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Correlation and interventional embolization therapy of posterior intercostal arteries-induced hemoptysis

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ABSTRACT. The incidence of posterior intercostal arteries-induced hemoptysis, its correlation with primary diseases, and the value of interventional embolization therapy were investigated. Clinical data, multislice spiral computed tomography (MSCT), digital subtraction angiography (DSA), and other imaging data of 143 cases of hemoptysis were retrospectively analyzed. After the offending vessels were subjected to interventional embolization therapy, patients were followed-up for observations of clinical efficacies and complications. Thirty-one patients (21.7%) showed 65 branches of posterior intercostal arteries as the non-bronchial systemic arteries involved in hemoptysis; pleural thickening was evident in 25 (80.6%) cases. Posterior intercostal arteries-induced hemoptysis was observed in 16 of the 27 (59.3%) patients with pulmonary tuberculosis, and in 9 of the 10 (90.0%) patients with pulmonary tuberculosis and pulmonary damage. Posterior intercostal

arteries-induced hemoptysis was correlated to pleural thickening ($P < 0.05$), which differed significantly among different underlying diseases ($P < 0.05$). Twenty-eight cases of 58 branches of posterior intercostal arteries were found to be involved in hemoptysis by preoperative chest CT angiogram (CTA); the intraoperative matching rates were 90.3% (28/31) and 89.2% (58/65), respectively. Thirty-one patients received transcatheter arterial embolization (TAE), of which 29 (93.5%) showed immediate hemostasis; 1 case had surgical treatment for ineffectuality, and 2 cases showed recurrence without serious complications. The posterior intercostal arteries were commonly involved in hemoptysis, and were closely associated with pleural thickening and pulmonary tuberculosis, especially when accompanied by pulmonary damage. Complete TAE could improve the treatment effect of hemoptysis and preoperative chest CTA was helpful for interventional embolization therapy.

Key words: Hemoptysis; Embolism; Therapeutic; Pleural thickening; Posterior intercostal arteries

INTRODUCTION

Massive hemoptysis is a common medical emergency observed in clinical settings, which is often difficult to control, is associated with substantial surgical trauma and risk, and is limited by many factors, such as the extent of disease, and the patient's own constitution, among others. Bronchial artery embolization (BAE) has been widely used in the treatment of massive hemoptysis in clinics owing to its exact therapeutic effectiveness, with an immediate success rate for hemoptysis of 90-95%. However, 5-10% of patients show hemostatic failure or recurrent bleeding shortly after treatment, which is closely related to the corporate offending vessels accompanied by non-bronchial systemic arteries (NBSA) involved in hemoptysis (Keller et al., 1987; Tamura et al., 1993; Sellars and Belli, 2001; Yoon et al., 2002, 2003, 2005; Yu-Tang Goh et al., 2002; Andersen, 2006; Corr, 2006; Kim et al., 2006). In recent years, increasing attention has been paid to NBSA in hemoptysis treatment; however, the posterior intercostal arteries have been relatively neglected. In this study, the clinical data of 143 cases of hemoptysis were retrospectively analyzed in the context of interventional therapy to determine the incidence of posterior intercostal arteries-induced hemoptysis and its correlation with primary diseases, as well as to evaluate the clinical value of interventional embolization therapy.

MATERIAL AND METHODS

Clinical data

The complete chest computed tomography (CT), computed tomography angiogram (CTA), and digital subtraction angiography (DSA) data of 143 patients who were diagnosed with acute massive hemoptysis or repeated hemoptysis in clinical settings were analyzed.

