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CLINICAL INVESTIGATIONS

# Embolization for Hemoptysis: A Six-Year Review

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## Abstract

*Purpose:* To review our method of embolization for hemoptysis.
*Methods:* Between 1993 and 1999, 134 patients were treated in our department for hemoptysis. One hundred and sixteen patients were followed up (18 were lost to follow-up) over a period ranging from 1 to 66 months (median 9.5 months, SD 14.81 months). Most cases were due to tuberculosis (83.6%) and malignancy (9.5%). One hundred and three required embolization. Vascular access was obtained via the femoral route but two cases required a brachial approach for abnormal branches of the subclavian artery. All abnormal vessels found were embolized using polyvinyl alcohol particles alone or in combination with gelfoam.
*Results:* Bronchial artery hypertrophy was found in 88.3% of cases; about a third of which had a nonbronchial systemic contribution. No angiographic abnormalities were found in 11.2%. Our failure rate was 18.4% (58% required surgery while 42% died from massive hemoptysis). Sixteen cases required multiple embolization sessions. No major complications were encountered.
*Conclusion:* Embolization is effective for treatment of moderate to massive hemoptysis. The majority of our cases were due to tuberculosis. Approximately one third had nonbronchial systemic artery contributions, indicating that a concerted search for these is mandatory.

**Key words:** Hemoptysis—Embolization—Tuberculosis—Bronchial artery

Bronchial artery embolization is now the established first-line treatment modality for massive hemoptysis, which is defined as blood loss of 300–600 ml over 24 hrs [1]. The procedure is usually done on an emergency basis as this condition carries a mortality rate of 50–85% [1]. The cause of death is usually asphyxiation rather than exsanguination. Most of these patients are extremely ill, as their existing respiratory reserve is already poor. Over the last few years, an increasing number of patients with moderate hemoptysis have been referred to our department for urgent angiography and embolization as well. Moderate hemoptysis is defined as three or more episodes of blood loss of 100 ml per day within a week [1]. Our hospital is a center for respiratory disease and it also services the Tuberculosis (TB) Control Unit for the entire country. We therefore see the majority of hemoptysis cases in Singapore. The purpose of this retrospective study was to assess our angiographic and embolotherapy techniques as well as the efficacy of our treatment methods.

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## Materials and Methods

Over a 6-year period, from 1993 to December 1999, a total of 134 patients presented with moderate to massive hemoptysis, in whom 163 angiographic procedures were performed. Follow-up ranged from 1 month to 66 months (median 9.5 months, SD 14.81 months). Eighteen of the 134 cases were lost to follow-up.

All 134 patients had angiography performed via the femoral route. Access was achieved by standard Seldinger techniques. In two cases the right brachial approach was required in addition to the femoral route, in order to successfully address abnormal branches of the right subclavian artery (Fig. 2). In all cases a 5 Fr vascular sheath was inserted to facilitate multiple catheter changes if necessary. Connection of the vascular sheath to a heparinized saline infusion system was not mandatory and was operator-dependent. However, if an infusion system was not connected, regular flushing of the sidearm of the vascular sheath with at least 10 ml of heparinized saline was necessary. Catheters used were all preshaped 5 Fr angiographic catheters; the commonest initial shape chosen was the Cobra-2. Other catheters employed were the Sidewinder or Simmons-1, the Shepherd's Hook, the Headhunter-1 and the Yashiro-type (all from Terumo, Tokyo, Japan). The guidewire used in all cases was the 0.035 inch angled slippery Terumo guidewire.

Pre-angiogram bronchoscopy was only occasionally performed. The decision to do so was dependent entirely on the referring chest physicians. This was not done consistently for the majority of the patients in our study for a number of reasons, such as: (1) unavailability of the endoscope or endoscopy suite, (2) unavailability of the

