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Can selective CT angiography reduce the incidence of severe complications during transcatheter arterial embolization or infusion chemotherapy for thoracic diseases?

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PURPOSE
To evaluate the usefulness of selective computed tomography (CT) angiography in preventing severe complications, such as spinal cord injury and broncho-esophageal fistula, during the transcatheter arterial embolization or infusion chemotherapy for thoracic diseases.

MATERIALS AND METHODS
Data from 28 patients with thoracic diseases were retrospectively analyzed in terms of selective CT angiography procedures carried out before transcatheter arterial embolization or transcatheter arterial infusion chemotherapy.

RESULTS
There were no spinal cord injuries (0/13 and 0/15) or broncho-esophageal fistula developments (0/13 and 0/15) during transcatheter arterial embolization and transcatheter arterial infusion chemotherapy, respectively.

CONCLUSION
We conclude that selective CT angiography is potentially useful for reducing the incidence of severe complications during transcatheter arterial embolization or infusion chemotherapy for thoracic diseases.

Key words: • *computed tomography, angiography* • *interventional radiology, complications* • *lung, diseases* • *mediastinum, diseases*

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Since the first reports on selective bronchial arteriography in 1964 (1), it has been widely used for the chemotherapy of lung cancer (2) and for the treatment of hemoptysis (3). Several transarterial interventional therapeutic techniques have been implemented since then, such as percutaneous transcatheter arterial embolization (TAE), percutaneous transcatheter arterial infusion (TAI) chemotherapy. With the technique of Seldinger, selective treatment may be done via the bronchial, intercostal, and internal mammarian arteries (4–7). In recent years, with the development of various instruments like coaxial microcatheter system, it has been possible to perform superselective bronchial and intercostal arterial catheterization (8).

With wide implementation of these techniques, several complications like spinal cord injury, esophageal ulceration, and broncho-esophageal fistula as a result of the embolization of the anti-cancer drugs and embolic materials to the esophageal and spinal vessels have been reported (5, 9–11). Extremely small anastomoses between the bronchial arteries and the spinal or esophageal branches, which are not detectable by digital subtraction angiography (DSA), may be defined with computed tomography (CT) angiography (12). In order to prevent the complications, it is necessary to advance the catheters and do the injection of the embolic material or the chemotherapeutics beyond the point from which the branches supplying blood to the esophagus and spinal cord arise. To date, there have been no reports evaluating whether selective CT angiography is effective in preventing the previously mentioned severe potential complications.

Materials and methods

Thirteen patients with hemoptysis due to tuberculosis, 12 patients with primary lung cancer and 3 patients with malignant mediastinal tumor were scheduled to undergo TAE and TAI and all were previously evaluated with CT angiography. Eleven of the patients enrolled into the study were males, while 17 were females and the age of the patients ranged between 42 and 75 years (mean, 58.4 years) (Table 1).

Transfemoral bronchial arterial catheterization was performed by the standard Seldinger technique under local anesthesia using a 5.0-F Mikaelsson catheter or a 5.0-F Cobra type catheter (Cook Inc., Bloomington, IN, USA). Five to 10 ml of 300 mg/ml iohexol (Omnipaque 300; Daiichi Pharmacy, Tokyo, Japan) were injected from the origin of the bronchial artery for DSA. The catheter was advanced as close as possible to the artery feeding the tumor or the bleeding point using a coaxial microcatheter (Tracker-18; Target Therapeutics, Fremont, USA), DSA and selective CT-angiography were then performed. Fifteen–thirty ml of 140 mg/ml iohexol (Omnipaque 140; Daiichi Pharmacy, Tokyo, Japan) were