These patients, including 106 males and 37 females ranging in age from 21 to 84 years old (mean age, 51.3 ± 14.1 years), were deemed to be unsuitable for surgical therapy after medical therapy failure, and underwent interventional therapy. Patients were divided into three groups according to the manifestation of different primary diseases: simple bronchiectasis, pulmonary tuberculosis and infection, and lung cancer. Seventy-five patients had simple bronchiectasis and infection. Twenty-seven patients had pulmonary tuberculosis, including 22 cases of secondary bronchiectasis, 10 cases accompanied by pulmonary damage (1 case accompanied by esophageal cancer), and 3 cases accompanied by *Aspergillus* infections, and 12 patients had pulmonary infection, including 5 cases of severe pneumonia, 1 case of pulmonary abscess, 3 cases of general pneumonia, 2 cases of *Aspergillus* infection, and 1 case of pulmonary sequestration combined with infection. Fourteen patients had lung cancer; 4 patients showed postoperative chest changes, 1 patient had pulmonary embolism, and 10 patients had cryptogenic hemoptysis. The clinical data of the 143 cases of hemoptysis were subject to retrospective analysis as well as multislice spiral CT (MSCT, CTA), DSA, and other imaging methods. The incidence of posterior intercostal arteries-induced hemoptysis was recorded, and its correlations with underlying diseases were analyzed. The diagnostic criteria of pleural thickening included extrapleural fat layer broadening and pleural thickness of more than 3 mm (Yoon et al., 2003). This study was conducted in accordance with the Declaration of Helsinki and with approval from the Ethics Committee of the First Hospital Affiliated to Fujian Medical University. Written informed consent was obtained from all participants.

Imaging

After receiving conventional chest scans, patients underwent enhanced CTA inspection and intravenous injection of 300 mg/mL (120 mL total) contrast agent iohexol through the elbow vein or the basilic vein at a 4-5 mL/s injection speed. Thereafter, SURESTAR technology was used for breath-hold fast scanning of the whole chest, with a scanning range from the superior margin of the seventh cervical vertebral body to the inferior margin of the first lumbar vertebral body.

The patients underwent selective and/or super selective endovascular embolization according to pathological BA and/or posterior intercostal arteries detection confirmed by preoperative CTA and intraoperative imaging. The embolization materials were as follows: gelatin sponge particles (Jinling Pharmaceutical Company Ltd.; China) and polyvinyl alcohol particles (Cook Company; USA) as the distal embolization agents, and homemade fine gelatin sponge strips (Jinling Pharmaceutical Company Ltd.) and spring coils (Cook Company) as the trunk embolization agents.

Clinical observations

The immediate hemostasis, recurrence, long-term efficacy, and complications were observed after interventional embolization therapy. The follow-up period ranged from 6 months to 5 years.

Statistical analysis

The data were analyzed with the SPSS13.0 software. The measurement data were

analyzed with χ^2 inspections. P <0.05 represented a statistically significant difference.

RESULTS

Correlations of incidence of posterior intercostal arteries-induced hemoptysis, preoperative CTA discovery, intraoperative matching rate, and pulmonary arteriovenous fistula (BPS) formation to pleural thickening

Sixty-five branches of posterior intercostal arteries-induced NBSA involved in hemoptysis were found in the intervention operations of 31 of the 143 patients (21.7%) with hemoptysis, and 48 of these branches (73.8%) were accompanied by BPS. Twenty-eight patients with 58 branches of posterior intercostal arteries were found in preoperative chest CTAs; the intraoperative total matching rates were 90.3% (28/31) and 89.2% (58/65), respectively. Among the 31 patients, 26 (81.9%) were accompanied by pleural thickening, and among the 48 branches of posterior intercostal arteries combined with BPS, 43 (89.2%) were accompanied by adjacent pleural hypertrophy. Statistical analysis showed that posterior intercostal arteries-induced hemoptysis and BPS formations were correlated to pleural thickening (P <0.05).

Correlation of pathological posterior intercostal arteries-induced hemoptysis with pleural thickening to underlying diseases

The pulmonary tuberculosis combined with pulmonary damage group was accompanied by posterior intercostal arteries involved in hemoptysis relatively more often than the other groups. In addition, since there were too few cases of underlying chest diseases to perform accurate statistical analyses, the data were appropriately treated according to experience and observation purposes. All of the patients were divided into the simple bronchiectasis group, the pulmonary tuberculosis combined with pulmonary damage group, the pulmonary tuberculosis not combined with pulmonary damage group, and the other cases group. Pairwise comparisons were conducted between groups. The results demonstrated a statistically significant correlation between posterior intercostal arteries-induced hemoptysis and BPS formation with underlying chest diseases (P <0.05, Table 1).

