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Nursing of a Patient with Arterial Air Embolism during CT-guided Lung Biopsy

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Abstract: *This case report aims to summarize the comprehensive nursing management of a patient who developed an arterial air embolism during a CT-guided lung biopsy. Upon occurrence of the embolism, prompt action was taken by the medical team: the needle was immediately withdrawn by the physician, and the nursing staff swiftly administered high-flow oxygen, adjusted the patient's position, and collaborated closely with the medical team to support emergency interventions. Multidisciplinary consultations were promptly initiated to establish an optimal treatment plan. Continuous monitoring of the patient's vital signs was crucial to ensure safety. Additional nursing interventions included prevention of lower extremity deep vein thrombosis, guidance on spontaneous breathing exercises, and the development of a personalized muscle strength rehabilitation program. Proactive measures were implemented to prevent air embolism, accompanied by comprehensive psychological support throughout the patient's care journey. These strategies significantly reduced the risk of complications, facilitating both short-term recovery and long-term quality of life. In this case, the patient made a successful recovery and was subsequently discharged. The nursing interventions and strategies outlined provide valuable insights for managing similar cases of air embolism during lung biopsy procedures.*

Keywords: *lung biopsy; Air embolism; CT guided; nursing*

1. Introduction

Lung cancer is common in China and threatens human health. Pathological biopsy has become the key to its early diagnosis and treatment. Lung biopsy, that is, CT-guided percutaneous lung biopsy, can diagnose histological lesions around the lung, and its significance is greater than that of bronchoscopic lung biopsy[1]. The sensitivity and specificity were 93%-98% and 98%-100%, respectively[2]. In addition, CT can provide valuable needle diameter and position relative to the target lesion during percutaneous biopsy of pulmonary nodules, so it is the technique of choice for the diagnosis of new or growing pulmonary nodules[3]. Although lung biopsy has the advantages of high accuracy, accurate positioning, small local minimally invasive injury, and less pain, there will be inevitable complications during and after the operation due to the influence of various subjective and objective factors[4]. The common complications include bleeding, hemoptysis, pleural reaction, pneumothorax, etc. The symptoms are generally mild, and the prognosis is good after symptomatic treatment. The uncommon complications included air embolism, pulmonary hemorrhage, tension pneumothorax, etc. Air embolism was extremely rare and fatal, with an incidence of 0.02%-0.18%[5]. Air embolism is mostly iatrogenic, which can be divided into arterial air embolism and venous air embolism. Arterial air embolism is caused by lung biopsy, arterial intubation or extracorporeal circulation. Venous air embolism occurs during pressurized intravenous fluids or catheter manipulation[6]. When patients complicated with air embolism, the onset is acute, the condition is serious, and the mortality rate is high. Only a few cases have been reported at home and abroad, and there are not many experiences and methods for clinical reference, but it should be paid enough attention. A successful case of arterial air embolism during CT-guided lung biopsy occurred in our hospital on May 25, 2022, and the nursing experience is reported as follows.

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2. Clinical data

2.1 Case data

A 66-year-old male patient was admitted to the hospital with the chief complaint of cough and a small amount of white mucous sputum without obvious inductions 2 months ago. CT showed a right lung mass with a long diameter of 9mm.Ct-guided lung biopsy was performed to confirm the pathological diagnosis. According to the designed puncture parameters, the biopsy needle was inserted step by step. During the process of needle insertion, the patient's body dodged, and a small amount of pneumothorax and subcutaneous emphysema were found in CT reexamination. During the process of needle insertion, the patient's cooperation was poor, and the position of the right pulmonary nodule was still not reached after many times of needle adjustment. During the process of needle adjustment, the patient was suddenly agitated, the head and face were cyanic, and the electrocardiogram monitoring showed that the blood oxygen saturation decreased to 80% and the heart rate decreased to 42 beats/min. Reexamination of plain CT showed a small amount of gas in the right brain and aortic arch, and then the patient developed drowsiness and did not respond to calls. The patient was considered to be complicated with arterial air embolism and was urgently transferred to ICU.