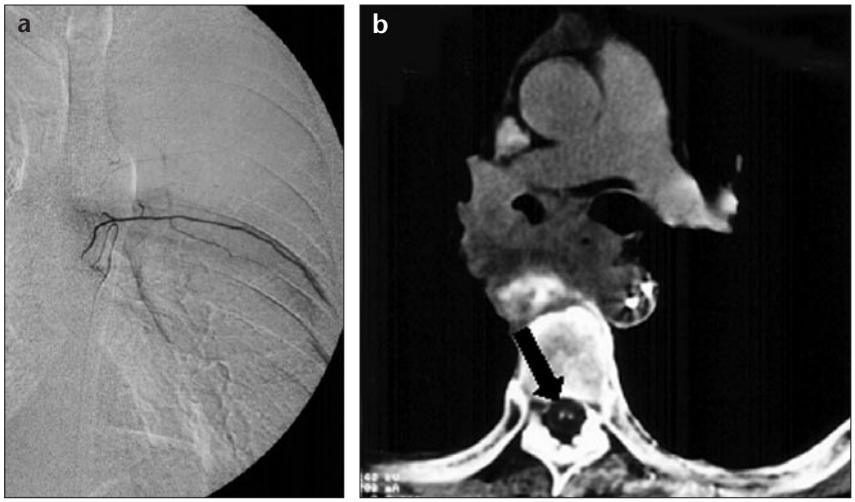

Figure 1. a, b. Patient no 26. Angiogram via the left sixth intercostal artery **(a)** shows enhancement of part of the tumor. Neither spinal nor esophageal branches can be seen on angiography. Selective CT angiogram via the left sixth intercostal artery **(b)** shows spinal cord enhancement *(black arrow)*.

Table 1. Basic characteristics of patients

Patient No.	Gender	Age	Diagnosis	Artery for selective CT angiography
1	M	45	mediastinal tumor (germ cell tumor)	rt.IMA, rt.BA
2	M	56	hemoptysis	rt.BA, rt.ICA
3	F	62	hemoptysis	rt.BA, rt.ICA
4	M	75	lt. lung cancer (squamous cell carcinoma)	lt.BA, lt.ICA, rt.BA
5	M	58	mediastinal tumor (thymic cancer)	lt.BA, lt.ICA, rt.ICA
6	M	60	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA, rt.ICA
7	M	74	hemoptysis	rt.BA
8	M	63	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA, rt.ICA
9	M	51	mediastinal tumor (germ cell tumor)	lt.IMA, rt.IMA
10	M	55	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA, rt.ICA
11	F	52	hemoptysis	lt.BA
12	F	52	hemoptysis	lt.BA, lt.ICA
13	M	56	lt. lung cancer (squamous cell carcinoma)	lt.BA, lt.ICA, rt.BA
14	F	58	hemoptysis	lt.BA
15	M	74	hemoptysis	rt.BA, rt.ICA
16	M	61	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA
17	F	54	hemoptysis	rt.BA
18	M	58	hemoptysis	lt.BA, lt.ICA
19	F	62	rt. lung cancer (adenocarcinoma)	lt.BA, rt.BA, rt.ICA
20	M	42	lt. lung cancer (squamous cell carcinoma)	lt.BA, lt.ICA, rt.BA, rt.ICA
21	F	50	hemoptysis	lt.BA, lt.ICA
22	M	67	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA, rt.ICA
23	M	52	hemoptysis	lt.BA
24	F	63	hemoptysis	lt.BA
25	F	68	rt. lung cancer (adenocarcinoma)	lt.BA, rt.BA
26	F	55	rt. lung cancer (squamous cell carcinoma)	lt.BA, lt.ICA, rt.BA, rt.ICA
27	M	58	hemoptysis	lt.BA, lt.ICA
28	F	55	rt. lung cancer (squamous cell carcinoma)	lt.BA, rt.BA, rt.ICA, rt.IMA

lt.: left, rt.: right, BA: bronchial artery, ICA: intercostal artery, IMA: internal mammary artery, M: male, F: female

injected at a rate of 0.5 to 1.0 ml/sec for selective CT angiography to evaluate the distribution of contrast medium. CT scanning was started 10 sec after the beginning of contrast medium administration. All angiographic examinations with CT were performed in the same study using a system which combined CT and angiography (Advantx ACT; GE Healthcare, Milwaukee, WI, USA). This system consisted of a single detector CT unit and an angiography system. CT images were obtained in a single breath-hold with the entire lesion imaged using a helical CT system. The beam width was 5 mm, the table moved at a speed of 5 mm/sec, and the matrix was 512 x 512.

The patients in whom the bronchial artery did not supply blood to the lesions underwent catheterization of the intercostal or the internal mammarian artery. We then performed DSA and selective CT arteriography under the same conditions as for the bronchial artery.

Gelatin sponge (Gelfoam; Upjohn, Kalamazoo, MI, USA) particles that had been cut into small fragments (1 x 1 mm) were used for TAE. Cisplatin (50 mg) used for TAI was injected at a rate of 2.0–2.5 mg/min.

If esophageal wall or spinal cord enhancement was observed on selective CT angiography via artery through which the treatment was to be administered, transarterial catheter therapy was not performed.

Results

The details of selective CT angiography and complications of procedures were summarized in Table 2. For 1 patient with lung cancer (patient no. 26), the spinal cord enhanced on selective CT angiography from the left sixth intercostal artery (Fig. 1). There were no complications for this and other lung cancer patients.

