

## **Respiratory defense in COVID-19 critical area: how tens of thousands of respirators saved lives in Hubei Province**

As no specific medicine has been developed, the current treatment for patients with new crown is mainly symptomatic support treatment. For critical patients, the key to successful treatment is to help them survive the refractory hypoxemia period and avoid multiple organ damage. The National Health Care Commission's diagnosis and treatment program includes four kinds of respiratory support for severe and critical patients. Mechanical ventilation is the most important way. Ventilator treatment, in order to achieve the best results, requires very professional and meticulous care. If you neglect a little, you may lose all your achievements. With the spread of the new crown, ventilator has become the most popular anti epidemic medical equipment.

After a month and a half of support in Jingmen, Hubei Province, Xu Peifeng returned to Zhejiang for two weeks of isolation. He wasn't idle. "Every day, he was working out and preparing to play the whole game - not that we played the whole game in the first half of China and the second half of the world."

Xu Peifeng, a respiratory therapist from Shao Yifu Hospital of Zhejiang University, arrived in Jingmen on the afternoon of February 12 and joined the team in Jingmen first people's hospital.

"When I first arrived, the situation was not optimistic. Looking at the patients whose condition had deteriorated extremely, I felt helpless." Memories of Xu Peifeng. In February 16th, when novel coronavirus pneumonia patients were crowned in the Zhejiang critical care medical team in Jingmen, 915 Cases were diagnosed and 33 died in Jingmen. The mortality rate was the first in Hubei. "Our first priority is to reduce death."

According to a statistics released by the Chinese Medical Association in February, 13.8% of the new crown and 4.7% of the critical cases were severe cases. In critical cases, the crude mortality rate is as high as 49%. A retrospective study published in the lancet in late February showed that 32 (61.5%) of 52 critically ill patients died within 28 days after admission to the ICU, and 26 of them developed acute respiratory distress syndrome (ARDS) before death, accounting for 81%.

The clinical manifestations of ARDS are shortness of breath and distress, progressive hypoxemia (lack of oxygen in the blood). Normal adults breathe 12 to 20 times a minute to ensure the body's oxygen supply. In patients with ARDS, they may breathe more than 45 times per minute, but they are still lack of oxygen. The consequence of continuous hypoxemia is the failure of heart, brain, kidney and other important organs, which eventually leads to the death of the body.

Experts involved in the first-line treatment in Wuhan believe that the key to successful treatment is how to help severe patients survive the refractory hypoxemia period and avoid multiple organ function damage.

Since no specific drug has been developed for the new coronavirus, the current treatment methods are mainly symptomatic support treatment. For a large number of severe and critical patients who have respiratory failure or even progress to ARDS, the main treatment method is to use ventilator and other equipment to help patients maintain breathing, guarantee the oxygen supply of the body, and strive for time for the recovery of the immune system and the implementation of other treatment methods.

In this sense, novel coronavirus pneumonia is a battle of respiratory security for severe and critically ill patients. With the global outbreak, the main weapon of this "battle" - ventilator, has become the most popular medical equipment. When British Prime Minister Boris Johnson was asked by US President Trump how he felt after his diagnosis, his first sentence was "we need a ventilator"!

At the beginning of the outbreak of the domestic epidemic, there was also a tense situation of equipment and manpower. Under such circumstances, Xu Peifeng and tens of thousands of other medical workers put themselves into the front line of anti epidemic in Hubei Province.

#### Passive start

In the new crown epidemic in China, most of the deaths are concentrated in Hubei Province. According to the statistics released by the National Center for Disease Control and prevention, the number of deaths in Hubei Province began to increase rapidly from late January to mid February, peaked on February 12 (242 cases were newly increased on that day), and gradually slowed down after February 23.



In late January, the mortality rate of new crown patients in Hubei Province once exceeded 5%.

Xu Peifeng thinks that there are two reasons for the high early mortality. First, local medical resources are limited, and it is difficult to cope with the outbreak. "For example, in a county under Jingmen, the patient's chest is very stuffy and short of breath, but the local conditions are limited, so he can only do routine oxygen therapy. There may be a ventilator, but it is also a small machine, which may be difficult to help the patient to get better." On the other hand, "we are also gradually deepening the cognitive process of this disease, not immediately can take the most effective treatment."