Table 1. Correlation of posterior intercostal arteries-induced hemoptysis and pleural thickening to underlying diseases.

Items	Simple bronchiectasis group	Pulmonary tuberculosis combined with pulmonary damage group	Pulmonary tuberculosis non-combined with pulmonary damage group	Other case groups	χ^2	P
Posterior intercostal arteries-induced hemoptysis	10.7% (8/75)	90.0% (9/10)*	41.2% (7/17)*	17.6% (7/41)	40.128	<0.05
Pleural thickening	4% (3/75)	100% (10/10)*	58.8% (10/17)*	4.9% (2/41)	46.323	<0.05

*Compared with the simple bronchiectasis group and other case groups, P <0.05.

Clinical efficacy and complications

In this group of patients, 31 patients underwent 33 interventional embolization

therapies, of which 29 patients showed immediate hemostasis after TAE, with a hemostatic rate of 93.5%; one patient had a surgical operation for ineffectiveness and 2 patients with recurrence underwent additional interventional embolization therapy for hemostasis. All of the posterior intercostal arteries underwent embolization by using gelatin sponge particles, gelatin sponge strips, or polyvinyl alcohol particles. There were no spinal cord injuries or other serious complications. Thirty of the 31 patients underwent follow-up for more than six months.

DISCUSSION

NBSA-induced hemoptysis is also commonly referred to as non-bronchial systemic collateral vessels, including posterior intercostal arteries, inferior phrenic arteries, esophageal inherent arteries, left gastric arteries, internal thoracic arteries, and subclavian arteries, etc. (Keller et al., 1987; Tamura et al., 1993; Sellars and Belli, 2001; Yu-Tang Goh et al., 2002; Corder, 2003; Yoon et al., 2002, 2003, 2005; Andersen, 2006; Corr, 2006; Kim et al., 2006). Of the 143 hemoptysis patients who underwent interventional operations, 31 (21.7%) were found to have 65 branches of posterior intercostal arteries involved in hemoptysis. This rate differs from the 36.0% of hemoptysis associated with NBSA and blood supply detected by Yoon et al. (2005) by using 16 slices spiral CT angiography, and included the posterior intercostal arteries, inferior phrenic arteries, esophageal inherent arteries, left gastric arteries, internal thoracic arteries, subclavian arteries, and other branch vessels into the statistical range of NBSA.

NBSA is normally kept out of the blood supply in lung tissues. However, after pleural thickening or long-term chronic inflammatory stimulation of adjacent pleural intrapulmonary lesions, NBSA could produce several types of pathological changes and participate in the blood supply, so that lung tissues become the offending vessels of hemoptysis. Yoon et al. (2003) suggested that more than 3 mm of pachynsis pleurae in chest CTs could indirectly indicate that the corresponding NBSA would be involved in the intrapulmonary blood supply and that the blood supply of NBSA-induced hemoptysis was closely related to intrapulmonary lesions. NBSA is involved in the blood supply of intrapulmonary lesions, forming an anatomical condition of physiological shunting. The pleural blood vessels nourish the intrapulmonary lesions, or the pulmonary lesions are spread to the pleura, which then cause the pleural vascular proliferation to construct an abnormal vascular bed between the peripheral vessels in the chest wall and the intrapulmonary blood vessels, thereby forming an abnormal vascular access. Therefore, whether NBSA is involved in the blood supply of intrapulmonary lesions and forms a short circuit is closely related to whether or not the pleura are normal. Significant pleural thickening is often an important marker of the NBSA blood supply (Yoon et al., 2003, 2005). In the present study, 21.7% (31/143) of patients showed hemoptysis induced by posterior intercostal arteries. The statistical analysis showed that although the posterior intercostal arteries-induced hemoptysis was correlated to pleural thickening, the correlation was not positive (Table 1, Figures 1 and 2). In addition, among the 65 branches of posterior intercostal arteries that produced NBSA to induce hemoptysis, 48 were combined with BPS, accounting for 73.8%; 43 of these branches were accompanied by adjacent pleura incrassation, accounting for 89.2%. This result confirmed that the pleura lesions were correlated to NBSA, which is consistent with the literature.

