Sequential mechanical ventilation improves hemodynamics, cardiac function and neurohumoral status in elderly patients with acute left heart failure

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ABSTRACT

Objective: To analyze the effect of sequential mechanical ventilation on improving hemodynamics, cardiac function and neurohumoral status in elderly patients with acute left heart failure. Methods: A total of 90 cases of elderly patients with acute left heart failure were randomly divided into observation group and control group, control group received conventional mechanical ventilation therapy, observation group received sequential mechanical ventilation, and then differences in hemodynamics, cardiac function and neurohumoral status were compared between two groups after treatment. Results: 24 h after treatment, mPAP, PCWP and RAP levels of observation group after treatment were lower than those of control group, and CO level was higher than that of control group; LVEF value was higher than that of control group, and SVR, LVEDV and LVESV values were lower than those of control group; 12 h and 24 h after treatment, plasma Nt-proBNP, ANP, R, Ang II and ALD levels of observation group were significantly lower than those of control group. Conclusion: Sequential mechanical ventilation can optimize the illness in elderly patients with acute left heart failure, and plays a positive role in promoting patients’ cardiac function recovery, restoring homeostasis and other aspects.

1. Introduction

Left heart failure trends to occur in elderly people with hypertension and diabetes, and in the case of acute onset, the condition is critical and the mortality rate is high. In addition to routine anti-heart failure drug treatment, mechanical ventilation is currently considered as a reliable way to maintain pulmonary ventilation function. According to the establishment of artificial airway or not, mechanical ventilation can be divided into invasive positive pressure ventilation (IPPV) and noninvasive positive pressure ventilation (NIPPV), and IPPV applies to patients with spontaneous breathing disorders and poor consciousness and helps to clear the airway secretions; NIPPV is suitable for patients with good consciousness and patients after weaning of IPPV, and there are airway drainage and poor impermeability if it is applied in unconscious patients[1,2]. Given the advantages and disadvantages of IPPV and NIPPV, some scholars recommend the combination of the two to form invasive-non-invasive sequential mechanical ventilation, which is suitable for different periods of acute heart failure in patients[3]. In the study, sequential mechanical ventilation was applied in elderly patients with acute left heart failure, and the effect of the ventilation mode on optimizing hemodynamics, cardiac function, neurohumoral status and other aspects was mainly elaborated.

2. Information and methods

2.1. General information

A total of 90 cases of elderly patients with acute left heart failure who received emergency treatment in our hospital from August 2013 to August 2015 were included, and the inclusion criteria were: (1) the acute left heart failure was mainly characterized by acute pulmonary edema; (2) 60 years old; (3) PaO<sub>2</sub>&lt;60 mmHg and oxygenation function further declined; (4) without serious underlying pulmonary diseases; (5) with disturbance of consciousness; (6) patients’ families signed informed consent. Exclusion criteria: (1) with serious liver and kidney dysfunction; (2) with blood system or immune system diseases; (3) with...
malignant tumor diseases. 90 patients were randomly divided into observation group and control group (n=45), control group included 25 male cases and 20 female cases that were 60-72 years old and (65.48±6.11) years old in average, 42 cases were with hypertension and 39 cases were with coronary heart disease; observation group included 24 male cases and 21 female cases that were 61-74 years old and (64.31±7.48) years old in average, 43 cases were with hypertension and 38 cases were with coronary heart disease. Two groups of patients were not statistically different in distribution of age, gender and history of hypertension and coronary heart disease (P>0.05), and they were comparable.

2.2. Treatment methods

Observation group received sequential mechanical ventilation, specifically as follows: were connected to the breathing machine via oral trachea cannula and received invasive positive pressure ventilation (IPPV), and in accordance with the principle of low tidal volume and low positive end-expiratory pressure, bi-level positive air pressure ventilation was adopted, and midazolam was used early to block spontaneous breathing in patients (to prevent man-machine confrontation). Inspiratory-phase airway pressure was set to 10-20 cmH₂O (maximum of 22 cmH₂O), expiratory-phase airway pressure was 4-5 cmH₂O (maximum of 8 cmH₂O), respiratory frequency was 16-20 times/min, inspiratory/expiratory ratio was 1:2, and inhaled oxygen concentration was 60% and could be gradually adjusted to 16-20 times/min, inspiratory/expiratory ratio was 1:2, and inhaled oxygen concentration was 60% and could be gradually adjusted to 35%-45% according to patients' conditions. Spontaneous breathing trial (SBT) was conducted when patients met the following conditions: 1) the cardiac function was improved; 2) pulmonary infiltrative shadow become smaller; 3) pulmonary rale decreased, the tube could be drawn if the patients could tolerate spontaneous breathing, then bi-level positive air pressure (BiPAP) was conducted, the inspiratory pressure was adjusted, the machine could be removed when the inspiratory pressure 5 cmH₂O, and oxygen supply via nasal catheter was adopted. If SBT failed, the original ventilation was maintained, and after SBT succeeded, subsequent ventilation scheme was conducted.