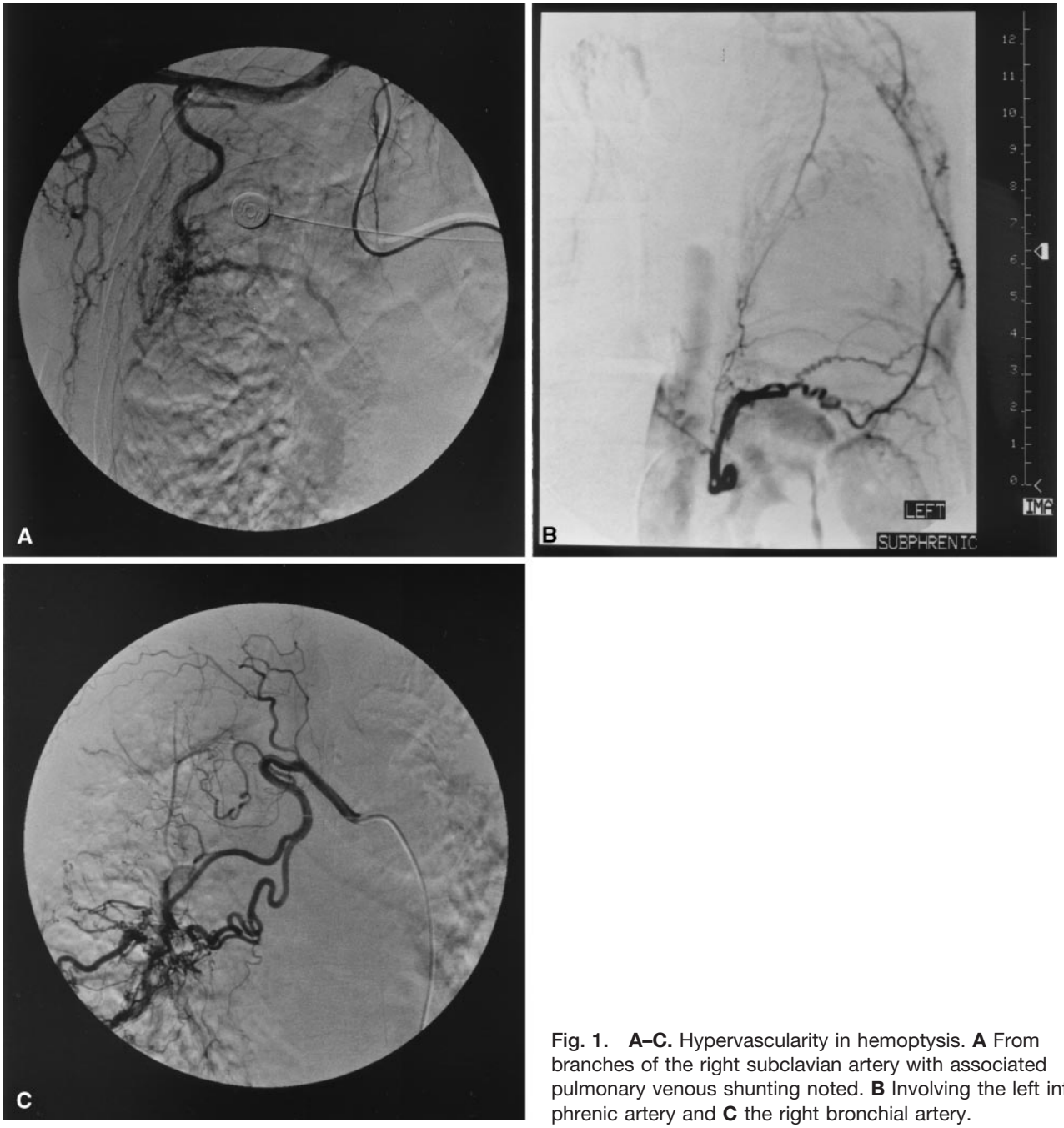


**Fig. 1. A–C.** Hypervascularity in hemoptysis. **A** From branches of the right subclavian artery with associated pulmonary venous shunting noted. **B** Involving the left inferior phrenic artery and **C** the right bronchial artery.

endoscopist or (3) inability of the patient to tolerate the inadvertent time delay incurred by endoscopy, which would be an additional step prior to reaching the angiography suite.

Although endoscopic findings would have been useful in helping to ascertain the side of bleeding in cases of diffuse lung disease, such as in cases of cystic fibrosis or TB bronchiectasis, we did not insist on this procedure prior to starting our intervention. In any case, whether or not endoscopic findings were available, vessels to both lungs were studied angiographically.

Digital subtraction selective bronchial angiography was performed in all cases via hand injection rather than a power injector. The contrast medium used was the non-ionic contrast iohexol (Omnipaque; Nycomed, Princetn, NJ, USA). All procedures were done in our angiographic suite on either the GE Advantx system or the newer Toshiba DFP 2000A. Following bronchial angiography (and embolization where necessary), a painstaking search for abnormal nonbronchial systemic vessels was performed i.e., selective angiography of the intercostal, subclavian (Fig. 1A) and inferior phrenic (Fig. 1B) arteries. If embolization was performed, the catheter was removed from the patient and flushed thoroughly with saline to ensure that the lumen and hub of the catheter were completely clear of any remnant embolic material prior to searching for further abnormal vessels. A flush thoracic aortogram was generally not performed as it was felt that this did not always demon-