The national health and Health Commission's diagnosis and treatment program includes four types of respiratory support for patients with severe and critical diseases: (1) oxygen therapy: nasal catheter or mask oxygen inhalation; (2) high flow nasal catheter oxygen therapy or non-invasive mechanical

ventilation; (3) invasive mechanical ventilation; (4) pulmonary Resurrection or extracorporeal membrane oxygenation (ECMO, artificial lung). Among them, ordinary oxygen therapy has limited effect on critical patients, and the cost of ECMO is too high, which is also embarrassing to use. Ventilator becomes the most important respiratory support equipment.

Jingmen No.1 Hospital is a top three hospital. Xu Peifeng remembers that when he first arrived, because the ward was an ordinary ward before, the equipment was quite tense. There was only one V60 (a Philips ventilator model) for a large non-invasive ventilator. Although there are about 67 small non-invasive machines, their performance is relatively poor. "When we found out about this situation, we began to actively contact for assistance. Later, we donated about 20 ventilators in total, and the tension was relieved."

It is understood that in general, even if the ventilator is fully configured according to the ICU bed, one bed for one, it is only about 1% of the total bed. In Wuhan City, according to the 2017 City Statistical Yearbook, 45 top three hospitals in the city have more than 90000 beds in total. According to the ratio of 1%, the ventilator configuration in the city is also less than 1000, far from meeting the demand. Since the outbreak of the new crown epidemic, the number of severe patients in Hubei Province has exceeded 11000 (more than 9000 in Wuhan).

Therefore, while medical teams from all over the country have been rushing to Hubei, ventilator and other equipment from all over the country and even the world have been continuously transported to Hubei by means of purchase and donation. As of February 24, the Ministry of industry and information technology coordinated the delivery of 15000 ventilators to Hubei. By March 3, there were about 14000 non-invasive ventilators and more than 2900 invasive ventilators for Hubei Province. According to media reports, ICBC Europe even went to Philips headquarters in the Netherlands to contact and order respirators to support Wuhan.

After the hardware is in place, there are still new problems. Xu Peifeng mentioned that after a respiratory therapist supporting Wuhan went there, he found that the local medical staff reported that a ventilator was broken and could not be used. "In the past, when I saw that one of the small joints did not match, I immediately changed the joint for him and retested it. The machine can be used immediately. If you don't have specialized knowledge in this field, you may just have to watch it, and it's useless to have equipment. "

### Fight for life and death

Yu Zhenghao, head nurse of RCU in respiratory and critical care medicine department of Wuhan Central Hospital, introduced that "for general mild respiratory failure, ordinary oxygen therapy is used, such as double nasal oxygen tube or oxygen mask; if there is a slightly heavier respiratory failure or high demand for oxygen concentration, it may be upgraded to high flow oxygen therapy. If the patient's respiratory distress is obvious, and the parameter of high flow rate is raised to a certain degree, or it cannot be improved, then it may be necessary to enter non-invasive (ventilator) treatment. "

The biggest difference between mechanical ventilation and ordinary oxygen therapy is the increase of external air pressure assistance. Using a noninvasive ventilator, the ventilator presses air into the lung through a certain high pressure when inhaled, and gives a lower pressure when exhaled, which makes people exhaust carbon dioxide from the vent hole on the mask through the nose and mouth.

As a novel coronavirus pneumonia device, which is an effective device to replace artificial ventilation, it is the key medical equipment for treating severe diseases such as new crown pneumonia. How does a ventilator work?

"Rather than relying on the patient's own efforts to breathe, the machine helps the patient to breathe." Yu Zhenghao said, "so as long as the condition allows, we usually use high flow (nasal tube oxygen therapy) and noninvasive ventilator alternately."

"We have several so-called miraculous cases here." Yu Zhenghao was most impressed by a female patient in her 70s. When she was in the most critical stage, her renal function had failed, but she survived and transferred out of the ICU. "I remember that for three or four days in a row, there were only 340 ml of urine per day. But her willpower is very strong. She basically uses V60 to treat her. She cooperates very well. In the whole process, her respiratory rate, including heart rate, is quite controllable. Renal function has also been corrected, without dialysis. "

It is understood that the turbine power of V60 ventilator is large, and it can automatically adjust the oxygen concentration according to the severity of hypoxia, and the regulating range can reach 21% - 100% (normal air oxygen content is 20%). According to Kong Jieyan, an expert in ventilator products from Philips, the problem of air leakage caused by non-invasive breathing opportunities can be solved by using dual-a technology in V60, which can calculate the air leakage in real time and accurately replenish the air; in addition, it can automatically adjust the trigger sensitivity, so that the machine can "sense" the patient's inspiratory action, and then cooperate with the air supply.