Control group received IPPV ventilation consistent with that of observation group, the ventilation parameters were consistent, they continued to receive mechanical ventilation when the cardiac function and pulmonary manifestation were improved, the pressure was adjusted and kept at 5-10 cmH₂O, PEEP was adjusted to 4-5 cmH₂O, and after the indicators were stable, the tube was drawn, the machine was removed and oxygen supply via nasal catheter was adopted.

2.3. Observation indexes

2.3.1. Hemodynamic parameters

24 h after treatment, two groups of patients received hemodynamic detection at the bedside, Swan-Cans float catheter was indwelled via subclavian approach, pressure and ECG monitoring were connected, and pulmonary artery pressure (mPAP), pulmonary capillary wedge pressure (PCWP), right atrial pressure (RAP) and cardiac output (CO) were measured.

2.3.2. Cardiac function parameters

24 h after treatment, echocardiography was used to detect left ventricular ejection fraction (LVEF), systemic vascular resistance (SVR), left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV) of two groups after treatment.

2.3.3. Neurohumoral factors

12 h and 24 h after treatment, 2 mL of peripheral blood was collected from two groups, let stand at room temperature for 15 min and centrifuged for 10 min at 3 000 r/min, and the plasma was collected and cryopreserved in -80 °C refrigerator for testing. Enzyme-linked immunosorbent assay (ELISA) was used to determine plasma N-terminal pro-brain natriuretic peptide (Nt-proBNP) atrial natriuretic peptide (ANP), renin (R), angiotensin II (Ang II) and aldosterone (ALD) level.

2.4. Statistical methods

SPSS 23.0 was used to input and analyze the data obtained in the study, measurement data was in terms of (mean ± SD), comparison between groups was by t test, correlation analysis was by unary linear regression and P<0.05 was set as the standard of statistical significance in differences.

3. Results

3.1. Hemodynamic parameters

24 h after treatment, analysis of hemodynamic parameters mPAP, PCWP, RAP and CO of two groups measured by Swan-Cans float catheter after treatment was as follows: mPAP, PCWP and RAP levels of observation group after treatment were lower than those of control group, CO level was higher than that of control group, and differences in hemodynamic parameters mPAP, PCWP, RAP and CO were statistically significant between two groups (P<0.05), shown in Table 1.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>mPAP (kPa)</th>
<th>PCWP (kPa)</th>
<th>RAP (kPa)</th>
<th>CO (L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>45</td>
<td>3.47±0.41</td>
<td>2.15±0.26</td>
<td>1.57±0.19</td>
<td>5.58±0.61</td>
</tr>
<tr>
<td>Control</td>
<td>45</td>
<td>4.52±0.49</td>
<td>3.11±0.34</td>
<td>2.12±0.23</td>
<td>4.25±0.48</td>
</tr>
<tr>
<td>t</td>
<td></td>
<td>5.384</td>
<td>6.092</td>
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<td>6.861</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td>&lt;0.05</td>
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</tr>
</tbody>
</table>

3.2. Cardiac function indexes

24 h after treatment, analysis of cardiac function indexes LVEF, SVR, LVEDV and LVESV of two groups after treatment was as follows: LVEF value of observation group after treatment was significantly higher than that of control group, SVR, LVEDV and LVESV values were significantly lower than those of control group, and differences in cardiac function indexes LVEF, SVR, LVEDV and LVESV were statistically significant between two groups after treatment (P<0.05), shown in Table 2.
Table 2.
Comparison of cardiac function index values between two groups after treatment.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>LVEF (%)</th>
<th>SVR (kPa•s)</th>
<th>LVEDV (mL)</th>
<th>LVESV (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>45</td>
<td>43.28±4.21</td>
<td>124.28±14.92</td>
<td>121.73±14.39</td>
<td>58.35±6.11</td>
</tr>
<tr>
<td>Control</td>
<td>45</td>
<td>38.26±4.05</td>
<td>145.22±16.73</td>
<td>140.58±17.24</td>
<td>68.63±7.19</td>
</tr>
<tr>
<td>t</td>
<td>6.384</td>
<td>8.394</td>
<td>8.681</td>
<td>7.293</td>
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</tr>
<tr>
<td>P</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

