

Application of Blocking Unilateral Main Pulmonary Artery in Pulmonary Lobectomy of Lung Cancer

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OBJECTIVE To explore the application of blocking the unilateral main pulmonary artery (MPA) in pulmonary lobectomy (PL) for patients with stage II and III lung cancer, and to retrospectively analyze the methods of surgery for blocking the unilateral main pulmonary artery, perioperative indications, intraoperative concerns and postoperative cardio-pulmonary complications.

METHODS During a period from January 2006 to January 2008, intra-pericardial, or extra-pericardial separation and blockade of the left or right MPA followed by completion of various PLs were conducted for 30 lung cancer patients in stage-II to III with ill-defined anatomic structure of the pulmonary hilum and difficult pulmonary angiodiastasis.

RESULTS In the 30 patients, 5 were diagnosed as stage-IIb, 11 stage-IIIa, and 14 stage-IIIb. During the surgery, giant tumors at the superior pulmonary lobe, with a diameter of over 10 cm, were seen in 13 cases, in which tumor invasion in the extra-pericardiac pulmonary artery was found in 5 cases. Hilar lymphadenectasis with severe tumor adhesion to pulmonary blood vessel could be seen in 20 cases and partial tumorous invasion in the pericardium in 7. In most of the cases, adhesions existed around the tumor, aorta, superior vena, and azygous vein. Invasion of the laryngeal and vagus nerves on the left side was found in 3 cases. Of the 30 patients, simple PL was conducted in 12, and sleeve lobectomy combined with a pulmonary arterioplasty in 18 cases. With a blockade of unilateral MPA, no intraoperative hemorrhage of pulmonary blood vessels occurred during surgery, when there was a clear surgical field of vision. Both PL and lymphadenectomy were smoothly completed in the 30 patients. The healthy pulmonary lobes with normal function were kept and total pneumonectomy was avoided. The time of blocking the pulmonary artery ranged from 10 to 30 min, and intraoperative blood loss was from 200 to 300 ml. Postoperative complicated acute pulmonary edema occurred in 5 patients and tachycardia in 7 cases. Nevertheless, all patients recovered and left the hospital after treatment. No severe cardiopulmonary complications were found in all patients of the group.

CONCLUSION Blocking the unilateral MPA is effective to decrease the risk of intraoperative hemorrhage in the PL. It can shorten the time of surgery, improve the excision rate of lung cancer, and cut down on the rate of total pneumonectomy.

KEY WORDS: lung tumor, pulmonary artery, blockade, pulmonary lobectomy.

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Introduction

Most lung cancer lesions are located around the center of the lung. The pulmonary artery and its branches are prone to encasement and invasion of the tumor and lymphatic tissues, and arteriorrhesis and arterial hemorrhage frequently occur in the separation of lobar artery during pulmonary lobectomy (PL). Therefore, management of pulmonary artery is the key to the PL. During a period from January 2006 to January 2008, 456 lung cancer patients had undergone a PL in our hospital. In our group, after blocking the unilateral main pulmonary artery (MPA), PL was uneventfully and smoothly conducted in the 30 patients with an ill-defined anatomic structure of the pulmonary hilum and difficult separation of the pulmonary blood vessels. The outcome of surgery was satisfactory. It was reported as follows.

Materials and Methods

General data

There were a total of 30 patients in our group, and 18 were male and 12 female, with the age ranging from 37 to 80 years. Squamous carcinoma of the lung was found in 22 cases, adenocarcinoma in 7, and adenosquamous carcinoma in 1. Excision of the superior lobe of left lung was done in 12 of the 30 cases, and that of the inferior lobe of left lung in 2, the superior lobe of right lung in 14, and the superior and middle lobe of right lung in 2. Of the 30 cases, sleeve lobectomy in combination with a pulmonary arterioplasty (PA) was performed in 18, because of the tumor encroachment into the pulmonary artery or its rootlet. Clinical staging was based on the 1997 WHO TNM standard of lung cancer. There were 5 cases with stage-IIb, 11 with stage-IIIa, and 14 with stage-IIIb.

Intraoperative findings

Giant tumor at superior pulmonary lobe was found in 13 of the cases ($d > 10$ cm), which involved in the extra-pericardial pulmonary artery in 5. Lymphadenectasis of the pulmonary hilum with severe tumor adherence to pulmonary blood vessels was found in 20 cases, and partial invasion of the pericardia in 7. In most of the cases, various degrees of tumor adhesion to the aorta, superior vena cava and azygos vein were seen, and invasion of the recurrent laryngeal nerve and vagus nerve at left pulmonary lobe occurred in 3.

