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Clinical Study

Bronchial and Nonbronchial Systemic Artery Embolization in Management of Hemoptysis: Experience with 348 Patients

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Background. We aimed to report our experience with bronchial artery embolization (BAE) in the management of moderate recurrent and/or life-threatening hemoptysis. *Methods*. We evaluated the demographics, clinical presentation, radiographic studies, short- and long-term efficacy, and complications in patients Who underwent BAE, at a tertiary university hospital, from 2003 to 2012. *Results*. Three hundred forty-one patients underwent BAE for the management of moderate recurrent or life-threatening hemoptysis. Pulmonary TB and bronchiectasis were the most common etiologies for hemoptysis in our locality. The most common angiographic signs for hemoptysis were hypervascularity and systemic-pulmonary artery shunt. BAE was successful in controlling hemoptysis immediately in 95% of patients and at 1 month in 90% of patients. Recurrence of hemoptysis was observed in 9.6% of patients, and reembolization was indicated in 85% of those cases. Complications of BAE were self-limited acute and subacute complications, while chronic complications were not recorded during this study. *Conclusions*. TB and bronchiectasis are the commonest etiologies for moderate recurrent or life-threatening hemoptysis in our locality. Hypervascular lesions from the bronchial arteries and nonbronchial systemic arteries represented the major vascular abnormalities. Bronchial and nonbronchial systemic artery embolizations were effective to control both acute and chronic hemoptyses, with no serious complications.

1. Introduction

Hemoptysis, when massive and untreated, has a mortality rate of >50% [1]. In the majority of cases, the source of massive hemoptysis is the bronchial circulation. However, nonbronchial systemic arteries can be also a significant source [2]. Bronchial artery embolization (BAE) involves selective bronchial artery catheterization and angiography, followed by embolization of any identified abnormal vessels to stop the bleeding. It is a safe and effective nonsurgical therapeutic option for patients with massive hemoptysis. Nonbronchial systemic arteries, however, can be a significant source of massive hemoptysis and a cause of recurrence after successful BAE.

Chronic recurrent hemoptysis can occur in chronic lung disorders such as bronchiectasis and tuberculosis in which hemoptysis is troublesome though not immediately lifethreatening [3]. Recent studies [3–5] have confirmed the effectiveness of BAE in the management of moderate (more than or equal to three episodes of 100 mL of bleeding per day within 1 week) and even mild (chronic or slowly increasing) hemoptysis cases. Knowledge of the bronchial artery anatomy, together with an understanding of the pathophysiologic features of massive hemoptysis, is essential for planning and performing BAE in affected patients. In addition, interventional radiologists should be familiar with the techniques, results, and possible complications of BAE and with the characteristics of the various embolic agents used in the procedure [2, 6]. Herein, we describe our 10 year experience with 348 patients who underwent bronchial arteriography (BA) and BAE. The aims of this study were to detect the etiology of moderate recurrent or life-threatening

hemoptysis in our locality, to study the different angiographic signs of hemoptysis, and to evaluate the short- and long-term efficacy and complications of BAE.

2. Patients and Methods

Our hospital is a tertiary referral center, where most of the patients are referred for the evaluation of hemoptysis. The clinical and radiographic data of all patients subjected to BA due to moderate recurrent or life threatening hemoptysis between 2003 and 2012 were accessed through our chest and radiology departments. The inclusion criteria consisted of all patients undergoing BA with or without BAE. The clinical records were reviewed and the following data and images were collected for analysis: age, gender, clinical features, chest radiographs, chest computed tomography (CT) scans, bronchoscopy, BA, BAE, results or complications related to BAE, and followup. In addition, all available arteriograms were reviewed to identify the anatomy and study abnormalities and to review the embolization techniques and results. The etiologies of hemoptysis were diagnosed based on the combination of clinical, radiological, microbiological, and histological findings, when available. Hemoptysis was considered idiopathic if no specific disease was diagnosed or evolved during followup. Life-threatening (massive) hemoptysis was defined as expectoration of at least 200 mL of blood per hour in a patient with normal or nearly normal lung function, production of at least 50 mL of blood per hour in a patient with a chronic respiratory failure, or more than two episodes of moderate hemoptysis within a 24 h period [7]. Moderate hemoptysis was defined as more than or equal to three episodes of 100 mL of bleeding per day within 1 week [5].