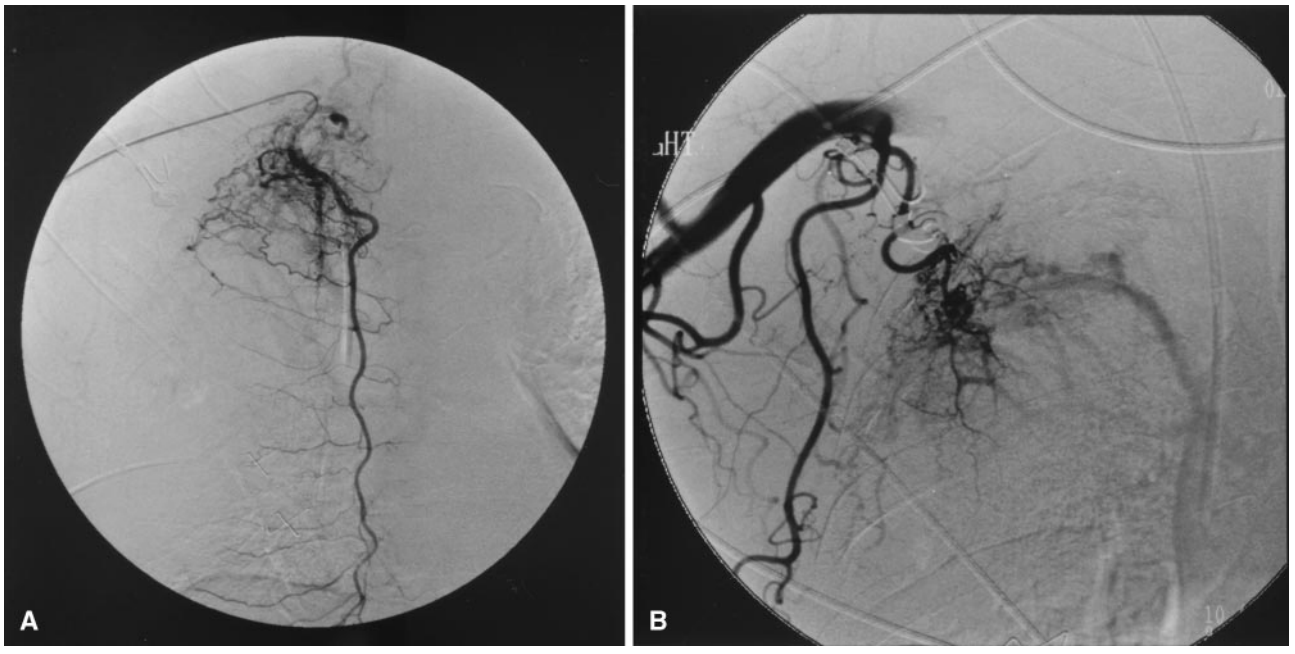


**Fig. 2.** **A, B.** Right brachial artery approach for addressing abnormal branches of the right subclavian artery which could not be cannulated via the femoral route.

strate hypertrophied systemic vessels adequately. Total contrast volume used was limited arbitrarily to 7 bottles of 50 ml. If this was exceeded, the procedure was halted for the day and continued the following day.

If no angiographic abnormalities were detected, the procedure was halted. Pulmonary angiography was not routinely performed.

A coaxial microcatheter system was employed without hesitation if stable cannulation of the offending vessel could not be achieved with the larger 5 Fr catheter or if more distal cannulation of the vessel was required. The microcatheter systems at our disposal were the Tracker-18 and Tracker-325 systems (Target Therapeutics, Fremont, CA, USA), the Mass Transit system (Cordis Endovascular Systems, Miami, FL, USA) and the GT-Leggario system (Terumo Corporation, Tokyo, Japan). The commonest microcatheter system used was the Tracker-18 system. The guidewire employed with this system is the Taper-16 guidewire (0.016 inch, tapered to 0.014 inch). The embolic material used was polyvinyl alcohol (PVA) particles, at least 300 $\mu$m in size. The PVA used was Contour (Target Therapeutics, Fremont, CA, USA), 355–500 $\mu$m, or Ivalon (Nycomed Laboratories, Paris, France), 300–600 $\mu$m. Occasionally these particles were used along with gelfoam particles.

Follow-up of the 116 patients was by review of all clinical casenotes over the study period. This reflected all outpatient follow-up reviews as well as repeat admissions.

## Results

Etiology of the hemoptysis was as shown in Table 1, with the vast majority of cases being due to TB. The age range of patients was from 19–96 years (mean 59 years). Our youngest case was due to right middle lobe syndrome, while our oldest was due to malignancy. Our youngest TB hemoptysis patient was 30 years old. The male to female ratio was 81:35.

**Table 1.** Etiology of hemoptysis

| Etiology | No. of cases |
|---|---|
| *Pulmonary tuberculosis* | *97* |
| *Malignancy* | *11* |
| Lung carcinoma | 10 |
| Chondrosarcoma | 1 |
| *Others* | *8* |
| Middle lobe syndrome | 2 |
| Lobar pneumonia | 1 |
| Sequestrated lung | 1 |
| Congenital absent pulmonary artery | 1 |
| Diffuse pulmonary haemorrhage | 3 |

Of the 116 patients followed up from 1993, 13 (11.2%) were angiographically normal and, therefore, no embolization was performed. Of the 13 patients with normal angiograms, five had TB, four had a malignancy and four were listed under “others” (3 “diffuse pulmonary hemorrhage”, 1 lobar pneumonia). The percentage of TB patients with normal angiograms was therefore extremely low (5.2%), while that in patients with hemoptysis due to malignancy was higher (36.4%). The clinical outcome for these 13 cases is shown in Table 2.

The abnormality demonstrated during angiography was that of hypervascularity, which resulted in marked hypertrophy and tortuosity of the vessels concerned (Fig. 1C), increased vascularity of their small branches, pseudoaneurysm formation, parenchymal staining and venous shunting, as described by Tanaka et al. [2]. Contrast extravasation into the airways was occasionally visualized, usually in cases of

**Table 2.** Outcome of 13 angiographically normal cases

| Patient no. | Etiology | Follow-up | Outcome |
|---|---|---|---|
| 1 | TB | 48 months | No hemoptysis |
| 2 | TB | 1 day | Died from hemoptysis |
| 3 | TB | 1 month | No hemoptysis |
| 4 | TB | 9 months | No hemoptysis |
| 5 | TB | 12 months | Had (L) upper lobectomy; no haemoptysis after surgery for 12 months |
| 6 | Ca | 2 months | No hemoptysis |
| 7 | Ca | 5 months | No hemoptysis |
| 8 | Ca | 1 month | No hemoptysis |
| 9 | Ca | 1 week | Died from hemoptysis |
| 10 | DPH | 13 months | No hemoptysis |
| 11 | DPH | 1 day | Died from hemoptysis |
| 12 | DPH | 1 month | No hemoptysis |
| 13 | Pneumonia | 1 month | No hemoptysis |

Ca, carcinoma; DPH, diffuse pulmonary hemorrhage

severe hemoptysis. Such angiographic runs tended to produce severe bouts of coughing and consequently more hemoptysis.

One hundred and three patients required embolization to try to control their hemoptysis. A patient was listed as "failed embolization" if surgery was required to control the bleeding despite embolization or if the patient died from hemoptysis.