Surgical procedures

In the surgical procedure, interruption of the unilateral MPA was carried out because of difficult separation of the lobar artery and its branches from the tumor and a potential arteriorrhesis. Usually, extra-pericardial separation at the proximal part and blockade of MPA by a blocking strip or atraumatic blood vessel forceps were

carried out followed by interruption and ligation of the lobar artery. Since the rootlet of the branch of the left MPA is long, stretching out to the apicoposterior segment of the superior pulmonary lobe from pericardium, with 22.6 ± 3.7 mm in length^[1], this method is especially suitable for patients with an excision of the left pulmonary lobe. If there is a severe adhesion between the central-type neoplasm, or intumescent lymph nodes and branching vessels, or there is an involvement in the branching vessels, deliberate dissection of the vessels of pulmonary hilum is not necessary. As soon as a slight dissection of the pulmonary hilum was conducted and the diameter of the root of pulmonary hilum decreased in size, the pulmonary lobes to be excised were completely blocked from the root of the hilum of the lung using an auricular clamp. Then the tumor and the branching vessels at the root were resected together. After removing the resected tissues, injury to the pulmonary artery was repaired again and the remaining nodes cleared up.

If intra-pericardiac separation of the MPA on affected side was found difficult, or the tumor has severely encroached on the pericardium, an intra-pericardiac blockade of the MPA on the affected side could be done. The pericardium was longitudinally dissected in the space between pulmonary hilum and diaphragmatic nerve. After exploration of the anatomical position of pulmonary artery, a careful sharp separation of the MPA on affected side and reentry site of the pericardium was carried out using a tangential clamp, and after that, the blockade of the pulmonary artery was followed using a blocking strip or atraumatic blood vessel forceps. Afterwards, PL and lymphadenectomy were conducted according to the previous methods, or partial excision of the pericardium and PA were concurrently performed.

Results

With blockade of the unilateral MPA, the intra-operative blood loss was reduced and the operating field well-defined. PL and lymphadenectomy were routinely completed in all the 30 patients, without unexpected intra-operative hemorrhage. Comparing the surgery procedures we had done with the conventional PL, the intra-operative blood loss was less, i.e. about 200-300 ml, therefore, the blood transfusion was not needed due to reducing the time of surgery by 30 to 40 min. After surgery, no severe cardiopulmonary complications in relation to blockade of pulmonary artery, such as respiratory failure, pulmonary atelectasis etc., occurred in the patients.

Discussion

The consensus among the thoracic surgeons today is that surgery for patients in stage-T4 lung cancer with MPA involvement will produce favorable short term and long term benefits^[2]. However, separation of the lobar

vessels gets very difficult during the surgery because tumors or metastatic lymph nodes frequently invade and circumvolute on pulmonary hilum and artery, caused by cancer, or lymphatic metastasis. Moreover, total pneumonectomy is commonly used, because the pulmonary vessels are more fragile than the general vessels, and the angiorrhesis and hemorrhage frequently occur when separating the artery under stress. However, total pneumonectomy has led to resection of part of the normal lung, with more postoperative complications and a high death rate in the patients. Wen et al.^[3] reported that after total pneumonectomy of lung cancer, the incidence rate of complications was 86.5%, among which incidence of severe cardiopulmonary complications was 21%. Following total pneumonectomy, complications adversely affected the postoperative quality of life and survival time of the patient. However, sleeve lobectomy which is suitable for stage-IIb and stage-III lung cancer patients could effectively excise regional tumor, and the intra-operative death rate is low. In addition, the method of surgery is suitable to the patients with contradictions to total pneumonectomy^[4]. As expected, the postoperative survival time is extended in lung cancer patients with sleeve lobectomy compared with those with total pneumonectomy. The 5-year survival rate was 50.3 % in the group with sleeve resection of the pulmonary lobe, and only 30.6% in group with a total pneumonectomy^[5]. Zhang et al.^[6] also reported that angiopoesis or PL with bronchoplasties and pulmonary arterioplasties could obtain the same results as total pneumonectomy, and these would especially be suitable for the partially advanced lung cancer patients with poor cardiorespiratory function and unable to undergo total pneumonectomy. Therefore, we propose that total pneumonectomy for lung cancer should, if possible, be refrain, especially in the case of senile lung cancer patients with severely compromised or declined lung function.

Separation of pulmonary artery is a critical step of PL. Our experience has shown that the order of surgery for angiotomy and bronchial dissection could be flexible. Once there is a difficult angiodiastasis, or a possible angiorrhesis, an interruption of unilateral MPA could be conducted. Angiopoiesis, or angiorrhaphy should be done at the angiodiastasis, or at the sites of possible angiorrhesis, or at tumor invasion of the vessels. Concurrently, we also observed that the intra-pericardial MPA was rarely involved and was easily separated in most of the lung cancer patients. PL was done by blocking the unilateral MPA. Since the blood flow from the pulmonary artery on affected side was blocked and the tension of distal pulmonary artery decreased, the risk of angiorrhesis in separating the pulmonary artery could be effectively reduced. Even though there was an angiorrhesis at separation of the pulmonary artery, hemorrhage did not occur. Moreover, arteriorrhaphy, or angiopoesis can easily be completed. Less hemorrhage occurred during the surgery, with the distinct field of

operation and the surgical procedure was facile. The surgeon could usually accomplish PL and lymphadenectomy for the patients with stage-III lung cancer patients, who failed to achieve an exairesis by a conventional method of surgery, to get an opportunity of surgery and a more satisfactory therapeutic result. Also, the duration of surgery could be shortened compared with the conventional method. So, it is a preferred method of surgery.