Indications for embolotherapy in this study were to control bleeding urgently in patients with life-threatening hemoptysis; whereas in those with moderate hemoptysis, it was indicated for patients who were unresponsive to medical treatment in cases of significant bilateral pulmonary disease, inadequate lung function to tolerate surgery, and unresectable carcinoma, for patients unfit or refusing surgery, and in cases of failure to localize a bleeding source radiologically and/or bronchoscopically. The objective of the embolotherapy was the occlusion of all diseased arteries and this was defined as technical success, whereas clinical success was defined as cessation of bleeding for at least 1 month [8]. The study was approved by the local ethical committee and a written consent was obtained from all patients who participated in the study.

2.1. Technique of BAE. BAE was performed during active bleeding or soon after bleeding cessation in 341 out of 348 patients. The remaining 7 patients had hemoptysis secondary to pulmonary artery aneurysms associated with intramural thrombi due to Behcet's disease. In the later cases, the hemoptysis responded well to medical therapy and BAE was not done. At first, the site of bleeding was localized by computed tomography pulmonary angiography (CTPA) with or without flexible fiberoptic bronchoscopy. The later was performed in cases of moderate recurrent hemoptysis with either suspected lung cancer, hemoptysis of uncertain origin or to provide specimens for bacteriological examinations in suspected cases of tuberculosis (TB) or other infections. All patients were subjected to clotting time, prothrombin time and concentration, complete blood count, liver function tests, and kidney functions to exclude systemic causes of hemoptysis.

Under local anesthesia, transfemoral bronchial arteriography was performed percutaneously in the majority of cases, while transaxillary approach was done in only 6 cases, using 5F or 4F catheter. Both bronchial arteries and non-bronchial systemic arteries were opacified. The diagnostic angiographic injections were always selective into the bronchial, intercostals, subclavian, internal mammary, intercostobronchial, and inferior phrenic arteries. Both ionic and nonionic contrast media were used. The X-ray machine used for this angiographic study was Optimus M200 Polydiagnost Digital Cardiac Imaging (Philips Medical Systems, Best, The Netherlands) with digital subtraction facilities. With the exception of 7 patients with Behcet's disease associated with pulmonary artery aneurysms, bronchial or non-bronchial arteries were found to be abnormal with arterial enlargement, regions of hypervascularity, or systemic-to-pulmonary artery shunting. Teurmo 3F catheter with its guide wire 0.53 mm (Terumo Europe NV, Leuven, Belgium) was used for superselective catheterization of intercostals or bronchial arteries to bypass the origin of anterior spinal artery in 11 cases or coronary artery in 3 cases. The embolization materials used were nonabsorbable particles of polyvinyl alcohol (PVA) (Ivalon; Nycomed SA; Paris, France), 355–500 μm in size (some larger vessels required particles as large as 2 mm), and fibred platinum coils of 2 and 3 mm in size (MicroNester Embolization Coils; Cook, Bjaeverskov, Denmark). Pulmonary artery angiography was performed in the 7 cases of pulmonary artery aneurysms to detect the localization of the feeding artery, while a 7F triple lumen Swan Ganz pulmonary artery catheterization was performed in systemic-pulmonary artery fistula for balloon inflation to close the pulmonary fistula prior to BAE.

All patients were followed up monthly in a period that ranged from 12 to 42 months. Immediate control, late control or recurrence of hemoptysis as well as appearances of any complications after embolization was evaluated during this period.

2.2. Statistical Analysis. Data were analysed using the Statistical Product and Service Solutions (Windows version 16.0; SPSS Inc. Chicago, USA).