"Of course, when the noninvasive treatment reaches a certain level, for example, the most obvious is that the patient's oxygen saturation and blood gas index have not been improved significantly, or some internal environment (the environment in which the cells are located in the body) is abnormal, such as acid-base imbalance, we need to carry out a higher level of respiratory support according to the diagnosis and treatment specifications." Yu Zhenghao said.

According to the diagnosis and treatment plan, respiratory distress and / or hypoxemia did not improve or even worsen within 1-2 hours after using high flow nasal catheter oxygen therapy or noninvasive ventilation, and tracheal intubation and invasive mechanical ventilation should be carried out in time.

The human trachea is located below the pharynx and passes through the bronchus to the lungs. Hundreds of millions of alveoli with an average diameter of 0.2 mm are connected to the end of the bronchus. With breathing action, the alveoli stretch and relax, exchanging oxygen and carbon dioxide with the capillaries, so as to maintain metabolism. Endotracheal intubation is to put a special hose through the mouth or nose, through the glottis into the patient's trachea, so as to establish an artificial

airway connecting the ventilator. The ventilator will directly input oxygen of certain pressure into the lungs to help the alveoli damaged by the virus to relaxate and complete the ventilation function.

The intubation process is often breathtaking, and life and death are between minutes and seconds.

Because the intubation process is extremely painful, it is difficult for the patient to tolerate in a fully awake state, so anesthesia is needed. About one minute to one and a half minutes after the injection of narcotic drugs, the patient's spontaneous breathing will stop, and it is likely to die of hypoxia. That is to say, the time for doctors to "turn the tide" is up to 90 seconds. In these 90 seconds, the intubation doctor needs to quickly remove the respiratory mask the patient was wearing before, put the visual laryngoscope into the mouth, expose the glottis, and then quickly put the catheter into the trachea. Some patients are fat or have smaller mandible, and they need to press to expose glottis.

The intubation process is extremely risky for patients and doctors. On the one hand, it is necessary to prevent foreign bodies from slipping into the airway and causing asphyxia; on the other hand, it may cause respiratory and cardiac arrest due to vagus reflex when epiglottis is provoked. In addition, the moment of intubation, the droplets from the patient's lower respiratory tract, the virus load is very high. Even if the on-site medical personnel take strict preventive measures, because of face-to-face close contact, the possibility of infection is still very high. Due to the existence of such risks, as well as the exposure of airway after intubation, which increases the risk of additional infection of patients, it is controversial whether intubation or non-invasive use as much as possible.

"If the airway is opened for another second, the patient and the medical staff will be at risk for another second. So it can be done in 10 seconds, we will never delay to 20 seconds. " Said an anesthesiologist who supports Wuhan.

For this reason, the team of doctors who intubated the patients with severe new crown was also called "intubation Death Squadron" or "intubation commando".

There is no lack of professionalism and refinement

No matter noninvasive or intubation, after the ventilator is connected, the patient's blood gas index may be improved quickly, but to improve the respiratory function and reach the offline standard, it is less than one week, more than half a month or even longer. During this period, even a small problem may lead to failure.

Some people describe the feeling of wearing a breathing mask as follows: "it's a bit like being confined in a very small space, and you can't breathe. You don't know how the breathing opportunity is. Will you be given air or inhaled next? I feel very nervous. "

These problems, on the one hand, put forward requirements for the hardware performance of the ventilator, for example, Philips uses dual-a technology to minimize the maladjustment of patients. On the other hand, it is also necessary for the medical staff to fully communicate with the patient before getting on the machine, do a good job in explanation and emotional comfort, and try to avoid man-machine confrontation (the spontaneous breathing and the ventilator are not synchronized, out of step).

"There are some serious cases of claustrophobia." Xu Peifeng said that the patient was suddenly locked in a closed space, and saw the fully armed medical staff, who were seriously ill and had no family members to visit. Some of them suffered from aggregated diseases, and even their relatives died of misfortune or were uncertain. "If the mentality is broken, there is no way to treat them without good cooperation."