2.2 Treatment process and clinical outcome

After admission, the multi-disciplinary team (MDT) model was implemented to determine the diagnosis and treatment plan and nursing measures for patients.The patient was trained to exhale and inhale before performing the puncture, and the blood pressure was in the normal range.After the discovery of air embolism, the primary rescue measures are to give oxygen and position nursing immediately. Dexamethasone sodium phosphate injection 5m and epinephrine 1mg were injected intravenously. Mechanical ventilation, sedation and analgesia, anti-infection, dehydration to reduce intracranial pressure, anti-epilepsy, anti-platelet, crown expansion, lipid-lowering, edaravone application, nutritional support, maintenance of water and electrolyte balance, and symptomatic treatment were given.One day later, the patient was in coma with GCS score of 2, intermittent irritability, and frequent convulsions. Brain injury caused by air embolism was considered.The patient's VTE risk score was 3 points, with moderate risk, and the patient was treated with pneumatic therapy of both lower limbs for venous thrombosis prevention.Two days later, the patient was awake, the left upper limb muscle strength was grade 2, the left lower limb muscle strength was grade 0, and the right limb muscle strength was grade 5. The patient was instructed to perform spontaneous breathing exercise.CT examination of the head and chest showed multiple ischemic changes in the right cerebral hemisphere, and the possibility of infarction was considered to be caused by arterial air embolism. Although the patient was awake, he was likely to have neurological dysfunction, and he continued to take active treatment with ventilator assisted breathing.Five days later, the patient's oxygen saturation and oxygen partial pressure were normal, and he was weaned from the machine and extubated.Seven days later, the patient's vital signs were stable, his consciousness was clear, he did not complain of discomfort, and there was no more seizures. The muscle strength of the left upper limb was grade 3, the muscle strength of the left lower limb was grade 2, and the muscle strength of the right limb was grade 5, and the muscle strength of the left limb was still poor.

3. Cause analysis

According to the Chinese expert consensus on percutaneous needle biopsy of thoracic tumors (2020 edition)[7]. It is reported that the current consensus believes that the mechanism of arterial air embolism during lung biopsy is that air directly enters the pulmonary vein along the coaxial cannula or there is injury in the process of needle puncture, resulting in iatrogenic bronchial or alveolar-pulmonary venous fistula[8]The air first enters the pulmonary vein and then returns to the left heart, and finally acts in the systemic circulation to bring the air to the arterial vessels. The causes of occurrence include: biopsy cavity or vascular inflammatory lesions (such as ground glass shadow), cough, positive pressure ventilation, etc[9].Integrated in this case, though, according to the designed needle depth, and into the needle puncture Angle, but there are still some small pulmonary vein under CT scan was not found, patients with poor at the same time, the body dodge, therefore in the process of piercing cause pneumothorax, damage to the pulmonary vein at the same time, the inside of the chest cavity gas along the needle into the pulmonary vein, Finally, it causes cerebral air embolism through the systemic circulation.

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4. Care

4.1 Emergency care

When the patient had air embolism, the nurses cooperated with the doctors to implement rescue measures for the patient at the first time, and administered drugs according to the doctor's advice, and real-time chest compression when necessary.

4.1.1 Give oxygen immediately

When complicated with arterial air embolism, the delivery of 100% pure oxygen is the first choice of treatment, whether it is oxygen inhalation through a mask or emergency tracheal intubation with mechanical ventilation[9].100% oxygen ventilation can change the partial pressure balance of the gas, and nitrogen in the blood is absorbed faster, accelerating the elimination of the gas[10]. In addition, hyperbaric oxygen chamber treatment is the first-line treatment measure to eliminate bubbles and improve tissue oxygen saturation[11]. According to the literature[12]Patients with air embolism should be treated with hyperbaric oxygen within 30 hours, and it has been clinically proven to be effective in reversing neurological deficits. There are also reports in the literature[11] showing that immediate hyperbaric oxygen therapy in patients with intraoperative arterial air embolism can reduce mortality to 7%, and this literature clearly indicates that later hyperbaric oxygen therapy also has some efficacy in survivors and neurological recovery. In this case, the hyperbaric oxygen chamber treatment was started after communication with the patient's family members, but the family members did not agree and the hyperbaric oxygen chamber treatment was not performed, so it is impossible to make further reports on the efficacy of the hyperbaric oxygen chamber.

4.1.2 Posture nursing

Posture nursing is to use the principle of gas buoyency to effectively prevent or reduce the gas in the systemic circulation from entering the brain, and even make the gas that has entered exit the fatal part through the change of body position, and finally be slowly absorbed[12].According to the literature[13]In case of concurrent air embolism, the needle should be immediately withdrawn and the patient should be placed in the Trendelenburg Position. However, if there is a large amount of gas in the left heart chamber, the patient should be placed in the right lateral position immediately, so that the position of the left atrium will be higher than that of the left ventricle, which can effectively prevent the gas from entering the systemic circulation through the outflow tract located at the bottom of the left ventricle and causing serious complications[14].In this case, according to the patient's clinical manifestations and CT images, after the patient was determined to be complicated with arterial air embolism during the operation, the patient was placed in a headlow position at the first time, which effectively avoided the air continuing to enter the brain with systemic circulation and reduced the degree of brain edema.