3. Results

Three hundred forty-eight patients were submitted to BA. Of them, BAE was performed in 341 patients. They were 247 (71.0%) males and 101 (29.0%) females. Their mean age was 45 ± 18 years (range from 16 to 74 years). Sixty-one patients (17.5%) had life-threatening hemoptysis when they were evaluated, while 287 patients (82.5%) had moderate recurrent hemoptysis. The two major symptoms were hemoptysis in

Table 1: Etiology of life-threatening and moderate recurrent hemoptyses*.

Etiology	Patients no. (%)
Active TB	94 (27.0)
TB sequelae	104 (29.9)
Bronchiectasis	77 (22.2)
Mycetoma	28 (8.1)
Lung abscess	20 (5.8%)
Lung cancer	14 (4.0%)
Behcet's disease	7 (2.0%)
Cryptogenic	4 (1.0%)
Total	348 (100%)

*TB: tuberculosis.

Table 2: Angiographic signs of hemoptysis.

Abnormality	Patients no.	Percentage
Hypervascular lesions supplied from	341	98%
Bronchial arteries	226	65%
Intercostal arteries	157	45%
Intercostobronchial arteries	80	23%
Internal mammary arteries	80	23%
Fistula between pulmonary artery and	120	34.5%
Bronchial arteries	70	20%
Intercostal arteries	49	14%
Internal mammary arteries	28	8%
Sharp shutdown of pulmonary arterial flow with retrograde filling from systemic arteries	120	34.5%
Pulmonary artery aneurysms	7	2%

336 patients (96.5%) and dyspnea in 112 patients (32%). Chest roentgenograms which were performed in all patients were abnormal in 313 patients (90%). Chest roentgenograms were suggestive of the etiology of hemoptysis in only 90 patients (25.8%). Fifty-five patients had normal chest roentgenogram findings (15.8%). CT scanning was performed in 300 patients (86.2%), and the findings were abnormal in all patients. In 288 patients (82.7%), the findings of CT scans were suggestive of the etiology of hemoptysis, and in 50 patients (14.3%) they were suggestive of focal hemorrhage. Bronchoscopy was performed prior to angiography in 287 patients (82.5%). Bronchoscopy identified the bleeding lobe in 214 patients (74.5%), lateralized the side of bleeding but not the specific lobe in 44 patients (15%), and was not helpful in 48 patients (16.7%). Pulmonary tuberculosis, either active or via its sequelae, represented the most common cause of hemoptysis in the treated patients (57%), followed by bronchiectasis (22%) (Table 1).

The most common angiographic sign for hemoptysis was hypervascularity (98%), followed by systemic-pulmonary artery shunt (34.5%), while pulmonary artery aneurysms represented the least common finding (2%) and were found exclusively in patients with Behcet's disease (Table 2). It was noticed that all cases with systemic-pulmonary shunt showed a sharp cutdown of the pulmonary arterial blood flow, on the affected side, with retrograde filling of pulmonary artery from systemic arteries. A spinal artery was identified in 11 of our patients (7%), with 3 occurring on the left side and 8 occurring on the right side, while a connection between the coronaries and bronchial arteries was detected in 3 (1.8%) cases. An example of hypervascularity lesions due to pulmonary TB sequelae is shown in Figure 1.

Overall, a total of 722 arteries were embolized. The average number of arteries embolized per patient was 2.1. The distribution and number of embolized arteries are shown in Table 3. The following agents were used to embolize arteries in our patients: polyvinyl alcohol in 293 (86%) patients, coils in 7 (2%) patients, and polyvinyl alcohol and coils in 41 (12%) patients. Coil embolization was decided in patients with enormous bronchial arteries with high flow and in those with large systemic-to-pulmonary shunts. There was no relation between rebleeding and the use of any particular agent or the type of embolization performed. BAE was successful in controlling hemoptysis immediately (defined as no recurrence of bleeding within 24 h) in 324 of 341 patients (95%). Control of hemoptysis at 1 month was observed in 308 patients (90%); 272 of these patients (88%) had prior massive and 36 (12%) had prior moderate hemoptysis. Thirty-three patients (9.6%) had recurrent hemoptysis >1 month after undergoing BAE. Twenty-eight patients (8%) developed recanalization of previously embolized arteries as well as collateralization and required repeat embolization. In two patients, hemoptysis resolved with antimycobacterial therapy. Three patients with mycetoma underwent surgery.

