among children with CP[3]. The majority have severe spastic quadriplegia, intellectual disability and epilepsy. So, respiratory dysfunction is greatly related to life prognosis, especially to risk factors for death in children.

The use of positioning to improve respiratory function has been studied in both healthy and clinical populations across different age groups[2]. Current evidence strongly supports that prone positioning has a beneficial effect on gas exchange, respiratory mechanics, lung protection and hemodynamics because it redistributes transpulmonary pressure, stress and strain throughout the lung and unloads the right ventricle[4]. Conceptually, prone positioning may result in a more uniform distribution of lung stress and strain, leading to improved ventilation-perfusion matching and regional improvement in lung and chest wall mechanics[5]. A previous study showed that prone positioning, compared to supine positioning, markedly reduced the overinflated lung area while promoting alveolar recruitment[6].

However, implementation of the prone position is more difficult than the supine position and sidelying position because the patient's facial expressions are difficult to see, and the transfer is accompanied by suffocation risks due to obstruction of the nose, mouth and tracheostomy.

Although the effects on respiratory function by positioning in the supine, sitting and sidelying positions have been investigated[2], few reports have examined prone positioning.

The purpose of this study was to investigate the effects and safety of prone positioning for patients with severe motor disabilities.

Participants

We targeted ten participants (5 males, 5 females; mean age 40.8 ± 9.7 years) who suffered from quadriplegia caused by brain disease. Because of severe motor disabilities, they found it difficult to change posture by themselves. The participants visited our facility to participate in daytime activities. All participants include their family agreed to participate in this study. This study was conducted with the permission of the facility manager.

They attended the facility for 4.7 days on average (2–5) per week.

The diagnostic names of the subjects were nine CP and one head injury sequelae. All of the subjects with CP were gross motor function classification system (GMFCS) V level[7]. The level of motor function of the patient with head injury sequelae was equal to those with CP.

The subjects were transported in a manual wheelchair in all settings and limited in their ability to maintain antigravity head and trunk postures and control arm and leg movements.

Methods

The intervention period was 8 weeks. Pulse, blood pressure, oxygen concentration and respiratory rate were measured immediately before and immediately after each implementation. Muscle tone was measured on the intervention start date and the intervention end date. Adverse events were tracked throughout the intervention period as part of the safety assessment.

Because the subjects found it difficult to sit in a prone position on a flat surface due to joint contractures and deformities of limbs and trunk, we used a device to support the prone position that considered individual body structure. The device was a cube with a height of about 40 cm and was mainly used to hold the front of the trunk. This main material of the device was a Styrofoam block. The upper surface of the device where the trunk is grounded was a layer of urethane cushion. A wooden backing with cushioning material to support the head was used.

Three to four staff members supported the head, trunk and lower limb, respectively, for the transfer into the prone position of the subjects who had been tracheotomized. In order to prevent the neck from twisting, we carefully adjusted the timings at which the staff assisted the posture change. For a subject who was using a cannula in the tracheostomy, we removed the heat and moisture exchanger connected to the cannula because the discharge of secretions from the cannula was considerable in the prone position. During the prone position, due to the danger of obstructing the airways such as the nose and mouth, we performed proximal monitoring.

Table 1 Changes in measurement values before and after the intervention

Item	Before intervention	After intervention	p value
Respiratory rate (breaths /min)	15.9 ± 5.6	16.0 ± 4.8	0.779
SpO2 (%)	95.6 ± 1.3	96.5 ± 1.1	0.011
Pulse (beats/ min)	78.9 ± 11.2	79.2 ± 11.9	0.878
Systolic blood pressure (mmHg)	103.4 ± 9.1	103.5 ± 8.7	0.953
Diastolic blood pressure (mmHg)	66.4 ± 9.1	66.2 ± 9.4	0.905
Muscle tone (score)	10.3 ± 3.6	8.6 ± 3.7	0.036

Pulse, blood pressure, oxygen concentration and respiratory rate were measured immediately before and after implementation, and the average values were calculated. Muscle tone was evaluated using the Modified Ashworth Scale[8] to evaluate the left and right elbow flexor, and knee flexor muscles.

Adverse events were considered to be the onset of pneumonia after the prone positioning and accidents during transfer assistance.

Statistical analyses were performed using Wilcoxon signed rank test, before and after comparison of pulse, blood pressure, oxygen concentration, respiration rate and muscle tone. The statistical software was IBM SPSS statistics ver 22, and the risk rate was set to a significance level of less than 5%.

Results

The number of times of the prone position was performed on each patient was 6.3 times (range, 4–11) on average, and the average intervention time per session was 24.1 min (range, 20.2–31.1).

The results of changes in pulse, blood pressure, oxygen concentration, respiratory rate and muscle tone before and after the intervention are presented in Table 1.

Oxygen concentration showed a significant increase compared with before the intervention ($p < 0.05$). Muscle tone showed a significant decrease ($p < 0.05$). Pulse, blood pressure and respiratory rate did not show any significant change before and after the intervention. Natural levels of respiratory tract secretions were observed in 8 of 10 cases during the prone position.

No adverse events were observed during the intervention period.

Discussion

This study investigated the effects and safety of prone positioning in subjects with quadriplegia caused by brain disease.

The results of the intervention showed a significant increase in oxygen saturation after prone position. The subjects in this study included cases in which the oxygen saturation before intervention was SpO_2 94–97%. After the intervention, there was a significant improvement in oxygen saturation.

Even in CP patients who can walk, movement of the rib cage during deep breathing is decreased compared with healthy children[9], and upper thoracic hypoplasia is observed on a chest X-ray[10]. It is presumed that due to low momentum until about 6 years old, when the lung is fully developed, the compliance of the lungs and thorax is low. The compliance is also reduced by the tone of muscles around the upper extremities and in the intercostal muscles around the shoulder. Therefore, the patients of this study were at risk of respiratory dysfunctions such as pneumonia.