4.2 Make good condition observation to ensure patient safety

Disease observation is the most basic work of nurses. In this case, the patient was suddenly irritable, the head and face were cyanosis, the oxygen saturation dropped to 80%, and the heart rate dropped to 42 beats/min during the needle adjustment process, which suggested that during the whole process of lung biopsy, the nursing staff should closely monitor the changes of the patient's vital signs and pay attention to the changes of the patient's consciousness and nervous system. After the patient's emergency transfer to the ICU, the nursing staff continued to record the patient's vital signs, consciousness, pupil, skin condition, intake and output volume, and changes in the nervous system every hour to prevent new complications. Two days later, the patient woke up and five days later, the patient entered a stable rehabilitation period after pulling out the ventilator. The nursing staff closely observed the patient's psychological changes, physical activity and other nervous system rehabilitation, and carried out rehabilitation exercises for the patient.

4.3 Implement multidisciplinary consultation to determine the treatment plan

After the patient was transferred to ICU, the MDT team of experts from respiratory department, neurosurgery department, ICU, anesthesiology department, intervention department, psychology department and other departments was set up for the patient at the first time to formulate treatment plans and medication plans for the patient, evaluate and identify the patient's condition changes early, carry out risk assessment, and ensure the patient's safety.

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4.4 Muscle strength rehabilitation nursing

The muscle strength of patients after air embolism is damaged. Muscle strength rehabilitation nursing can restore the limb motor function of patients as soon as possible, and complete the corresponding training is of great significance to improve the quality of life of patients[15].In order to restore the patient's limb motor function as soon as possible, the nursing staff formulated a muscle strength rehabilitation plan for the patient: maintaining the limb functional position, implementing passive training, such as flexion, extension, abduction and internal rotation; Massage the skin, muscles and tendons of the left limb properly, and massage gently and step by step; Hot and cold towels were applied to stimulate the left limb muscles of the patient and exercise the contraction function of the muscles. In order to prevent muscle spasm, the patient's position was changed every 1-2h.Under various rehabilitation training, the muscle strength of the left upper limb changed from grade 2 to grade 3 after 5 days, and the muscle strength of the left lower limb changed from grade 0 to grade 2, so it is of great significance for patients to carry out muscle strength rehabilitation nursing as soon as possible. Muscle strength rehabilitation nursing could not be continued in our hospital due to the family members' request for discharge. Before discharge, the family members of patients were informed of the method of muscle strength rehabilitation nursing, and asked to conduct mental consultation and rehabilitation treatment.

4.5 Prevention of venous thromboembolism (VET) nursing

VET is one of the most serious complications and important causes of death in postoperative patients, especially in surgical patients[16], according to the literature[17]. The incidence of postoperative VTE is up to 63%.VTE seriously affects the rehabilitation of patients, increases medical costs, and even endangers the lives of patients, so the prevention of VTE plays a pivotal role in nursing work. Nursing staff should fully realize the benefits of VTE risk assessment to patients, and fully master the relevant knowledge and skills of VTE risk assessment and prevention. In this case, the patient's VTE score was 4 points, which was in a high-risk state. After multidisciplinary consultation, drug prevention + physical prevention was used for the patient. Thrombosis was prevented by subcutaneous injection of low molecular weight heparin sodium. Lower limb pressure was applied to treat Bid/d, 20min each time. The patients were instructed to perform ankle flexion and extension and surround movement for 10 minutes each time, 5 times a day. At the same time, physical preventive measures such as daily massage and plantar venous pump were used to accelerate the venous blood flow of lower extremities, reduce blood stasis, and reduce the risk of venous thrombosis of lower extremities. Nurses observed the skin color and temperature of lower limbs and sacrococcygeal region, and the pulse of dorsal foot artery every day. Ultrasound examination of both lower limbs was performed before the patient was discharged, which indicated that there was no thrombosis, indicating that VTE prevention nursing played a certain role.

4.6 Spontaneous breathing exercise nursing

Ventilator mechanical ventilation is to ensure the stability of vital signs during treatment, not to replace spontaneous breathing. When the extubation indications meet the conditions, the ventilator should be removed, otherwise the patient will have ventilator dependence, prolong the weaning time, and even can not resume normal breathing after weaning[18].Therefore, spontaneous breathing exercises are required before weaning the patient from the ventilator. In this case, the nursing staff and respiratory therapists were based on previous case reports[19], for patients with spontaneous breathing exercise plan, training in the machine condition first, then in the offline training, let patients were well exercise and functional exercise: nurse to breathe first demonstration, let the victim to imitate breathing exercise, try to deep breath, breath control frequency of 16 ~ 18 times/min, exercise 2 times a day, 30 min/time.Five days later, the patient could maintain spontaneous breathing for 24 hours in the offline state, and then the patient was weaned successfully.