In one of the 3 mediastinal tumor cases (patient no. 5), the anterior spinal artery was observed from the left first intercostal artery and esophageal wall enhancement was seen from the right second intercostal artery on selective CT angiography (Fig. 2). No complications were recorded in this or other mediastinal tumor cases undergoing TAI.

In one of the thirteen hemoptysis cases (patient no. 14), esophageal wall enhanced on CT angiography from the

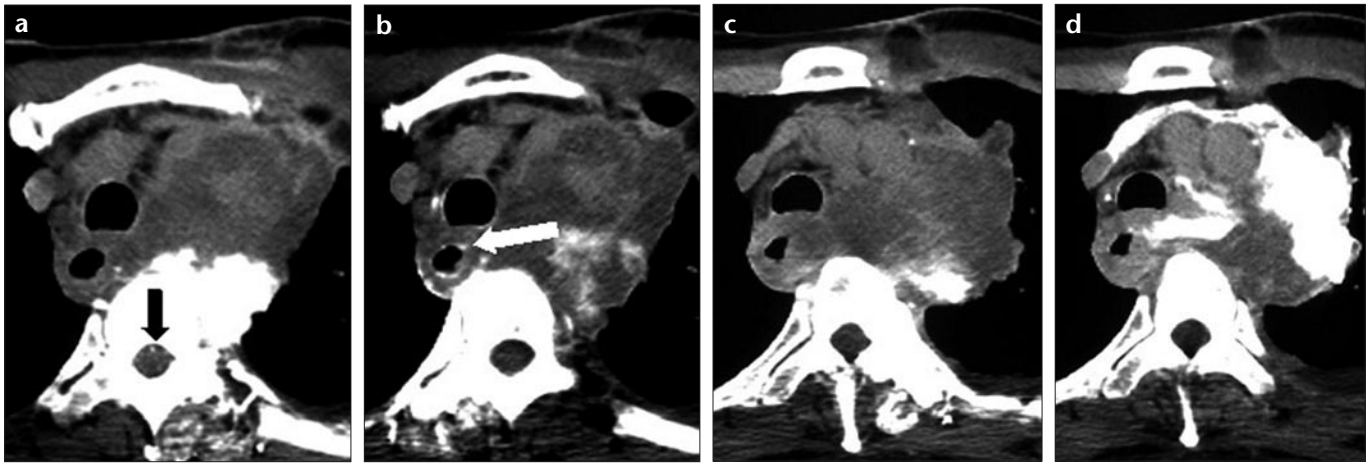

Figure 2. a-d. Patient no 5. Selective CT angiogram via the left first intercostal artery **(a)**, right second intercostal artery **(b)**, left third intercostal artery **(c)**, and left bronchial artery **(d)**. The anterior spinal artery is visualized by selective CT angiogram via the left first intercostal artery *(***a***, black arrow)*. Esophageal wall enhancement via the right second intercostal artery is seen *(***b***, white arrow)*.

Table 2. The details of selective CT angiography and complications of procedures

Patient No.	Feeding artery	Enhancement on selective CT angiography		Treatment	Side effects
		Esophagus	Spinal cord		
1	rt.IMA	(-)	(-)	TAI (rt.IMA)	(-)
2	rt.BA	(-)	(-)	BAE (rt.BA)	(-)
3	rt.BA	(-)	(-)	BAE (rt.BA)	(-)
4	lt.BA	(-)	(-)	BAI (lt.BA)	(-)
5	lt.BA, lt.ICA, rt.ICA	(+) (rt.ICA)	(+) (lt.ICA)	BAI (lt.BA)	(-)
6	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
7	rt.BA	(-)	(-)	BAE (rt.BA)	(-)
8	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
9	lt.IMA	(-)	(-)	TAI (lt.IMA)	(-)
10	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
11	lt.BA	(-)	(-)	BAE (lt.BA)	(-)
12	lt.BA, lt.ICA	(-)	(-)	BAE (lt.BA) + TAE (lt.ICA)	(-)
13	lt.BA	(-)	(-)	BAI (lt.BA)	(-)
14	lt.BA,	(-)	(-)	BAE (lt.BA)	(-)
15	rt.ICA	(-)	(-)	TAE (rt.ICA)	(-)
16	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
17	rt.BA	(-)	(-)	BAE (rt.BA)	(-)
18	lt.BA	(-)	(-)	BAE (lt.BA)	(-)
19	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
20	lt.BA, rt.BA	(-)	(-)	BAI (lt.BA,rt.BA)	(-)
21	lt.ICA	(-)	(-)	TAE (lt.ICA)	(-)
22	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
23	lt.BA	(-)	(-)	BAE (lt.BA)	(-)
24	lt.BA	(-)	(-)	BAE (lt.BA)	(-)
25	rt.BA	(-)	(-)	BAI (rt.BA)	(-)
26	rt.BA, lt.ICA	(-)	(+) (lt.ICA)	BAI (rt.BA)	(-)
27	lt.ICA	(-)	(-)	TAE (lt.ICA)	(-)
28	rt.BA, rt.IMA	(-)	(-)	BAI (rt.BA) + TAI (rt.IMA)	(-)