More than one session of embolization were performed in 143 (42%) patients. A total of 492 embolization sessions were done for 341 patients. Overall, 7 patients (2%) underwent surgery during the whole study period. Four patients underwent surgery within one week of bleeding after the 1st session of BAE: two patients for removal of mycetoma and two patients for extensive tuberculous lung affection. The other three patients underwent surgery for recurrent hemoptysis >1 month after undergoing BAE for removal of mycetoma. The followup revealed that 28 patients (8%) had died, 4 from massive hemoptysis and the remainder as a result of their disease process (12, bronchogenic carcinoma; 10, TB sequelae; 2 bronchiectasis).

Complications of BAE were in the form of self-limited acute and subacute complications (Table 4), while chronic complications were not recorded during the course of the study.

4. Discussion

To our knowledge, this is the largest review among the developing countries on the etiologies, angiographic findings, and outcomes of BAE in patients with life-threatening and moderate recurrent hemoptyses. Other studies [6–9] included a smaller number of patients.

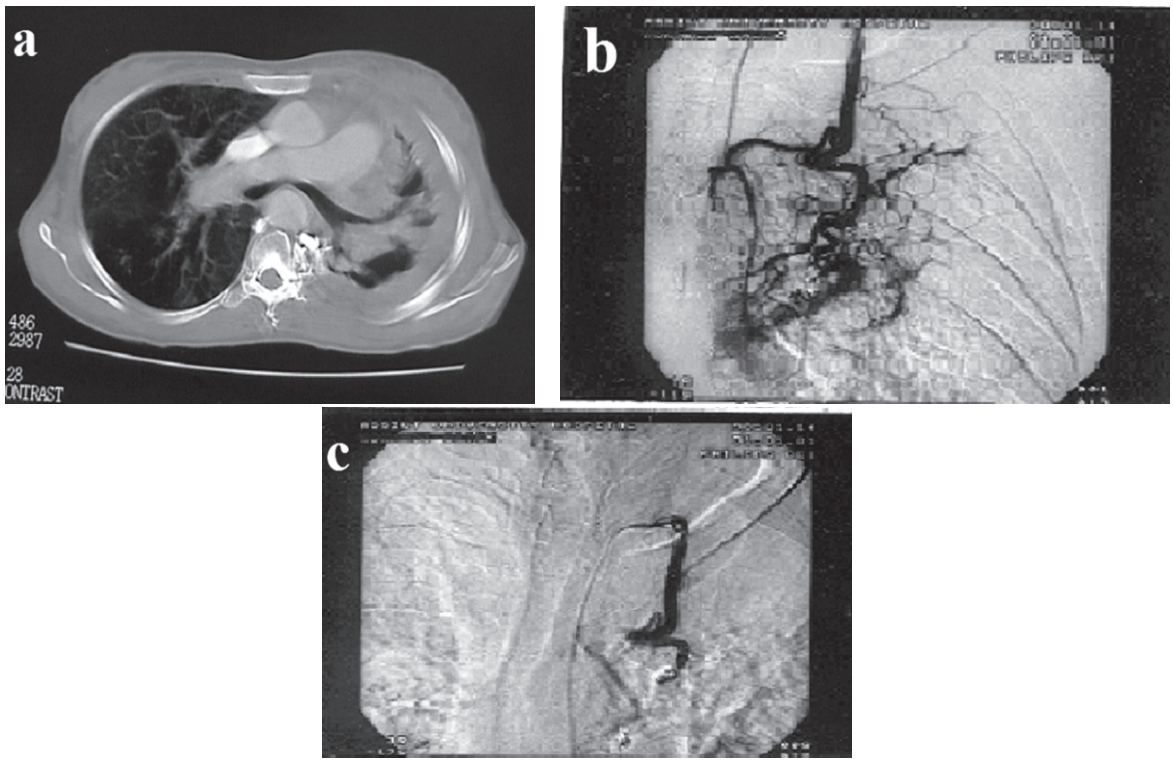

Figure 1: A 35-year-old female patient, presented with severe hemoptysis. Axial CT image (a) shows destroyed Lt lung due to TB sequelae. Angiographic study (b) illustrated hypervascularity lesions supplied by the internal mammary artery, with formation of internal mammary-pulmonary artery shunt. Postembolization radiograph (c) showed disappearance of the lesions and shunt.