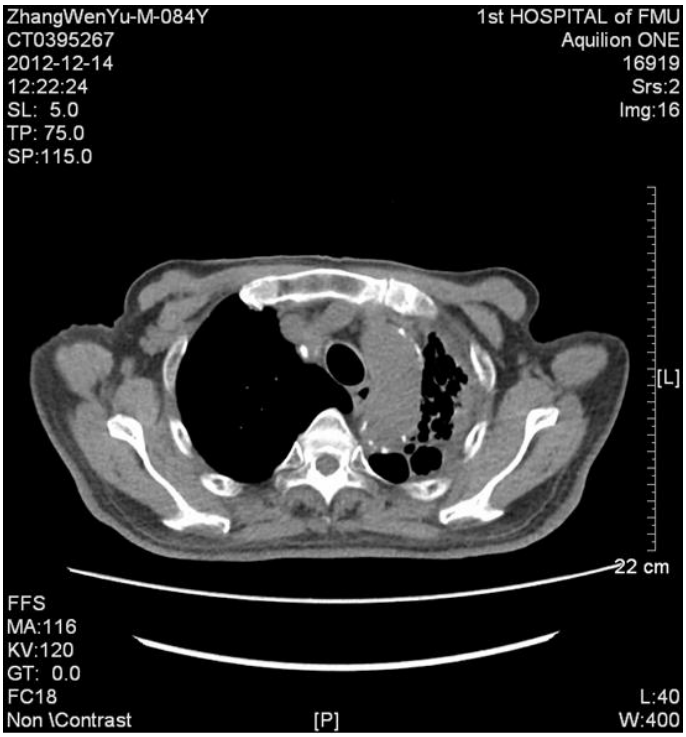

Figure 1. Male, 84 years, massive hemoptysis, chest scan, mediastinal window showed left upper lung damage, chest and back pleural thickening and extrapleural fat layer broadening.

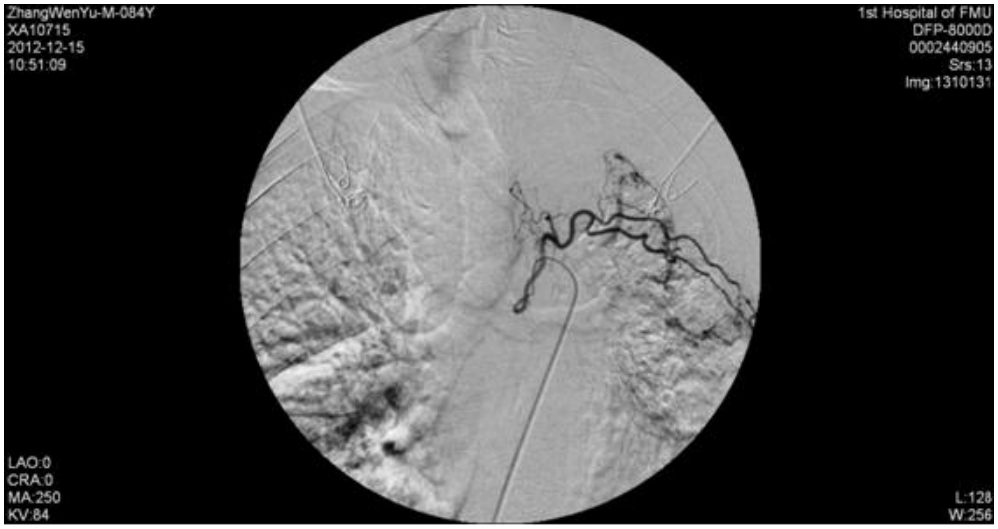

Figure 2. Same patient. Intraoperative DSA showed the left posterior intercostal arteries coarsening, circuity, disorder angiogenesis, and accompanied by BPS formation.