3.3. Neurohumoral factors

12 h and 24 h after treatment, analysis of plasma neurohumoral factors Nt-proBNP and ANP of two groups was shown in Table 3: plasma Nt-proBNP and ANP levels of observation group after treatment were significantly lower than those of control group; analysis of plasma neurohumoral factors R, Ang I and ALD was shown in Table 4: plasma R, Ang I and ALD levels of observation group after treatment were significantly lower than those of control group, and differences in serum Nt-proBNP, ANP, R, Ang I and ALD levels were statistically significant between two groups after treatment (P<0.05).

4. Discussion

Acute left heart failure is a clinical severe disease, accounts for more than 40% of the incidence of various heart failures, progresses quickly and has high mortality. After left heart failure occurs, suddenly declined cardiac contractility and sharply reduced cardiac output lead to the occurrence of acute pulmonary edema, ventilation dysfunction, etc., and the respiratory and metabolic alkalosis results in the occurrence of increased respiratory muscle work and secondary respiratory failure in patients[4,5]. After acute left heart failure, respiratory dysfunction is the most common and most serious complication that can further aggravate patients' cardiac function and increase blood circulation resistance. Research shows that mechanical ventilation can increase the intrathoracic pressure and reduce the venous return, which help to reduce left ventricular afterload and decrease the work of heart. Many studies have confirmed that mechanical ventilation can improve the circulatory function of patients with acute heart failure and help to optimize the disease. According to the establishment of artificial airway or not, mechanical ventilation can be further divided into invasive positive pressure ventilation (IPPV) and noninvasive positive pressure ventilation (NIPPV), IPPV is mainly used for patients with disturbance of consciousness and difficult spontaneous breathing, NIPPV is suitable for the patients with good state of consciousness and spontaneous breathing, and the two ventilation modes have both pros and cons[6]. With progress of treatment, patients with acute left heart failure would be in different states of consciousness and breathing, so many scholars recommend the combination of IPPV and NIPPV in the clinical treatment to form new invasive-non-invasive sequential mechanical ventilation technology, which, on the premise of meeting the patients' demand for ventilation, reduces ventilation complications as much as possible[7].

In the study, observation group of patients received sequential mechanical ventilation, and protective lung ventilation strategy was adopted to set low tidal volume and low positive end-expiratory pressure (PEEP). Inspiratory phase can increase the alveolar pressure, and low PEEP can prevent alveolar and small airway collapse, also increase the effective gas exchange area and reduce the ventilation dysfunction caused by left heart failure and alveolar effusion[8,9]. Foreign research on patients with heart failure has confirmed that positive pressure ventilation that adds PEEP can slow down the patients' heart rate, increase the partial pressure of blood oxygen and positively feed back to the patients' cardiac function at the same time, leading to increased left ventricular ejection fraction (LVEF). In order to define the effect of sequential mechanical ventilation on hemodynamics in patients, both groups of the study received hemodynamic testing at bedside after treatment, and it was found that mPAP, PCWP and RAP levels of observation group after treatment were lower and CO level was higher. Pulmonary artery pressure (mPAP), pulmonary capillary wedge pressure (PCWP), right atrial pressure (RAP) and cardiac output (CO) are all typical hemodynamic parameters, and float catheter indwelling in carotid artery and left heart can detect the real-time hemodynamic status in patients with heart failure and intuitively reflect the process of heart failure. After left heart failure, pump function weakens and blood accumulates in the lungs, causing elevated mPAP, PCWP and RAP levels and suddenly declined CO level, the study results show that the sequential mechanical ventilation effectively reduces the intrapulmonary pressure and increases the heart pump function, and this is mainly because that the mechanical ventilation improves pulmonary ventilation and oxygenation, produces favorable hemodynamic changes, inhibits sympathetic excitement and reduces the peripheral vascular resistance[10,11].

Table 3.
Plasma Nt-proBNP and ANP levels of two groups after treatment (ng/L).