It has been reported that prone positioning improves oxygenation ability in acute respiratory distress syndrome (ARDS) patients[1]. This positioning can prevent new pulmonary complications as part of respiratory physiotherapy. Prone positioning is used as an adjunctive therapy that improves oxygenation in the majority of patients with ARDS. Mancebo showed that an average of 17 hours per day of prone positioning for severe ARDS patients decreased the possibility of mortality[11]. In a multicenter, prospective, randomized, controlled trial for patients with severe ARDS, early application of prone-positioning sessions of at least 16 hours significantly decreased the 28-day to 90-day mortality[12]. It has been reported that the use of the prone position improves oxygenation within the first hour in ARDS patients[13]. Although the prone position was not included, Sheila[1] reported the influence of the supine position, the sitting position, and the sidelying position for CP of GMFCS V level with an intervention time of 20 min. The results showed that the use of therapeutic positioning in sitting and sidelying positions should be considered as a noninvasive intervention for a population with respiratory compromise.

Taking these results into consideration, even for a short period of intervention time compared with the ARDS case, it is estimated that the redistribution of the expansion gradient from the dorsal side to the ventral side leads to improvement of oxygen supply.

No adverse events were observed in this study during the intervention period. We followed the technique of Langer et al., who manually changed the position using four staff members as a postural change of prone position for ARDS patients. Attention was paid to avoid eye damage and unphysiologic movement of the extremities during the posture changes. In that way, no adverse events related to the prone position were observed during the intervention period[14]. Guerin et al. showed all institution that studied the effect of prone position on severe ARDS patients were skilled in the process of turning patients from the supine to the prone position, as shown by the absence of adverse events directly related to repositioning[12].

Factors considered to have led to the safety of this research were the implementation by 3 to 4 members of the care staff who were familiar with the physical condition of the subjects, consideration for the tracheostomy, monitoring in proximity to the subject, and use of a device for holding the prone position according to the subject's body shape.

In this case, pneumonia and fever were not observed during the intervention period. It was speculated that the natural discharge of respiratory tract secretions in the prone position could have influenced the prevention of aspiration.

In relation to the physical activity and the healthy life span of CP patients, sedentary behavior (SB) is known to have an adverse effect on health[15][16]. The metabolic equivalent of a task (MET) used in this table is a physiological measure expressing the energy cost of physical activities and is defined as the ratio of the metabolic rate during a specific physical activity to a reference metabolic rate (1 MET), set by convention at 3.5 mL O_2/kg/min. A recently published standardized definition of SB is any waking behavior characterized by an energy expenditure of 1.5 METs in muscular inactivity while in a sitting or reclining posture[17].

Therefore, strategies to increase physical activity levels in children and adolescents with CP are considered important for long-term health[18]. For patients with severe motor disabilities, such as the subjects in this study, who found it difficult to change posture, opportunities for attitude change are considered important exercise opportunities. Therefore, implementation of various posture variations is an important consideration for health life extension.

Although the relationship between postural change and life extension was not clarified because the long-term prognosis was not considered, due to the safety of implementation of prone position therapy, it is desirable to contribute to the prolongation of healthy life in the future.

From the results of this study, prone positioning for quadriplegic patients who present severe motor disabilities due to cerebral disease can be expected to have a certain effect even for short-term intervention, so it is possible to consider safe intervention according to the subjects.

A limitation of this study was that only ten cases were evaluated. Although it was possible to show that effective changes occurred using this method, it is necessary to carry out long-term intervention in the future and verify it including its effects.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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重度運動障害のある者における腹臥位ポジショニングの安全性

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ーキーワードー
脳性麻痺，腹臥位ポジショニング，重度運動障害

目的
本研究では，重度運動障害のある人の腹臥位ポジショニングの効果とリスクを考慮するための安全性の検討を行った．
対象
対象者は，脳原性疾患による四肢麻痺を呈した 10 名（男性 5 名，女性 5 名，平均年齢 40.8±9.7 歳）とした．診断名は，脳性麻痺 9 名，頭部外傷性脳損傷 1 名である．対象者の内，脳性麻痺者はすべて gross motor function classification system V レベルである．頭部外傷性脳損傷者も運動能力レベルは脳性麻痺の対象者に準じている．
方法
介入期間は 8 週間とした．脈拍，血圧，酸素濃度，呼吸数は，腹臥位実施直前と直後に評価し，筋緊張は介入開始日と介入終了日，有害事象は介入期間中に測定した．
有害事象に関しては，腹臥位実施後の肺炎発症や腹臥位への移乗介助での事故が生じたときは有害事象ありと判断した．
統計解析は，脈拍，血圧，酸素濃度，呼吸数，筋緊張の実施前後の比較は，Wilcoxon の符号付き順位和検定を用い分析した．統計ソフトは，IBM SPSS statistics ver 22 を用い，危険率は有意水準 5% 未満とした．
結果
腹臥位療法の実施回数は，平均 6.3 回（4～11），1 回あたりの平均介入時間は 24.1 分間（20.2～31.1）だった．
酸素濃度は実施前と比較して実施後に有意な増加を示した（$p<0.05$）．筋緊張は有意な低下を認めた（$p<0.05$）．
脈拍，血圧，呼吸数は，介入前後で有意な変化を認めなかった．介入期間中において，有害事象は認めなかった．
結論
本研究の結果から，脳原性疾患に起因する重度運動障害を呈する四肢麻痺者に対する腹臥位ポジショニングは，短時間の介入でも一定の効果が期待できるため，対象者に応じて安全に配慮して実施することが可能である．

利益相反基準に該当無し

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