Seventeen patients required repeat sessions of embolization: nine required two sessions, four required three sessions and four required four sessions. One of the 17 was lost to follow-up after the second session and the cause of his hemoptysis was not documented. Sixteen of the 17 patients who required multiple embolizations had TB. Details of the repeat cases are presented in Table 3.

The reasons for multiple sessions were:

1. Too many hypertrophied abnormal vessels to address at a single sitting. These patients were brought back to the angiography suite the next day for completion. Two of these were brought back specifically for embolization of right subclavian artery branches via the right brachial artery approach.
2. Hemoptysis recurred after a variable hemoptysis-free period, ranging from 5 days to 27 months. Those who required repeat embolizations within a few days most probably did not have all their abnormal vessels occluded during the initial session. Those who had a longer hemoptysis-free period had rebleeds due to hypertrophy of collaterals or other previously undetected bronchial arteries. Recanalization of previously embolized vessels was not the predominant cause of rebleeding.

The repeat embolization rate in our series was 15.5% (16 of 103). The success rate for controlling hemoptysis in these cases was 62.5%. We had six failures: four required surgery and two died from massive hemoptysis. Of the four who required surgery, two had mycetoma and two had just too many abnormal systemic vessels to be addressed angiographically and were better served with a lobectomy. Of our 10 successfully embolized patients, two eventually died but not from hemoptysis while the other eight are still alive and hemoptysis-free at follow-up.

There were a total of 87 patients with a single embolization session. There were 13 failed embolizations (14.9%): six (5 TB, 1 sequestrated lung) died from massive hemoptysis and seven (6 TB, 1 right middle lobe syndrome) required surgery. Seventy-six cases were due to TB, seven to malignancy and four to other causes. Of the patients with a malignant cause, two went on to surgery for excision of the tumor but were counted as successful embolizations because hemoptysis was controlled. The other five did not have surgery. There was sporadic hemoptysis in these five but not in large enough amounts to require a repeat angiogram/embolization. There were therefore no failures in our malignant cases. Of the patients with hemoptysis from "other" causes, one of the right middle lobe syndrome cases and the patient with the absent right pulmonary artery responded well to embolization and had no further episodes of hemoptysis. The other two cases failed embolization as noted above.

The total number of failed embolizations was 19 of 103 cases embolized (18.4%). The breakdown of our failures is shown in Table 4. Our overall success rate of embolization was 81.6%.

Total number of TB patients was 97, of whom five (5.2%) had no angiographic abnormality found. Seven (7.2%) had normal bronchial arteries but abnormal nonbronchial systemic arteries and 30 (30.9%) had both abnormal bronchial and nonbronchial systemic arteries. The remaining 55 (56.7%) patients had only abnormal bronchial arteries (Table 5). There were 17 failures among the 92 TB cases embolized (18.5%): 10 required surgery and seven died from massive hemoptysis (Table 4).

The total number of cases due to malignancy was 11, of which four (36.4%) had no abnormalities found, four (36.4%) had abnormal bronchial arteries only and three (27.3%) had abnormal nonbronchial systemic arteries only. There were no patients with both abnormal bronchial and nonbronchial systemic arteries (Table 5). All seven patients in this category who had embolization performed had adequate control of hemoptysis. Surgery was performed in two cases to excise the tumor but these patients both had no further hemoptysis (Fig. 3).

Eight patients had other causes of hemoptysis, of whom four (50%) were angiographically normal, two had abnormal bronchial arteries only and two had abnormal nonbronchial systemic arteries. There were no patients with abnormal bronchial and nonbronchial systemic arteries (Table 5). Of the four who were embolized, there were two failures (Table 4): one went on to surgery (right middle lobe syndrome) and one died from massive hemoptysis (sequestrated lung). The other two patients had no further hemoptysis. Our success rate in this category was therefore only 50%.

**Table 3.** Sixteen cases of repeat embolization

| Patient no. | Time between embolization sessions | | | Outcome |
|---|---|---|---|---|
| | 2nd E | 3rd E | 4th E | |
| 1 | 5 days | 8 months | | Died after 66 months; no hemoptysis after 3rd E |
| 2 | 3 days | 3 days | 2 days | Died from massive hemoptysis |
| 3 | 20 months | | | No hemoptysis for 5 months since 2nd E |
| 4 | 1 day, R. brachial | | | No hemoptysis for 5 months since 2nd E |
| 5 | 2 months | 19 months | 1 day | No hemoptysis for 5 months since 4th E |
| 6 | 5 months | | | No hemoptysis for 1 year since 2nd E |
| 7 | 4 days | 27 months | | No hemoptysis for 5 months since 3rd E |
| 8 | 2 months | 1 month | 5 months | No hemoptysis for 48 months since 4th E |
| 9 | 20 months | | | No hemoptysis for 13 months since 2nd E |
| 10 | 6 months | 9 months | 1 day | No hemoptysis for 48 months since 4th E |
| 11 | 1 day, R. brachial | | | R. upper lobectomy, no hemoptysis since |
| 12 | 1 day | | | Died 3 months later from massive hemoptysis |
| 13 | 1 month | | | Surgery for mycetoma; no hemoptysis until death |
| 14 | 1 month | | | Surgery for mycetoma; no hemoptysis for 18 months |
| 15 | 6 weeks | 2 weeks | 1 week | Upper lobectomy; no hemoptysis since |
| 16 | 4 months | | | No hemoptysis for 16 months since 2nd E |