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>12 h after treatment</th>
<th>24 h after treatment</th>
<th>12 h after treatment</th>
<th>24 h after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>45</td>
<td>482.15±55.09</td>
<td>338.91±44.65</td>
<td>144.36±17.59</td>
<td>106.95±13.28</td>
</tr>
<tr>
<td>Control</td>
<td>45</td>
<td>579.63±62.41</td>
<td>476.87±58.64</td>
<td>187.25±20.44</td>
<td>158.79±19.78</td>
</tr>
<tr>
<td>t</td>
<td>6.273</td>
<td>8.181</td>
<td>7.283</td>
<td>6.958</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.
Plasma R, Ang I and ALD levels of two groups after treatment.

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>12 h after treatment</th>
<th>24 h after treatment</th>
<th>12 h after treatment</th>
<th>24 h after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>45</td>
<td>2.59±0.32</td>
<td>2.09±0.36</td>
<td>233.16±25.23</td>
<td>184.56±21.37</td>
</tr>
<tr>
<td>Control</td>
<td>45</td>
<td>3.63±0.51</td>
<td>3.39±0.52</td>
<td>281.75±30.88</td>
<td>214.65±30.59</td>
</tr>
<tr>
<td>t</td>
<td>7.954</td>
<td>7.118</td>
<td>8.192</td>
<td>6.498</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td></td>
</tr>
</tbody>
</table>
Cardiac function decrease is the direct cause of left heart failure, so the heart function detection is also the most visible indicator to clarify the current situation and treatment efficacy of acute left heart failure. Left ventricular ejection fraction (LVEF) represents myocardial contractility, systemic vascular resistance (SVR) is inversely proportional to the cardiac output, and the left ventricular end-diastolic volume (LVEDV) and left ventricular end-systolic volume (LVESV) are inversely proportional to myocardial contractility[12]. It was found in the study that after observation group received sequential mechanical ventilation, LVEF value increased while SVR, LVEDV and LVESV values decreased, and it indicated that their myocardial contractility was enhanced and peripheral vascular resistance decreased, which contributed to the continuous blood circulation pumping. Sequential mechanical ventilation is that when lung congestion, breathing disorders and so on are eased after IPPV but have not reached the traditional standard of weaning yet, the tube is early drawn and replaced with NIPPV, and the main purpose is to shorten the time of IPPV and reduce the airway injury, ventilator-associated pneumonia and other complications caused by long time of IPPV[13]. The above results confirm that sequential mechanical ventilation can more effectively promote the cardiac function recovery in patients, the internal mechanism may be that for IPPV ventilation reduces preload and afterload of the left heart and improves myocardial compliance, and early extubation avoids respiratory muscle atrophy and breathing-machine-related complications, avoids the risk of breathing machine and also maximizes the role of positive pressure ventilation.

After acute left heart failure, the levels of a series of neurohumoral factors change in the body, and they are directly involved in the occurrence and aggravation of heart failure. In addition to focusing on cardiac function and hemodynamic state, clinical treatment of patients with heart failure also focuses on the change of neurohumoral factors, which is an important auxiliary means to judge the trend of disease. Study has confirmed that a variety of neurohumoral factors have been activated in the early heart failure, including the Nt-proBNP, ANP, R, Ang II, ALD, etc.[14]. Brain natriuretic peptide (BNP) and atrial natriuretic peptide belong to natriuretic peptide, brain natriuretic peptide is expressed in ventricle, atrial natriuretic peptide is synthesized by the atrium, and both can dilate blood vessels, increase baroreflex sensitivity, etc. As ventricular tension increases, BNP secretion increases, its release is directly proportional to ventricular dilatation and pressure load, and therefore, it is recognized as the sensitive and specific index reflecting left cardiac insufficiency. Nt-proBNP is the BNP split product, is the circulatory stable form of the BNP, and can objectively reflect the BNP level. Analysis in the study showed that plasma Nt-proBNP and ANP levels of observation group were lower after treatment. Study has also confirmed that the activation of renin-angiotensin-aldosterone system is associated with ventricular remodeling and cardiac function decline in patients with chronic heart failure[15]. Analysis in the study showed that plasma R, Ang II and ALD levels of observation group were lower after treatment, indicating that sequential mechanical ventilation can effectively regulate the abnormal neurohumoral factors, promote the optimization of myocardial and vascular function, reduce ventricular diastolic and systolic function injury and avoid further deterioration of disease in patients with heart failure.

To sum up, sequential mechanical ventilation can optimize the hemodynamics, cardiac function and neurohumoral status in elderly patients with acute left heart failure, and it helps to inhibit the deterioration of disease and improve treatment outcome.

References