Table 3: Distribution and number of embolised arteries.

Distribution of arteries	N. of arteries
Right bronchial artery	145
Left bronchial artery	94
Combined right and left bronchial trunks	26
Intercostal arteries	172
Right intercostal bronchial trunk	93
Left intercostal bronchial trunk	90
Lateral thoracic arteries	16
Systemic collateral arising from	
Right internal mammary artery	40
Left internal mammary artery	33
Inferior phrenic artery	7
Thyrocervical trunk	4
Costocervical trunk	2

Table 4: Complications of BAE*.

Complications	Patients no.	Percentage
Acute	122	36%
Shivering	68	20%
Vomiting	14	4%
Fever during embolization	10	3%
Transient back and LL pain	10	3%
Transient BA. spasm	7	2%
Transient shock	7	2%
Irritative cough	3	1%
Aortic subintimal injection	3	1%
Subacute	131	38.1%
Fever	100	29%
Interscapular pain	17	5%
Transient dysphagia	12	3.5%
Transient LL monoparesis	2	0.6%

*LL: lower limb; BA: bronchial artery.

Bronchial arteries are the main supply of the airways and the supporting structures of the lung while pulmonary arteries supply the lung, parenchyma and respiratory bronchioles. Bronchial circulation is the source of massive hemoptysis in 90% of cases [2]. Bronchial artery embolization for the treatment of hemoptysis was first described in 1973 by Remy et al. [10]. Management of patients with life-threatening hemoptysis is a therapeutic problem because such patients are often poor surgical candidates. Bronchial arteries vary significantly in their numbers and sites of origin. More than 70% of bronchial arteries arise from the descending aorta between the levels of the fifth and sixth thoracic vertebrae [11]. Up to 20% of bronchial arteries may have an aberrant origin (from other systemic arteries), and nearly 10% arise from the anterior surface of the aortic arch or the descending aorta. A spinal artery can originate from a bronchial artery in up to 5%

of patients, with right side being more common than the left side [2, 6]. A spinal artery was identified in 11 of our patients (7%), with 3 occurring on the left side and 8 occurring on the right side.

Our results revealed that underlying chronic lung diseases with extensive vascular abnormalities, like pulmonary TB, bronchiectasis, and mycetoma, accounted for 79.1% of all causes. These data are very similar to those reported by Chan and his colleagues [12]. Tuberculosis was reported as by far the main etiology (97.1%) for severe hemoptysis in 104 patients [4]. Other studies reported that bronchiectasis (20%) and lung cancer (19%) were the most encountered etiologies for hemoptysis [13]. BAE is recommended as the emergency nonsurgical procedure of choice in patients with hemoptysis due to pulmonary TB, as the risk of complications is low and immediate control of bleeding is achieved in 75–96.4% of patients [14, 15].

Hypervascularity was the most common angiographic abnormality (98% of cases) demonstrated during the course of this work. It means increased caliber and branches of a systemic artery supplying an abnormal lung parenchyma. All cases with systemic-pulmonary artery shunts demonstrated a sharp cutdown of pulmonary arterial flow on affected side with retrograde filling of pulmonary artery from systemic circulation. This can be explained by the pressure gradient between systemic and pulmonary circulations that led to physiological cutoff of the pulmonary arterial flow on the affected side. The main source of bleeding in our series was the bronchial arteries followed by the intercostals and intercostobronchial arteries. By contrast, pulmonary arteries had a minor role (Table 2). Nearly similar results were reported by Mal et al. [7].