**Table 4.** Failed embolization

| Etiology | Surgery | Death |
|---|---|---|
| *Tuberculosis* | | |
| Single embolization | 6 | 5 |
| Multiple embolization | 4 | 2 |
| *Malignancy* | | |
| Single embolization | 0 | 0 |
| Multiple embolization | 0 | 0 |
| *Others* | | |
| Single embolization | 1 | 1 |
| Multiple embolization | 0 | 0 |

**Table 5.** Breakdown of abnormal vasculature

| | Abnormal bronchials | Normal bronchials |
|---|---|---|
| *Tuberculosis* | | |
| Abnormal nonbronchial systemics | 30 | 7 |
| Normal nonbronchial systemics | 55 | 5 |
| *Malignancy* | | |
| Abnormal nonbronchial systemics | 0 | 3 |
| Normal nonbronchial systemics | 4 | 4 |
| *Others* | | |
| Abnormal nonbronchial systemics | 0 | 2 |
| Normal nonbronchial systemics | 2 | 4 |

Therefore, of the 103 cases embolized, 91 (88.35%) patients had abnormal bronchial arteries, 30 (33%) of whom had non-bronchial systemic contributions. Twelve of the 103 (11.65%) had abnormal nonbronchial systemic arteries but normal bronchial arteries.

No major complications such as stroke, transverse myelitis or bronchial infarction were encountered. The anterior spinal artery and the artery of Adamkiewicz were rarely visualized although there were a few cases in which spinal artery branches could be visualised only after distal embolization. Of our 116 cases followed-up, the artery of Adamkiewicz or the anterior spinal artery was seen in six (5.17%), either prior to embolization or only after distal embolization. However, since embolization was performed distal to the origin of these vessels, there were no complications encountered (Fig. 4).

There were sporadic complaints of chest pain during embolization of hypertrophied abnormal intercostal arteries but these were transient and did not persist after the procedure.

## Discussion

Embolization has been well established as the treatment of choice for hemoptysis since the studies of Bookstein et al. [3] and Remy et al. [4] in the 1970s. With the advent of digital subtraction angiography, nonionic contrast media and microcatheter coaxial systems, bronchial embolizations have become easier, faster and safer. Over the last 6 years we have achieved an overall success rate of 81.6% in our center. Our failure rate of 18.4% (19 of 103 patients who underwent embolization) was defined by patients who failed to achieve adequate control of hemoptysis which resulted in either surgery or death. A normal angiogram was seen in 11.2% of our patients.

Sixteen of the 103 (15.5%) patients embolized required repeat embolization. All these had hemoptysis due to TB. Of the 16, eight (50%) required more than one repeat session. In other words, those who rebleed tend to rebleed. This was noted by Hayakawa et al. [5], who reported that the recurrent bleeding rate increased from 28% to 46% after repeat embolization. Rebleeding is usually attributed to recanalization [6]. Tanaka et al. [6] quoted a figure of 87% being due to recanalization. Of the rebleeds caused by collaterals, all were due to TB with pleural thickening. It should be pointed out that in Tanaka et al.'s series, the embolic agent used was gelfoam. In our series, we used PVA particles or PVA