Indications

Presently, CT and enhanced MRI scanning are the major diagnostic tools used for deciding the degree of tumor invasion and feasibility of the complete excision of pulmonary lobes. Some difficulty remains in determining whether or not an intra-operative blockade of unilateral pulmonary artery is necessary. The decision is now made by surgeons based on the intra-operative situation. We believe that during the blockade of unilateral pulmonary artery for PL, the major indications including the following *i*) involvement of giant tumor in the superior pulmonary lobes, extending to most of the other lobes, or adhesion with the left or right MPA, with difficult separation of the pulmonary artery; *ii*) extensive pulmonary hilum or mediastinal lymph node metastasis, resulting in obstruction of the pulmonary hilum, and difficult separation of the pulmonary artery, and angiorrhesis and angiorrhagia; *iii*) lateral-wall adhesion, or fusion of tumor and MPA in central-type lung cancer, requiring surgical operation of the PA; *iv*) PA or neoplasty, aspects need to be considered. These are based on the opinion of the surgeons.

Intraoperative concerns

Pulmonary artery is divided into the nutrient and functional vessels. After blocking the pulmonary artery on affected side, i.e., the functional vessel, there is still a blood supply from bronchial artery, the nutrient vessel on affected side of the lung. Temporary blockade of the blood flow from the pulmonary artery on affected side has no effect on maintaining the postoperative pulmonary function. However, special attention of the followings should be paid during surgery: *i*) sharp dissection using tissue scissors, with aid of a right angle forceps, is suitable for intra-operative separation of the MPA and its branches on affected side, and blunt dissection may easily result in angiorrhesis and hemorrhage. A 4-0 atraumatic vascular suture and bandage, or neoplasty should be available during the surgery in case of angiorrhesis; *ii*) Thorough separation of the vessels is necessary before ligation of the lobar artery and its branches, in order to diminish the tension of vessel wall and limit angiorrhesis at the ligation; *iii*) after blocking the MPA on affected side, any change in the patient's blood pressure, heart rate, and saturation of blood oxygen should be closely observed, especially for those at advanced

age, or with preoperative insufficiency of cardiopulmonary functions; *iv*) skillful operative procedure, in a timely manner, i.e. the shorter the time for blocking the pulmonary artery, the better the therapeutic result. Jing et al.^[7] reported that intra-operative segmental blockade of the artery for more than 30 min may result in an interruption of hyperplasia of the endarterium. Moreover, prolongation of the blocking time can also damage the vascular endothelial cells of small vessels of the lung, thus resulting in an interstitial edema, increase of AV shunt, and postoperative hypoxemia in the patients^[8]. In 30 patients of our group, the time of blocking MPA on the affected side ranged from 10-30 min, without postoperative severe cardiopulmonary complications.

Postoperative complications

Acute pulmonary edema

This condition results from a slight ischemia of the lung on affected side and concurrently a flow of profuse blood flows into the pulmonary tissue at the unaffected side in a short time, following the blockade of unilateral pulmonary artery. An unobstructed respiratory tract, sufficient oxygen intake and shortening of the time for blocking the pulmonary artery as much as possible are the major means for preventing the condition. At the same time, input of the fluids are strictly controlled, especially the electrolyte fluids, and diuresis treatment is to be given if needed. In our group, the condition of the 5 cases having acute pulmonary edema was improved after active treatment.

Cardiac arrhythmia

Supraventricular tachycardia and ventricular premature beat were commonly seen in the cases, which might be related to a stimulation of the heart by operative procedure during the surgery, or an exposure of the heart to the pleural effusion after partial excision of the pericardium. Other authors believed that there was an obvious correlation between the chronic coronary artery affections and arrhythmia after surgery of lung cancer^[9]. Postoperative pain was considered as an inducement of the arrhythmia, and all conventional anti-arrhythmia treatments were available^[10]. In our group, supraventricular tachycardia occurred in 7 cases, 4 of which developed into paroxysmal atrial fibrillation. The patients' condition was improved after administration of drugs such as cedilanid, etc.

Prognosis

The effect of blocking unilateral pulmonary artery on the pulmonary function of postoperative patients remains controversial and further verifications of quantity of serial control studies are needed. The findings of the 30 patients in our group showed that a short period of pulmonary-artery blockade did not result in severe cardiopulmonary complications, such as postoperative acute

respiratory failure, adult respiratory distress syndrome, etc. In a comparative study in relation to the effect of various periods of pulmonary-artery blockade on the degree of ischemic injury of the lung in the mice, Liu et al^[11]. found that in rats, a 30-min blockade of the pulmonary artery could not obviously jeopardise lung function. Conspicuous pneumonema occurred in the group with a 60-min arterial blockade. The specific gravity between the moist and dry rales in the lung and the content of malonaldehyde (MDA) was apparently higher in the 60-min blockade group than that in the 30-min control group, while the PaO₂ and superoxide dismutase (SOD) was obviously lower in the 60 min group than that in the 30-min control group. Therefore, our suggestion is that the time of blocking pulmonary artery be within 30 min. Both physiological and pathological change in blockade of the pulmonary artery on affected side and in reperfusion for the pulmonary oligemia awaits the results of further studies.

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