Bronchial and non-bronchial arteriographies and embolizations were well tolerated by our patients. Control of bleeding was achieved immediately and at one month in 95% and 90% of cases, respectively. Our results are in agreement with those studies in [2–7] which proved that BAE is an effective procedure to stabilize many patients and to definitively treat some patients with hemoptysis. However, recurrent bleeding despite apparently adequate embolotherapy remains a considerable problem in 9% to 29% of patients after-embolization [2, 3, 6, 7]. Recurrence of hemoptysis may be due to incomplete angiography to identify all bleeding vessels, recanalization of the embolized artery, neovascularization, and collateral formation caused by persistent pulmonary inflammation [6, 7, 16]. In our series, recurrence of hemoptysis was observed in 10% of cases and reembolization was indicated in 8% of patients. Despite the fact that bronchial arteries are the most common source of life-threatening hemoptysis, non-bronchial systemic circulation may contribute between 10% and 30% of cases [2, 7]. The prevalence of abnormal non-bronchial systemic artery in our cohort was 33%. Missing the non-bronchial systemic arteries at initial angiography may result in early recurrent bleeding after successful embolization of the bronchial artery. So, a comprehensive search for non-bronchial systemic arterial supply should be made [2]. More recently, the development of multidetector row CT hase provided a comprehensive, noninvasive method of evaluating the entire thorax [9, 17]. At the same time, the combined use of thin-section axial scans and more complex reformatted images allows clear depiction of the origins and trajectories of abnormally dilated bronchial or non-bronchial systemic arteries that may be the source of hemorrhage requiring embolization [17, 18]. Only 2% of our patients underwent surgical treatment for treating hemoptysis or its recurrence during the course of this study. This might be explained by the fact that the majority of those patients had limited pulmonary reserve due to severe chronic lung disease. This finding again emphasizes the effectiveness of BAE in that it can help to avoid surgery in patients who are not good surgical candidates [2, 4, 6–9].

The embolizing materials used in the current study were PVA in the majority (86%) of cases and platinum coils, either alone or in combination with PVA (2% and 12% of cases, resp.). Various embolic materials, such as polyvinyl alcohol particles, coils, gelfoam, and microspheres, have been used for selective bronchial and non-bronchial systemic arterial embolizations in patients with hemoptysis [19, 20]. Each material has its own advantages and disadvantages. Gelfoam is costeffective, and the size can be controlled. However, recanalization can occur faster than PVA, because gelfoam is absorbed spontaneously. PVA particles are biocompatible and nonbiodegradable and are considered to be a permanent embolic agent. However, unpredictable proximal vessel occlusion and catheter blockage caused by clumping or aggregation of irregular-shaped PVA particles have been reported [4, 19].

There are much debates about the use of coils for BAE. Previous reports [21] have suggested that coils should not be used for BAE as they cause proximal occlusion and do not allow for repeated embolization if necessary. The use of coils might prevent repeat embolization of the same artery. However, their use provides safe, thorough, and proximal occlusion of the artery, which can be difficult to achieve with injectable particles alone. It is still possible to embolize feeding collaterals if rebleeding develops [2, 6, 22].

It is widely accepted that the use of coil is required for both safe and adequate occlusions in situations of enormous bronchial arteries with high flow, large systemic-to-pulmonary shunts and when distal embolization is to be prevented [8, 23, 24]. Moreover, embolization coils can be usefully employed to occlude a pulmonary artery aneurysm and may occasionally be used in the internal mammary artery to prevent embolization of a normal vascular territory and development of collateral vessels [2]. Previous reports had shown successful use of coil embolization in hemoptysis due to various etiologies; like cystic fibrosis [24], bronchial carcinoma [25], aspergilloma [8], bronchial artery aneurysm [26], and as a procedure to control hemoptysis prior to surgery [27]. Notably, coil embolization had proved effective and safe in both massive [2, 6, 8, 28] and moderate recurrent [6, 24] hemoptyses.

The complication rate for BAE has diminished gradually over the years. During the early phases of selective BA, several patients developed transverse myelitis as a result of the use of nonionic contrast agents, more neurotoxic materials, and the inadvertent embolization of the spinal arteries.