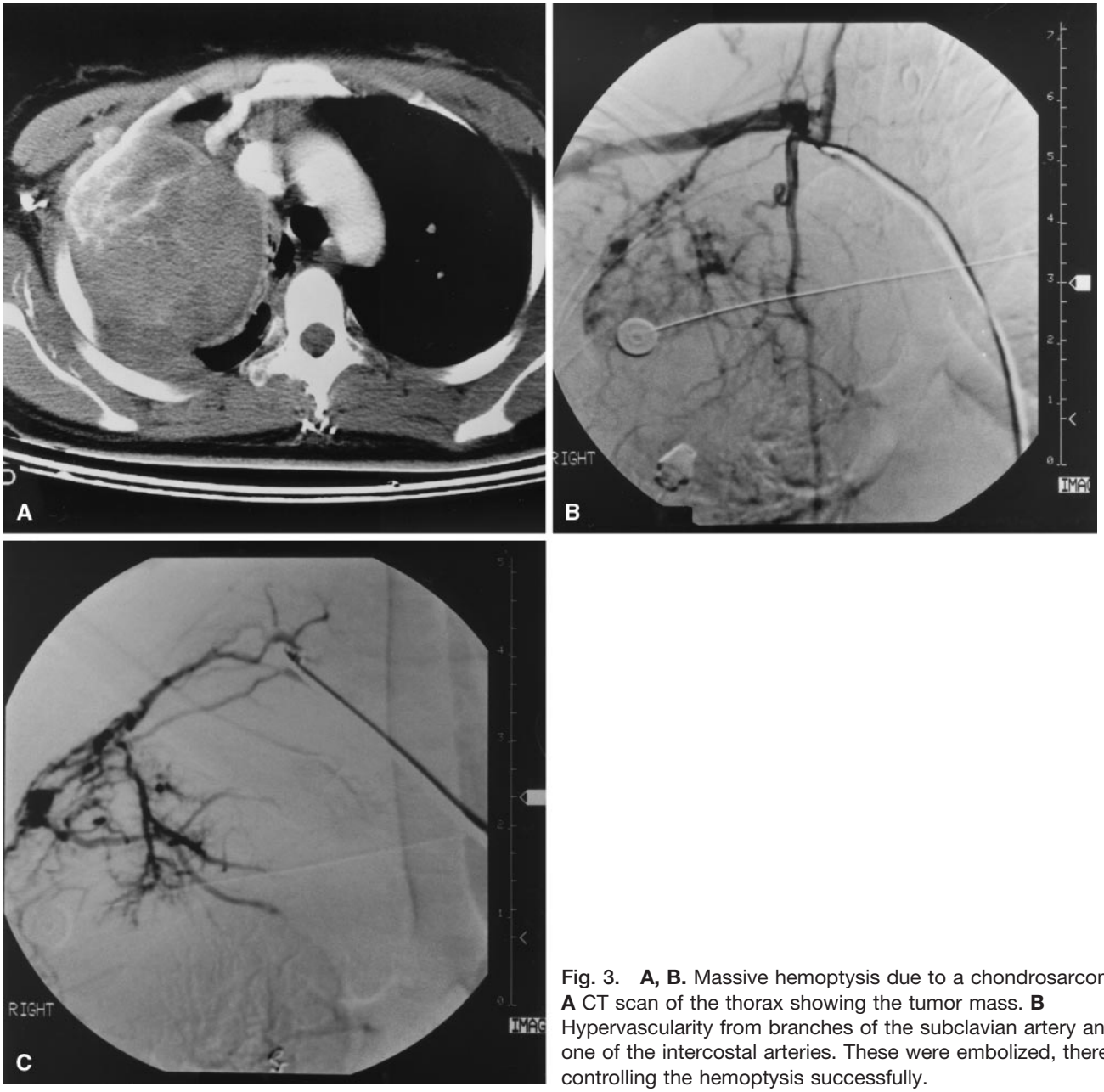


**Fig. 3.** **A, B.** Massive hemoptysis due to a chondrosarcoma. **A** CT scan of the thorax showing the tumor mass. **B** Hypervascularity from branches of the subclavian artery and **C** one of the intercostal arteries. These were embolized, thereby controlling the hemoptysis successfully.

followed by gelfoam after there was visible slowing of contrast flow distally but still good flow proximally. In the majority of cases we used PVA alone. Our repeat embolization rate was only 15.5% and all cases were due to TB. These were due mainly to hypertrophy of the collateral nonbronchial systemic arteries rather than recanalization of previously occluded vessels.

None of our non-TB cases which were successfully embolized required repeat embolization. This is in keeping with the finding by Tamura et al. [7] that long-term hemostasis is better in patients without documented pleural thickening. Such pleural abnormalities are usually seen in patients with chronic or previous tuberculous infection. Perhaps the use of PVA particles as opposed to gelfoam may be contributory to the fact that none of our non-TB patients required repeat embolization once hemostasis was achieved.

On the other hand, although our patients with hemoptysis due to malignancy responded well to embolization, this was provided an abnormality could first be demonstrated angiographically. About one third of our patients with hemoptysis from malignant causes had no abnormalities detected, compared with five of 97 TB patients (5.2%).

In our center, for all cases of hemoptysis, it was felt that a concerted search for nonbronchial systemic abnormalities should be performed. If hypervascularity was demonstrated, these vessels were embolized. About a third of our patients had associated abnormal nonbronchial systemic arteries. Whether or not embolization of all these vessels is necessary

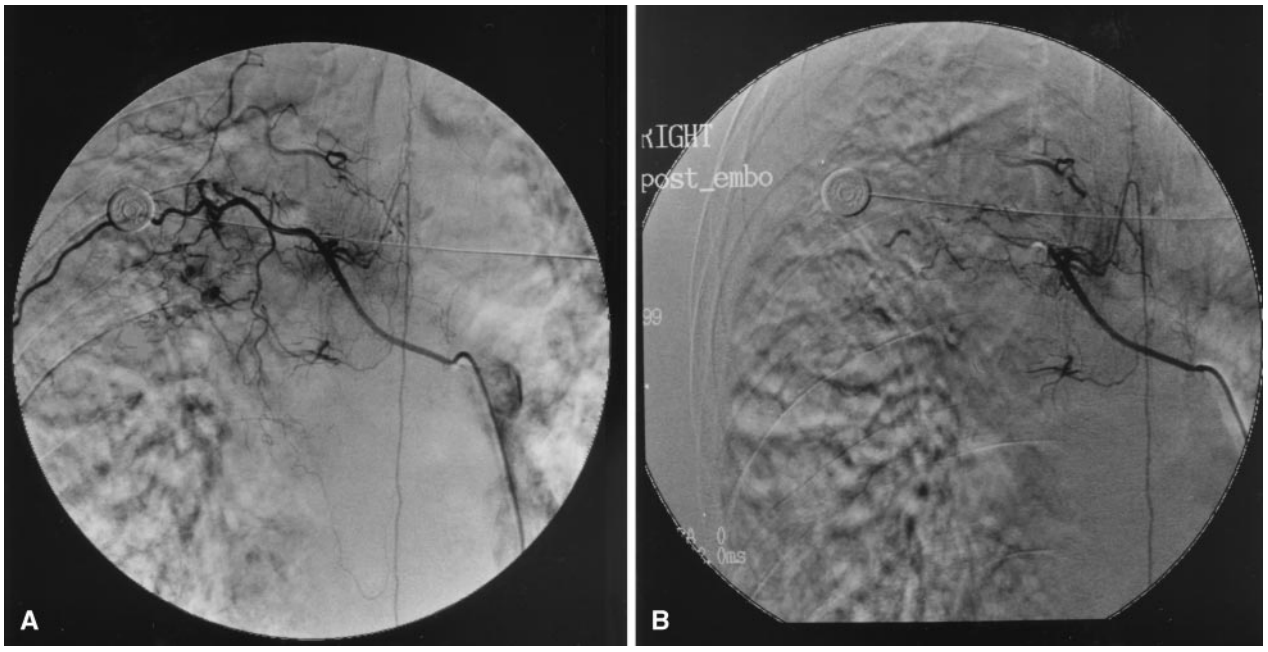


**Fig. 4. A, B.** Hypervascularity from one of the right intercostal arteries. **A** Initial diagnostic angiography showed the artery of Adamkiewicz. A microcatheter system was therefore required to embolize this vessel superselectively, to avoid damage to the anterior spinal artery. **B** Postembolization angiography showed satisfactory distal embolization with preservation of the artery of Adamkiewicz.