Yu Zhenghao used more non-invasive ventilators in the critical area of Wuhan Central Hospital. He also stressed that only by taking care and monitoring to the extreme can we better play the role of top equipment such as 202 and V60 (all ventilator models) and improve the success rate of treatment.

After upgrading to intubation, it is another case. In the words of an ICU doctor, intubation is not just the insertion of a tube in the trachea, but the beginning of a cruel life.

Before pulling out the tube, the ventilator must be connected 24 hours a day and cannot get out of bed. Through oral intubation, patients can't speak or eat, so they need to insert stomach tube to transport necessary water and food. If you can't urinate autonomously, you need to insert a catheter. In addition, there are artery monitoring tubes, intravenous infusion tubes and so on.

Most patients will feel restless or intolerable when they wake up. According to the diagnosis and treatment plan, sedative and muscle relaxant should be used in time. The follow-up management of these sleeping patients is a difficult problem.

Xu Peifeng said that in the general ICU ward, two or three medical staff may manage one bed in 24 hours, but for the new critical patients, the staffing may need to be 1:5 or 1:6. "The better the protection is, in the closed protective clothing, if you don't breathe well, the worse your health will be. You will also become a patient with hypoxemia. Then we need to do some physical activities. It's very difficult for four or five people to turn over one for the patient. Moreover, there are many tubes on the patient, which can't be twisted. We need to be very careful. "

Although more than 100 doctors and nurses have been sent to the ward, and the shift lasts 4 to 6 hours, there are not enough people. After the patient is connected to the ventilator, it is necessary to monitor all life indicators at any time, and constantly adjust the parameters of the ventilator to achieve human-computer cooperation. To do these works well, it requires a certain degree of professionalism.

In this outbreak, among the tens of thousands of medical staff supporting Hubei from all over the country, there are hundreds of respiratory therapists - Xu Peifeng is one of them - who are specially responsible for the maintenance and debugging of respirators and the formulation and implementation of respiratory treatment programs.

There are four respiratory therapists sent by Zhejiang medical team to Jingmen. They have more than 20 beds in the critical illness area of Jingmen first hospital. "Sometimes there is a problem to deal with. The effect is not the same as that of continuous fine management." "For a very simple example, a patient may have a blocked sputum at some point after turning over or after agitation," Xu said.



Intubation is full of risks, and it is not easy to pull out the tube。

The intubated patients were sedated for a long time. After their condition improved, the intubated patients should be extubated in time to recover their own breathing and reduce the side effects. But how to grasp the time of off-line? Will it face re intubation after extubation? They are all problems to be considered, with too many variables.

"Within 48 hours after the extubation, another intubation is called failed extubation." Said Xu Peifeng.

In his ward, a patient who had been intubated for a month, and finally the whole treatment team of five people voted to decide whether to remove the tube.

When the patient was just intubated, the situation was very bad. "If you can see him today, you may not see him tomorrow." Xu Peifeng introduced that in the process of intubation, in addition to prone position ventilation, chest wall high-frequency oscillation will be carried out. "We give him a vest with oscillation function for high frequency oscillation. It's equivalent to someone taking pictures on your back, which is conducive to a more even distribution of gas, and it can also loosen some secretions in the airway. "

After the condition gradually improved, whether to pull out the tube directly or not, the dispute followed.

Some members of the team think that although the patient's condition, imaging and ventilation are all better, the risk of extubation will be higher because of the decrease of muscle strength. Once the tube fails to be intubated, it will bring additional risks to doctors and patients.

"Lying motionless in bed for 24 hours is equivalent to aging for two years. What's more, a patient who has been in bed for more than 30 days with a lot of sedative and muscle relaxant drugs? " The medical team tried to wake up the patient, and found that the patient's respiratory rate reached more than 30 times per minute, nearly 1 times higher than the normal level, and the heart rate also exceeded 120. After waking up, the whole person was very upset.

A tracheotomy was also proposed. In general, if the patient who has been intubated for more than 2 weeks cannot be separated from the intubation in a short period of time, the doctor will consider tracheotomy, that is, inserting the respiratory catheter from the neck incision, changing the way of intubation through the mouth before, so as to manage the airway and suck out the sputum of the lower respiratory tract.