To prevent such neurologic complications, superselective BAE is utilized. This refers to embolization of more terminal branches of the arterial tree, beyond the origin of the spinal arteries. Tanaka and colleagues [29] concluded that by using superselective embolization distal to the spinal or mediastinal branches, neurologic complications could be avoided and that the embolization may be more effective. This is in contrast to the series by Mal et al. [7] who observed the following three episodes of spinal cord complications: Brown-Séquard's syndrome, which regressed after 4 months without sequelae; paraparesis with spontaneous regression after 2 weeks; and complete paraplegia without regression. These complications occurred despite good, selective catheterization of the bronchial artery. Importantly, none of our patients experienced any neurologic sequelae. If a spinal artery arises from a bronchial artery, we will only embolize the bronchial artery if we can achieve a stable distal position well beyond the spinal artery origin. There are 3 types of complications secondary to arteriography and BAE: acute, subacute, and chronic. Acute complications last less than one day and were reported in 36% of our cohort. These complications represented allergic reaction to contrast media injection and did not require any specific intervention apart from antihistamines, tranquilizers, analgesics, or steroids in severe allergic reactions. Catheter-related complications were in the form of subintimal injection in 1% of cases. Subacute complications last between 2–7 days. The most common effect was fever in 29%, followed by interscapular pain (5%), and transient dysphagia (3.5%), while transient left lower limb monoparesis was reported in 0.6% of cases. Fever was explained by tissue reaction to embolizing material or contrast media allergy. Transient dysphagia was due to embolization of the abnormal arteries connecting esophageal and bronchial arteries. Transient left lower limb monoparesis was secondary to reflux of embolic material into the aorta [2]. Fortunately, there were no chronic complications during the course of this study due to superselective injection of the bronchial arteries especially those with connection with spinal or coronary arteries.

5. Conclusion

Our results revealed that TB and bronchiectasis are the commonest etiologies for moderate recurrent or life-threatening hemoptysis in our locality. Hypervascular lesions from the bronchial arteries and non-bronchial systemic arteries represented the major vascular abnormalities. In experienced hands, bronchial and non-bronchial systemic artery embolizations were effective to control both acute and chronic hemoptyses, with no serious complications.

References

[1] E. Jean-Baptiste, "Clinical assessment and management of massive hemoptysis," *Critical Care Medicine*, vol. 28, no. 5, pp. 1642–1647, 2000.

[2] W. Yoon, J. K. Kim, Y. H. Kim, T. W. Chung, and H. K. Kang, "Bronchial and nonbronchial systemic artery embolization for life-threatening hemoptysis: a comprehensive review," *Radiographics*, vol. 22, no. 6, pp. 1395–1409, 2002.

[3] S. Lee, J. W. Chan, S. C. Chan et al., "Bronchial artery embolisation can be equally safe and effective in the management of chronic recurrent haemoptysis," *Hong Kong Medical Journal*, vol. 14, no. 1, pp. 14–20, 2008.

[4] A. Poyanli, B. Acunas, I. Rozanes et al., "Endovascular therapy in the management of moderate and massive haemoptysis," *British Journal of Radiology*, vol. 80, no. 953, pp. 331–336, 2007.

[5] M. Antonelli, F. Midulla, G. Tancredi et al., "Bronchial artery embolization for the management of nonmassive hemoptysis in cystic fibrosis," *Chest*, vol. 121, no. 3, pp. 796–801, 2002.

[6] K. L. Swanson, C. M. Johnson, U. B. Prakash, M. A. McKusick, J. C. Andrews, and A. W. Stanson, "Bronchial artery embolization: experience with 54 patients," *Chest*, vol. 121, no. 3, pp. 789–795, 2002.

[7] H. Mal, I. Rullon, F. Mellot et al., "Immediate and long-term results of bronchial artery embolization for life-threatening hemoptysis," *Chest*, vol. 115, no. 4, pp. 996–1001, 1999.