is open to debate. In a large series from Bombay, India in 1995 [8], Ramakantan et al. suggested that only the hypervascular bronchial arteries need be embolized. His group did not consider it necessary to embolize all nonbronchial systemic arteries supplying the lesion, as they were of the opinion that the mere presence of systemic hypervascularity was not an indication for embolization. It should be pointed out that in the Indian series the mean age of the patients was 31.5 years, which is younger than in our series. In 29 of their 38 rebleeds, bleeding eventually ceased with anti-TB treatment. In our series, the patients were all older and their hemoptysis was as a result of chronic or previous TB infection resulting in extensive scarring or post-TB bronchiectasis. These patients did not have active TB and were not being treated with anti-TB medication. Furthermore, many of these patients had poor respiratory reserve as a result of extensive scarring causing chronic reduction in lobar volume and compensatory emphysema. This would make surgery a less attractive option. Therefore, we felt that it was necessary to attempt embolization of all abnormal vessels, both bronchial and nonbronchial systemic in origin.

The use of a microcatheter system is now well established. Tanaka et al. [6] showed this clearly in their study. Inability to achieve stable cannulation of the abnormal vessel for embolization was a common indication for opening up the microcatheter set. This is very often the case in older patients with diffuse atherosclerotic disease of the aorta. In patients with hypertrophied collaterals from the nonbronchial system, the abnormal take-off of these vessels sometimes makes stable cannulation of the ostium impossible. This was commonly the case in abnormal branches of the subclavian artery such as the internal mammary artery and branches of the thyrocervical trunk. In such instances, the 5 Fr catheter merely sits at the ostium. Attempted embolization from this position would result in the catheter flicking out of the ostium or reflux of embolic material into the aorta and therefore to nontarget sites. The proximity of the vertebral artery to the thyrocervical trunk is one point in favor of the use of the microcatheter.

Another indication for the microcatheter is that distal embolization must be attempted as far as possible. This is often only achievable with the help of such a system. Furthermore, the risk of occluding the vessel with the 5 Fr catheter, either by vascular spasm or catheter wedging, is avoided with the use of the microcatheter.

If proximal occlusion is all that is desired, there is the risk of distal collateralization causing rebleeding. Access to these collaterals may be lost if the proximal aspect of the vessel was successfully embolized during a previous session. Furthermore, the risk of nontarget embolization is higher if distal cannulation is not achieved. The presence of branches to the spinal artery should always be borne in mind. If these branches are seen, it goes without saying that the tip of the catheter should be placed beyond their origin, prior to embolization. In most instances this is only achieved with the use of a microcatheter system. It should be noted that these branches are sometimes only opacified when the distal vasculature has been sufficiently embolized and the resistance in the distal vascular bed is increased. This was seen in a few of our patients. It was therefore standard practice in our