"It's a matter of great achievement that we have managed to bring a patient to such a level. Can we be conservative (choose tracheotomy)? But we think that after tracheotomy, infection may occur, leading to repeated illness, and there are many problems in later care. " Xu Peifeng said frankly.

Extubation or tracheotomy, both have advantages and disadvantages. Later he did an ultrasound and helped the director with an assessment. The conclusion is that the inspiratory muscle strength of the patients does decline very much, and the theoretical risk of extubation is greater. But tests of expiratory muscles showed normal function.

Xu Peifeng explained that the most important function of expiratory muscles is not to exhale, but to cough. "This patient can cough up phlegm by himself. Although the inspiratory muscle strength decreases, it can be assisted by a noninvasive ventilator."

Based on this judgment, we finally decided to pull out the tube. When pulling out the tube, the head of anesthesia department is next to ready to intubate again immediately, just in case.

Xu Peifeng introduced that the patient immediately changed to a noninvasive ventilator after extubation on March 9. After that, we will continue to monitor closely and adjust the parameters of the ventilator to make the patient transition smoothly.

"We are under great pressure. The director is still asking about the patient at three or four in the morning." Fortunately, after 3 days of non-invasive ventilator treatment, the patient continued to improve, and changed to high flow oxygen. Finally, the patient was successfully cured and discharged.

"If this patient as like as two peas, he would not be able to save it." Xu Peifeng exclaimed.

As of March 31, 928 cases were confirmed and 887 cases were cured.

Conclusion of a respiratory therapist: there are three experiences in the treatment of critical patients

At present, there is no specific medicine for the treatment of critical patients with new crown. "Rely on the ventilator to help the patient breathe, which requires professional skills and careful care. If there is no place, the patient may not be able to survive." That's what Xu Peifeng said. As a respiratory therapist,



he summed up the experience of the treatment of critical patients in the epidemic, and felt that there were three points that needed attention.

First, patients who meet the requirements should be treated at a higher level as early as possible. "Do not wait until the patient can't do it, the later the treatment effect is worse, the more active the intervention effect is better."

Secondly, in coping with ARDS, prone position ventilation is effective. It is not only the patients with serious ARDS who are intubated, but also the patients who use noninvasive ventilator and high flow oxygen therapy can adopt prone position ventilation. "It is suggested that we should try to sleep on our stomach as much as possible. All the patients here let them do it as much as possible. I think it is a very important measure to control the mortality rate."

Third, according to the patient's condition to give some appropriate means of lung rehabilitation. "For example, high frequency chest wall oscillation, airway oscillation, including inspiratory and expiratory muscle strength training, which we are doing, help patients get better quickly."

In fact, ventilator has been used in a small range in the SARS epidemic 17 years ago (severe cases of SARS finally appear ARDS). In Beijing Ditan Hospital, 61 patients were treated with non-invasive ventilator in the same year, 18 of them were later changed to invasive, and 36 cases were cured successfully.

Only when SARS hit, the training of respiratory professionals in China was just beginning. In 2003, Xu Peifeng was studying respiratory therapy in West China Medical Center of Sichuan University. At present, Sichuan University is also the only university in China that offers undergraduate respiratory treatment.

Xu Peifeng recalled that so far, there have been hundreds of respiratory therapy graduates from West China. These professional respiratory therapists are undoubtedly the backbone of the industry in China. According to media reports, they are often booked by major hospitals before graduation.

It is understood that Philips, which has the highest market share of ventilator in China, started to promote the level of respiratory treatment six or seven years ago. At present, Philips has cooperated with Sichuan Huaxi Hospital, Beijing Chaoyang Hospital, Wuhan Central Hospital and Zhejiang University Shao Yifu hospital where Xu Peifeng is located to establish a respiratory treatment clinical training center.

"In addition to respiratory therapists, physicians, and nurses, we can all train." A Philips person said. "For us, the purpose of the training center is not to train some people, but to train those people who usually use the ventilator and must use it well."

In this new outbreak, the importance of respiratory therapists and medical staff who have received professional training in respiratory treatment is obvious to all, but at the same time, the shortage of respiratory treatment professionals in China is also exposed. At present, although the new crown epidemic in China has been gradually controlled, the epidemic is not over, and is facing the input threat

brought by the global outbreak. In the "post new crown" period, the field of respiratory therapy may usher in an important development opportunity.

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