Research Article

Anesthesia Management of Precise Radiotherapy with Apnea Method

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ABSTRACT

Objective: To study the implementation of precise radiotherapy with apnea method and its effect on oxygen supply, blood pressure and heart rate, and to explore the safety and feasibility of precise radiotherapy with apnea method.

Methods: Two lung tumor patients received precise radiotherapy with apnea method, and 11 times of apnea positioning and treatment were carried out. The changes in blood oxygen saturation, blood pressure, heart rate, and end-expiratory carbon dioxide during the apnea period were observed, and the incidence ratio of adverse reactions was recorded.

Results: The mean apnea time of the two patients was 6.2 min, ranging from 3 min to 9 min; the mean radiotherapy time was 4.6 min, ranging from 1 min to 7 min; the change of SpO_2 was less than 1%, with the lowest SpO_2 of 97%; the mean increase of $ETCO_2$ during apnea period was 3.5 mmHg, with the highest $ETCO_2$ concentration of 59 mmHg, which occurred at the 8th minute in apnea; the mean anesthesia time was 53.5 min, ranging from 47 min to 60 min; the mean recovery time was 33.1 min, ranging from 30 min to 40 min. During the apnea period, the heart rate increased and the average arterial blood pressure increased. After the first time of apnea, there were blood blisters on the posterior pharyngeal wall of the patients, and no other adverse events or side effects occurred.

Conclusion: Precise radiotherapy with apnea is safe and feasible, which has high precision and advantages in the field of radiotherapy.

Keywords: Apnea; General anesthesia; Radiation therapy

Introduction

Precise radiotherapy with an apnea method is the latest technology in the field of radiotherapy [1]. In 2009, it was first carried out in the proton therapy center in Munich, Germany [2]. At present, it has been safely carried out on thousands of patients. This technology is generated with the trend of modern medical precision treatment. The precise radiotherapy with the apnea method can make the respiratory movement completely disappear by giving muscle relaxants under general anesthesia [3]. Because the two layers of splanchnic pleura stay close to each other, the lung will remain still and the relative position of the tumor will not move anymore, and the radiotherapy can be carried out under the condition of ensuring the oxygen supply of the patient, which can accurately locate the tumor to the utmost extent, increase the radiation dose of the tumor, and protect the normal tissue to the utmost extent [4].

Material and Methods

Case 1

Two cases of lung tumors, both male. One case was 80 years old. Two years after the colon cancer operation, he was found to have lung cancer in the reexamination. Through biopsy, he was confirmed as pulmonary metastasis (solitary) of colon cancer, with ASA level III and cardiac function level II. Another case was 52 years old. He was hospitalized for "hemoptysis for two weeks". After the comprehensive examination, he was confirmed as lung cancer, with SA level II and cardiac function level II. Preoperative

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Table 1: The detailed data during radiotherapy with the apnea method.

Times	1	2	3	4	5	6	7	8	9	10	11
Anesthesia time (min)	55	55	50	55	60	54	55	50	58	50	47
Apnea time (min)	3	6	7	5	6	5	3	9	8	8	8
Radiotherapy time (min)	2	4	5	4	5	4	1	7	6	7	6
Recovery time (min)	30	30	30	35	30	38	40	30	40	30	31
$ETCO_2$ change (mmHg)	5	15	11	13	12	16	5	25	25	24	26
Maximum $ETCO_2$	35	47	37	38	48	41	40	55	54	54	59
SpO_2 change (%)	+1	0	-1	-1	-1	-1	0	-1	-1	0	0
Minimum SpO_2	99	99	98	98	98	97	99	98	98	99	99

evaluation showed that 2 patients could tolerate general anesthesia and precise radiotherapy with apnea method.

Therapeutic method

Intramuscular injection of 0.5 mg atropine before operation. After entering the radiotherapy room, they opened the venous channel, took a radiotherapy position, and located the tumor on the treatment table. Gave preoxygenation for 5 minutes, and started anesthesia induction. 0.5 mg phencyclidine hydrochloride, 0.04 mg/kg midazolam, 0.25 mg/kg cisatracurium besylate, 0.15 mg/kg etomidate, 0.5 ug/kg remifentanil. After the respiratory movement disappeared, changed to artificial ventilation. Inserted the laryngeal mask after 120 s, fixed the laryngeal mask after confirming the position, connected the anesthesia machine to control the breath, and gave continuous pump injection of etomidate and remifentanil. After confirming that the vital signs of the patients were normal, connected the modified anesthesia machine ventilation equipment, used a constant oxygen flow rate (4 L/min) to supply oxygen continuously through the laryngeal mask under the apnea condition. Continuously monitored the heart rate, blood pressure, Oxygen Saturation (SpO_2), and End-expiratory Carbon Dioxide ($ETCO_2$), and recorded every 2 minutes (there were no $ETCO_2$ waveform and value during apnea, so only recorded the value at the beginning and the end). All the staff left the radiotherapy room during the radiotherapy. After the radiotherapy ended, immediately changed to controlled respiration, stopped pump injection of anesthetics, and sent to the recovery room. During the waking up period, gave midazolam intermittently according to the changes in heart rate and blood pressure to keep the vital signs stable. When the respiration of the patient recovered, they gave atropine, neostigmine, and flumazenil as antagonists. Remove the laryngeal mask after consciousness, and sent back to the ward after the vital signs kept stable. In the first case, there were 6 times of apnea during the treatment period, including 1 time for positioning the tumor in the CT room. From the next day, the patient started receiving radiotherapy, QOD, with 5 times in total. In the second case, there were 5 times of apnea during the treatment period, including 1 time for positioning the tumor in the CT room. From the next day, the patient started receiving radiotherapy, QOD, with 4 times in total. 1-6 was the first case, 7-11 was the second case.