The most common underlying diseases inducing hemoptysis mainly include lung bronchogenic carcinoma and infectious lung diseases in western countries, whereas in non-western countries, pulmonary tuberculosis, including tuberculous bronchiectasis, is the most common hemoptysis-inducing underlying disease (Tamura et al., 1993; Sellars and Belli, 2001; Yu-Tang Goh et al., 2002; Yoon et al., 2002, 2005). In the present study, the most common underlying diseases that induced hemoptysis were bronchiectasis and pulmonary tuberculosis, as shown in Table 1, especially those combined with pulmonary damage and related to pleural thickening. The most common underlying disease of posterior intercostal arteries-induced hemoptysis was pulmonary tuberculosis, especially when combined with lung damage. This was mainly caused by the fact that pulmonary tuberculosis usually originated from the apex of the double upper lungs and the back section of the double lower lobes, thus easily causing pleural thickenings in the breast and the back, which are the main blood supply areas of the posterior intercostal arteries.

Multislice CTAs were helpful for evaluating hemoptysis in patients. The interventional physicians comprehensively learned about the preoperative vascular distribution in the patients' chests, and the potentially bleeding vessels could play important guiding roles in the operation and curative effects, especially in hemoptysis patients with NBSA involved in the blood supply. This could effectively improve the success rate of immediate hemostasis and reduce the hemoptysis rate of short-term or even long-term recurrence (Chapman et al., 2000; Wong et al., 2002; Chun et al., 2003a,b; Remy-Jardin et al., 2005; Norgaard et al., 2006; Khalil et al., 2008; Sirajuddin and Mohammed, 2008). In this patient group, 58 branches of posterior intercostal arteries in 28 patients were detected to be involved in hemoptysis through the preoperative chest multislice CTAs, with intraoperative matching rates of 89.2% (58/65) and 90.3% (28/31). Yoon et al. (2003) suggested that CT has a sensitivity of 80%, a specificity of 86%, a positive prediction rate of 73%, a negative prediction rate of 91%, and an accuracy rate of 84% in predictions of the NBSA blood supply, with the highest specificity of blood supply from the posterior intercostal arteries. Therefore, preoperative and intraoperative discoveries of these pathological posterior intercostal arteries and their embolisms are very important to control bleeding and prevent recurrence. It is generally believed that preoperative chest CTA inspections could greatly reduce the duration of interventional operations and ray irradiation, further illustrating the importance of preoperative chest CTAs. It was suggested that hemoptysis outpatients should first undergo enhanced lung scans to exclude any lung diseases, followed by chest CTA inspection to find the offending vessels inducing hemoptysis prior to embolization intervention.

This group of hemoptysis patient showed clear effects after interventional therapies, without any occurrence of paraplegia or other serious complications. The most serious complication in the posterior intercostal artery embolization was spinal cord injury. According to our experience, it is necessary to learn about the anatomy structures, normal variations, and mutual relationships of the posterior intercostal arteries and spinal arteries. Furthermore, careful preoperative analysis of CTA images and intraoperative analysis of DSA images of posterior intercostal arteries are necessary to eliminate the common stem of spinal arteries, the microcatheter should be used for further intubation as far as possible, and strict observations of feeling in the lower limbs are necessary during the operation. Once any anomaly appears, immediate anticoagulation, dilatation, and other therapies should be given.

In conclusion, during the treatment of major hemoptysis by bronchial artery embo-

lization, the posterior intercostal arteries involved in the blood supply should be carefully looked for. This might not only improve the efficiency of the treatment, but might also help to reduce the recurrence rate. In addition, the preoperative chest CTA was found to be helpful for the discovery of the offending vessels inducing hemoptysis prior to performing the embolization intervention.

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