DSA: digital subtraction angiography, lt.: left, rt.: right, BA: bronchial artery, ICA: intercostal artery, IMA: internal mammary artery, BAE: bronchial artery embolization, BAI: bronchial artery infusion chemotherapy, TAE: transcatheter arterial embolization, TAI: transcatheter arterial infusion chemotherapy

origin of the left bronchial artery. In this case, we advanced the catheter as close as possible to the bleeding point using a coaxial microcatheter, and then performed selective CT angiography. On selective CT angiography, esophageal wall enhancement disappeared and TAE was performed (Fig. 3). There were no complications in this or other hemoptysis cases undergoing TAE.

Discussion

Indications for transcatheter embolization and infusion chemotherapy for hemoptysis and thoracic neoplasms have broadened as new devices allowed more selective treatment. There are several reports on transcatheter arterial therapy for pulmonary and mediastinal diseases. TAI has been applied for advanced lung cancer (6), mediastinal tumors (7), and metastatic pulmonary tumors (13). Recently, TAI has been performed even for centrally located early-stage lung cancer (14). Transcatheter arterial therapy has the advantage of repeatability. However, severe complications such as bronchoesophageal fistula and spinal cord injury have been described (5, 9–11). In these reports, complications appeared after transcatheter arterial therapy, because spinal and esophageal branches not being visualized on DSA images were reached selectively through the arteries into which the therapy was to be administered. For this reason, the anti-cancer drug or embolic material infused via the bronchial or intercostal artery was distributed into the spinal or esophageal branches, resulting in