4.7 Preventive nursing of air embolism

Air embolism is the most rare and serious complication of lung biopsy, according to the literature review[20]With accurate CT scan, skilled and standardized operation of puncture doctors, and perfect cooperation of patients, the occurrence of air embolism still cannot be avoided. This should attract the attention of medical staff, and strive to minimize the incidence of air embolism. According to this case, the following experience was summarized: before puncture, nursing staff actively explained the surgical process to the patient, and instructed the patient how to hold his breath during puncture, but did not do Valaslva maneuver (forced exhalation with closed glottic) to cooperate with the operation; When the

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patient's body appeared to dodge during the operation, the nursing staff should carry out psychological nursing in time to soothe the patient's mood and inform the patient not to cough violently. During the whole process, nurses were always vigilant in order to find out the patient's abnormality in time and cooperate with doctors to prepare for first aid. Before puncture, doctors should read the film repeatedly to determine the puncture position, the length and Angle of the puncture needle, and try to put the needle in place as much as possible to avoid repeated adjustment of the needle.

4.8 Targeted psychological nursing was given throughout the course

Psychological care for nursing staff in language communication way to provide effective psychological support to patients, to eliminate patients' tension, anxiety, fear and other negative emotions, improve nursing curative effect, make patients feel the care and attention from the medical staff, so that the patients have a better state of body and mind to actively cooperate with the clinical treatment, speed up the recovery. In this case, before the patient underwent lung biopsy, the nursing staff patiently explained the surgical process, inspiratory breathing method, position placement method, postoperative nursing method, etc. The patient's body appeared to dodge during the operation, and the nursing staff provided psychological comfort and encouragement. When air embolism occurred during the operation, the nursing staff advised the patient not to be nervous and overly anxious through communication, and informed the patient that all medical staff would always accompany him through the difficulties. Patients in the ICU sane, nursing staff in addition to psychological interventions for patients and families, also actively in-depth communication with patients, inform the present physical condition, but don't tell patients excessive anxiety, let the patient to listen to music, read his newspaper to patients, and invite the good prognosis of patients to share the treatment process and explained their own psychological journey, It enhances the rehabilitation belief of patients, reduces the degree of anxiety, improves the quality of sleep, and makes patients feel the personalized care from medical staff. Before discharge, the anxiety level of psychological evaluation was reduced compared with before.

4.9 Health guidance and strengthening continuous nursing

In addition to health guidance for tumor treatment, patients should be given health guidance for rehabilitation treatment after air embolism. In this case, the patient was instructed to take drugs according to the doctor's advice every day outside the hospital, to review blood routine and liver and kidney function every week, to inform the time of the next return to the hospital, and to conduct pre-hospitalization review of enhanced CT. The patients were guided to visit the neurology department outside the hospital, and rehabilitation treatment was performed as soon as possible, and the myocardial enzymes of the electrocardiogram were regularly reviewed. The patient's family members were informed about the precautions in life, including continuing rehabilitation exercise, appropriate exercise, paying attention to reasonable rest, and preventing venous thrombosis of lower limbs. Patients' treatment and rehabilitation were followed up to prevent poor follow-up compliance and delay of treatment and rehabilitation. Nurses regularly followed up patients by telephone every week, asked patients' conditions, strengthened health guidance, did not answer patients' questions and provided targeted health education.

5. Summary

Arterial air embolism during lung biopsy is an exceedingly rare but life-threatening complication with a high mortality rate, warranting heightened vigilance among medical staff. While the condition is critical, timely prevention, early detection, and prompt intervention can significantly reduce the risk of irreversible outcomes. Immediate actions, such as withdrawing the needle, administering high-flow oxygen, adjusting the patient's position, and close collaboration with the medical team, are essential. Early multidisciplinary consultation is also crucial to establish an effective treatment plan.

Nursing management plays a pivotal role in ensuring patient safety, including vigilant monitoring, prevention of lower extremity venous thrombosis, assistance with spontaneous breathing exercises, and implementation of individualized muscle strength rehabilitation programs. Proactive prevention of air embolism, alongside comprehensive psychological support, can help minimize patient risk. Continuous nursing care is essential for enhancing both the short-term recovery and long-term quality of life. In this case, the patient made a successful recovery and was discharged, providing a valuable reference for nursing management of air embolism in similar clinical scenarios.

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