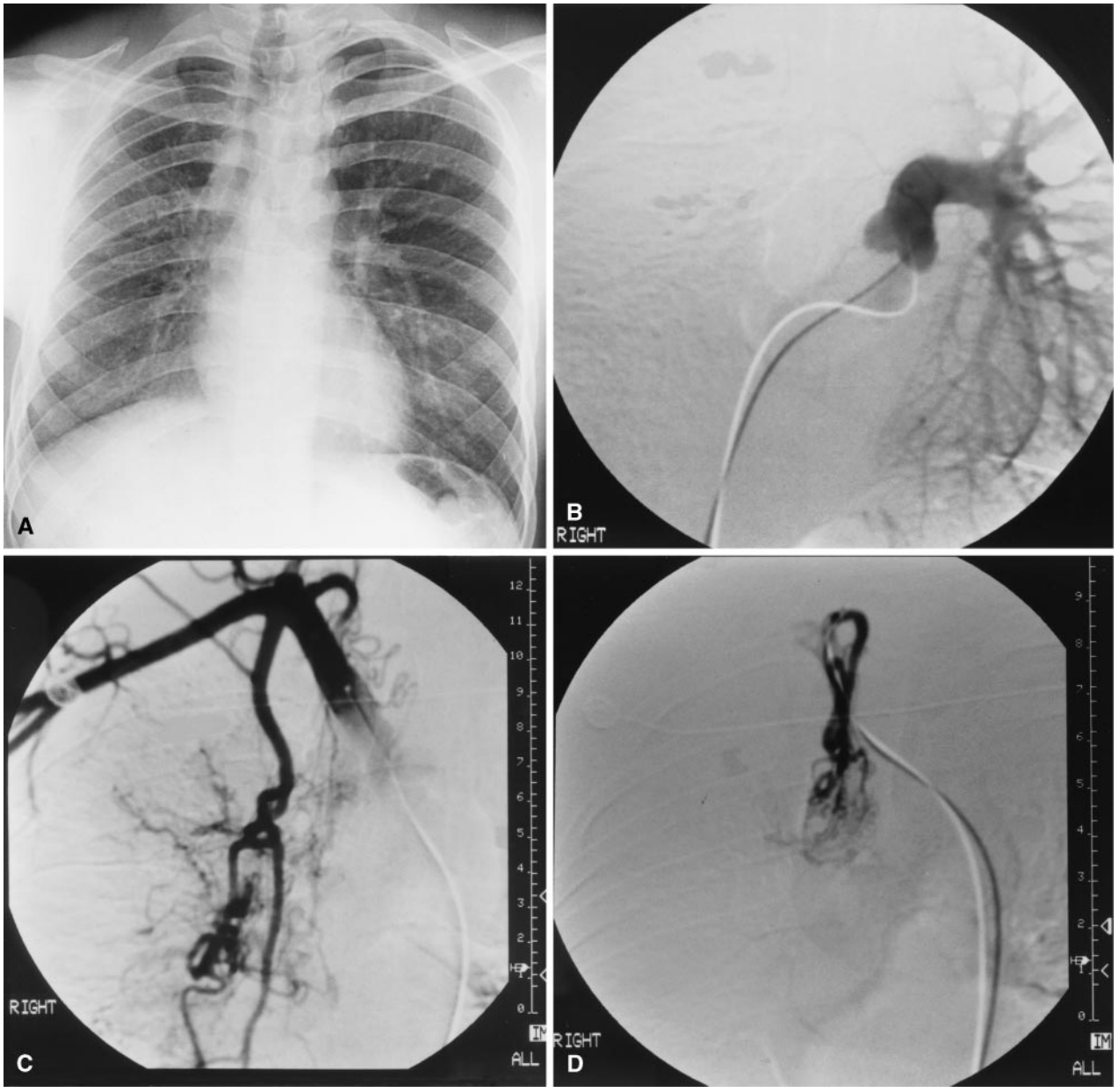


**Fig. 5. A–D.** A young Bangladeshi man presenting with massive hemoptysis. **A** Chest radiograph showed reduction in right lung volume with a small right hilum. **B** Pulmonary angiogram confirmed the diagnosis of a congenitally absent right pulmonary artery. **C** Right subclavian angiogram showed hypervascular branches causing hemoptysis. **D** These were selectively cannulated and embolized. Hemoptysis was subsequently controlled.

center to try to achieve cannulation as distal to the vertebral column as possible. The use of embolic particles larger than 200–250 $\mu$m in size is said to be safe, as these are supposed to be too large to enter the spinal arteries [1]. Uflacker et al. [9] demonstrated radicular arteries in 42 of their 75 patients and none of them had any neurologic deficits following embolization. This group, however, never demonstrated the anterior spinal artery by intercostobronchial or bronchial artery injection.

Esophageal branches from the bronchial artery also tend to be closer to the midline. We therefore also attempted more distal cannulation, away from the midline, in order to avoid these branches and therefore reduce the possibilty of postembolization dysphagia.

A thoracic aortogram was generally not performed as we felt that it did not adequately demonstrate abnormal vessels. A normal thoracic angiogram done at the start of the procedure did not preclude the selective hunt for abnormal bronchial or nonbronchial systemic arteries. Selective cannulation and angiography of the vasculature was therefore mandatory, as tedious as it may sound. Following identification and embolization of the abnormal bronchial arteries,

the further search for nonbronchial systemic abnormalities should be carried out. Of particular importance are the subclavian artery and its branches (most commonly, the internal mammary artery) for upper lobe lesions and the inferior phrenic artery for lower lobe lesions. For abnormal branches of the subclavian artery, the brachial approach is a viable alternative route if cannulation from the groin proves impossible (Fig. 2).

Pulmonary angiography is not routinely performed for hemoptysis in our center. A pulmonary arterial cause of hemoptysis is rare and the lesion to look out for, especially in the context of a TB center such as ours, would be the Rasmussen aneurysm, which is seen in cavitary tuberculosis when the cavity erodes into a pulmonary artery. A pulmonary angiogram should therefore be considered in cases of persistent or recurrent hemoptysis despite normal systemic arteriography [10]. Among our 134 patients, pulmonary angiography was performed only once, and this was for a rather unusual case of massive hemoptysis (Fig. 5). This 26-year-old man had a congenitally absent right pulmonary artery which was initially undiagnosed until the patient arrived in our angiography suite and the interventional radiologist viewed the chest radiograph. The pulmonary angiogram was performed to confirm the diagnosis. Hemoptysis was due to the hypertrophied and tortuous abnormal collaterals from the right subclavian artery supplying the right pulmonary vasculature. These were embolized using PVA particles followed by gelfoam pellets. The patient has remained hemoptysis-free in the 11 months following embolization.

## Conclusion

Embolization for hemoptysis is an effective means of treatment. Our overall success rate was 81.6%. Success rate for patients with TB was 81.5%, for those with malignancy, 100% and for non-TB/nonmalignant hemoptysis (i.e. “others”), 50%.

As about one third of our patients had associated nonbronchial systemic artery hypervascularity, we feel that a concerted search for and embolization of these vessels is mandatory. All patients with both bronchial and nonbronchial vascular abnormalities were patients with TB.

The relatively high rate of normal angiography seen in hemoptysis due to malignancy indicates that this condition may not always be amenable to embolization. However, when the abnormal vasculature is indeed demonstrated and subsequently embolized, hemoptysis is satisfactorily controlled.

The rate of repeat embolization in our series was relatively low at 15.5%, and these cases were all due to TB because of hypertrophy of collaterals. Those patients who did require repeat embolization had a higher tendency to have more than one repeat session (50% had more than two sessions). In some of these patients, their age and poor respiratory function make the option of surgery less viable. Multiple sessions of embolization should be continued as long as the hemoptysis can still be controlled by this method.

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