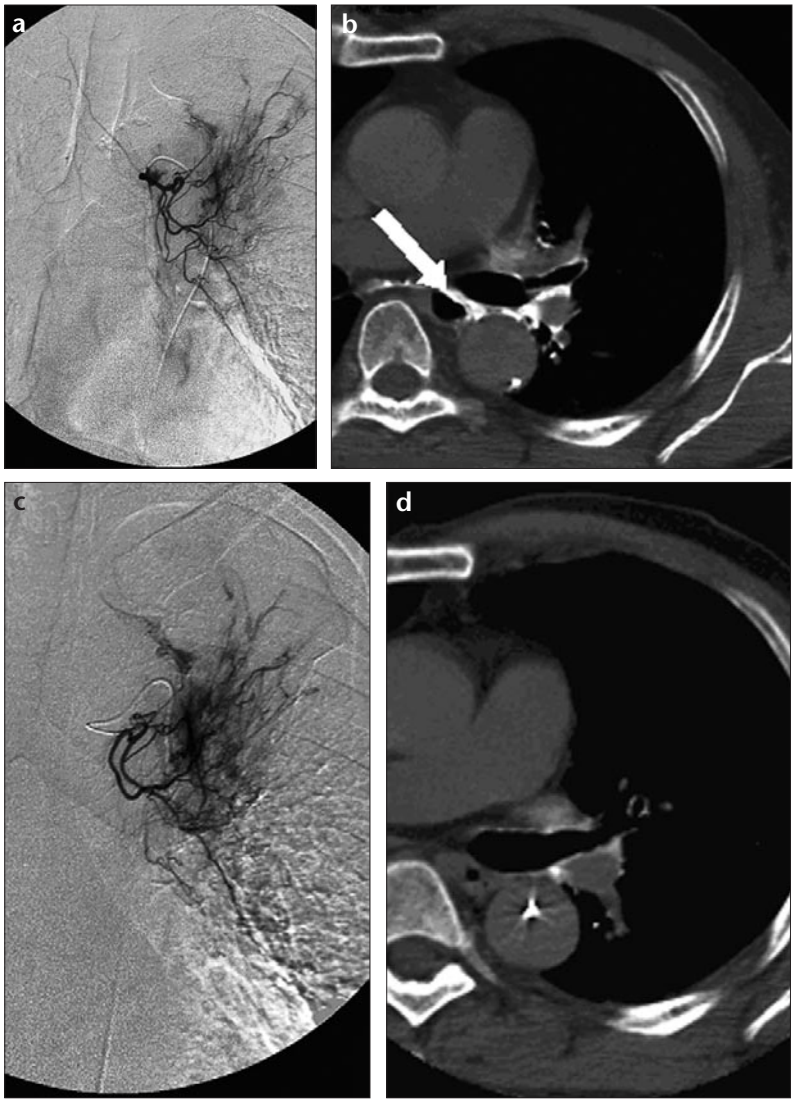

Figure 3. a-d. Patient no 14. Angiogram via the origin of the left bronchial artery **(a)** shows hypertrophic arteries that supply a hypervascular lesion in the left upper lobe. There is bronchopulmonary shunting with visualization of the branch of left upper lobar pulmonary arteries. Neither spinal nor esophageal branch is shown on angiography. CT angiogram via the origin of the left bronchial artery **(b)** shows an esophageal wall enhancement *(white arrow)*. Spinal cord enhancement is not shown. Superselective angiogram via the left bronchial artery with coaxial microcatheter **(c)** shows hypertrophic arteries that supply a hypervascular lesion in the left upper lobe. Neither spinal nor esophageal branch is shown on angiography. Superselective CT angiogram via the left bronchial artery **(d)**. Esophageal wall enhancement that is shown on CT angiogram via the origin of the left bronchial artery disappeared, and then, bronchial artery embolization was performed.

inadvertent effects on the spinal cord or esophagus. Moteki et al. performed both DSA and CT angiography from the origin of the bronchial artery for 21 patients, but neither spinal nor esophageal branches were detected by DSA in any of their patients, although enhancement of the spinal cord was observed in 8 (38.1%) and enhancement of the esophageal wall in 18 (85.7%) on CT angiography (12). Their report confirmed the existence of extremely small anastomoses between the bronchial arteries and the spinal or esophageal branches, apparently not detectable by DSA.

In a previous report, spinal cord injuries occurred in 1.4% of cases (2/140) during TAE for hemoptysis (15) and in 1.1% (3/277) during TAI using cisplatin (10). Esophageal ulceration or bronchoesophageal fistula occurred in 1.1% of cases (3/277) during TAI using cisplatin (10). Bronchoesophageal fistula is a rare complication of TAE for hemoptysis, with only 3 cases being reported previously (9, 16, 17). In our study, the spinal cord injury incidence was 0% (0/13 and 0/15) during both TAE and TAI, as was the esophageal ulceration or bronchoesophageal fistula incidence (0/13 and 0/15) during TAE and TAI, respectively.

The usefulness of superselective bronchial artery embolization with a coaxial microcatheter system for preventing spinal cord injury has been described in recent years (8, 18). However, Herve et al. (19) insisted that superselective bronchial artery embolization may be a promising way of preventing spinal cord injury, although the risks of complications may not be completely eliminated. In our study, esophageal wall enhancement was observed in 1 patient (3.6%), and the spinal cord enhanced in 2 patients (7.1%) on selective CT angiography using a coaxial microcatheter. Compared with a previous study (12) in which CT angiography was performed via the origin of the bronchial artery, there was less probability of seeing enhancement of the esophageal wall or spinal cord in our study. These results suggested the usefulness of superselective catheterization for reducing severe complications during transcatheter arterial therapy for thoracic diseases. However, enhancement of the esophageal wall or spinal cord on selective CT angiography can not guarantee the prevention of severe complications. The presence of spinal cord enhancement on selective CT angiography should be considered as a contraindication for transcatheter arterial embolization or infusion chemotherapy, because of the high risk of spinal cord injury due to anti-cancer drugs or spinal cord infarction due to embolic agents. Esophageal wall enhancement on selective CT angiography should be regarded as a contraindication for transcatheter arterial infusion chemotherapy, because the risk of esophageal wall injury due to anti-cancer drugs is high. Esophageal wall enhancement on selective CT angiography should not be regarded as a contraindication for transcatheter arterial embolization. In such cases, in order to prevent esophageal necrosis due to peripheral embolization of the esophageal wall, large pieces of gelatin sponge or microcoils are recommended.

The major limitation of our study is the small number of patients, although

the potential use of selective CT angiography prior to transcatheter arterial therapy for thoracic diseases for the prevention of severe complications such as bronchoesophageal fistula or spinal cord injury is highly promising.

In conclusion, selective CT angiography may reduce the incidence of severe complications. Furthermore, the imaging modalities used for this evaluation, the combination of selective CT angiography and DSA images obtained via the artery through which the treatment was to be administered, was found to be more useful than DSA alone.

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