Results

The detailed data during radiotherapy with the apnea method referred to **Table 1**. The mean apnea time of the two patients was 6.2 min, ranging from 3 min to 9 min; the mean radiotherapy time was 4.6 min, ranging from 1 min to 7 min; the change of SpO_2 was less than 1%, with the lowest SpO_2 of 97%; the mean increase of $ETCO_2$ during apnea period was 3.5 mmHg, with the highest $ETCO_2$ concentration of 59 mmHg, which occurred at the 8th minute in apnea; the mean anesthesia time was 53.5 min, ranging from 47 min to 60 min; the mean recovery time was 33.1 min, ranging from 30 min to 40 min. During the apnea period, the heart rate increased and the average arterial blood pressure increased. After the first time of apnea, there were blood blisters in the posterior pharyngeal wall of the patients, and no other adverse events and side effects occurred.

Discussion

With the rapid development of computer technology and three-dimensional imaging technology, precise radiotherapy has become the current mainstream of radiotherapy and the direction of future development [5]. The basic requirement of precise radiotherapy is to achieve

a high dose in the target area and reduce the radiation to the surrounding normal tissues as much as possible, to improve the gain ratio of the treatment [6]. The movement of organs caused by respiratory movement makes the thoracic and abdominal tumors deviate with respiration, even out of the radiation area set in the radiotherapy plan [7].

Therefore, breathing control has become a hot research topic. Scholars have put forward many methods to solve the tumor displacement caused by respiratory movement in radiotherapy, such as breath holding technology, respiratory gating technology, four-dimensional radiotherapy technology [8], and real-time tumor tracking technology, etc. However, all these methods have some defects such as not enough accuracy, expensive equipment and patient-ventilator asynchrony, etc [9]. The precise radiotherapy with apnea method can make the respiratory movement completely disappear and the relative position of the tumor no longer move by giving muscle relaxants under general anesthesia [10]. The radiotherapy can be carried out under the condition of ensuring the oxygen supply of the patient by using a special oxygen supply method, which can accurately locate the tumor to the utmost extent, increase the radiation dose of the tumor, and protect the normal tissue to the utmost extent. At the same time, it can reduce the radiotherapy times and hospitalization days, speed up bed turnover and save medical expenses [11].

Under normal circumstances, the oxygen reserve of a normal person is sure to be completely depleted within 5 minutes without breathing, and then followed by asystole. In our two cases, we conducted radiotherapy under general anesthesia and apnea condition and used a special oxygen supply method to ensure that the patients would not be lack of oxygen during apnea. Our data showed that in 11 times of treatments, the range of apnea time was 3 min-9 min, and the average apnea time was 6.2 min, and the longest apnea time was 9 min. During this period, there was almost no change in blood oxygen saturation, and only the end-expiratory carbon dioxide increased. $ETCO_2$ increased by 3.5 mmHg per minute on average, and the highest concentration of $ETCO_2$ was 59 mmHg. The blood pressure and heart rate were normal. The radiotherapy times reduced from 30-35 times to 5 times, and the hospitalization days reduced from 6-8 weeks to 2 weeks. This technology was first used in Germany in 2009, and now it is widely used in a proton therapy center in Munich, Germany. Their literature reports showed that [12] the anesthesia technology of apnea was safe. They implemented apnea for 3025 times in total, and no adverse events occurred. The basic principle of this technology is that O_2 is easier to diffuse in the lungs than CO_2. Even without breathing, O_2 will diffuse into the alveoli due to the concentration gradient. With constant oxygen flow and pressure, the patient can maintain oxygenation without breathing by supplying oxygen through trachea intubation. In the absence of respiration, the $ETCO_2$ level will increase by 2 mmHg/min-4 mmHg/min. If the apnea time is short, there will be no negative effect on the patient. Our observation results were similar. In the literature they adopted tracheal intubation, which was safer than laryngeal masks in our cases. But the compliance and tolerance of the patient might be poorer, and the patient may not be able to tolerate tracheal intubation for many times. Their literature also showed that [12], the movement range of thoracic and abdominal tumors during the ordinary radiotherapy was 2 cm-4 cm, while the movement range during the precise radiotherapy with apnea method was 0.1 cm-0.2 cm. The radiation damage to the normal tissue was very small, so that the radiation dose could be increased. And the radiotherapy times and the hospitalization days would be reduced. Therefore, the precise radiotherapy with the apnea method has a great advantage in the radiotherapy of thoracic and abdominal tumors, which are greatly affected by respiratory movement.

Conclusion

Precise radiotherapy with an apnea method is a revolutionary progress in the field of radiotherapy, which may be more helpful for heavy ion and proton therapy.

Conflict of interest

The authors state no conflict of interest.

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