[8] E. Serasli, V. Kalpakidis, K. Iatrou, V. Tsara, D. Siopi, and P. Christaki, "Percutaneous bronchial artery embolization in the management of massive hemoptysis in chronic lung diseases: immediate and long-term outcomes," *International Angiology*, vol. 27, no. 4, pp. 319–328, 2008.

[9] R. K. Chawla, A. Madan, D. Mehta, and K. Chawla, "Controlling hemoptysis: an alternative approach," *Lung India*, vol. 27, no. 2, pp. 99–101, 2010.

[10] J. Remy, C. Voisin, M. Ribet et al., "Treatment, by embolization, of severe or repeated hemoptysis associated with systemic hypervascularization," *La Nouvelle Presse Medicale*, vol. 2, no. 31, pp. 2060–2068, 1973.

[11] J. F. Stoll and M. A. Bettmann, "Bronchial artery embolization to control hemoptysis: a review," *CardioVascular and Interventional Radiology*, vol. 11, no. 5, pp. 263–269, 1988.

[12] V. L. Chan, L. K. So, J. Y. Lam et al., "Major haemoptysis in Hong Kong: aetiologies, angiographic findings and outcomes of bronchial artery embolisation," *International Journal of Tuberculosis and Lung Disease*, vol. 3, no. 9, pp. 1167–1173, 2009.

[13] B. Hirshberg, I. Biran, M. Glazer, and M. R. Kramer, "Hemoptysis: etiology, evaluation, and outcome in a tertiary referral hospital," *Chest*, vol. 112, no. 2, pp. 440–444, 1997.

[14] A. M. Gross, A. H. Diacon, M. M. van den Heuvel, J. van Rensburg, D. Harris, and C. T. Bolliger, "Management of life-threatening haemoptysis in an area of high tuberculosis incidence," *International Journal of Tuberculosis and Lung Disease*, vol. 13, no. 12, pp. 875–880, 2009.

[15] B. S. Shin, G. S. Jeon, S. A. Lee, and M.-H. Park, "Bronchial artery embolisation for the management of haemoptysis in patients with pulmonary tuberculosis," *International Journal of Tuberculosis and Lung Disease*, vol. 15, no. 8, pp. 1093–1098, 2011.

[16] U. B. S. Prakash, "Bronchial artery embolization for massive hemoptysis," *Journal of Bronchology*, vol. 10, no. 1, pp. 3–6, 2003.

[17] A. E. Yıldız, O. M. Arıyürek, E. Akpınar, B. Peynircioğlu, and B. E. Çil, "Multidetector CT of bronchial and non-bronchial systemic arteries," *Diagnostic and Interventional Radiology*, vol. 17, pp. 10–17, 2011.

[18] H. Mori, Y. Ohno, Y. Tsuge et al., "Use of multidetector row CT to evaluate the need for bronchial arterial embolization in hemoptysis patients," *Respiration*, vol. 80, no. 1, pp. 24–31, 2010.

[19] S. Hahn, Y. J. Kim, W. Kwon, S. W. Cha, and W. Y. Lee, "Comparison of the effectiveness of embolic agents for bronchial artery

embolization: gelfoam versus polyvinyl alcohol," *Korean Journal of Radiology*, vol. 11, no. 5, pp. 542–546, 2010.

[20] A. Khalil, M. Fartoukh, M. Bazot, A. Parrot, C. Marsault, and M. F. Carette, "Systemic arterial embolization in patients with hemoptysis: initial experience with ethylene vinyl alcohol copolymer in 15 cases," *American Journal of Roentgenology*, vol. 194, no. 1, pp. W104–W110, 2010.

[21] S. Saluja, K. J. Henderson, and R. White, "Embolotherapy in the bronchial and pulmonary circulations," *Radiologic Clinics of North America*, vol. 38, no. 2, pp. 425–448, 2000.

[22] J.-Y. Chun, R. Morgan, and A.-M. Belli, "Radiological management of hemoptysis: a comprehensive review of diagnostic imaging and bronchial arterial embolization," *CardioVascular and Interventional Radiology*, vol. 33, no. 2, pp. 240–250, 2010.

[23] B. Ghaye and R. F. Dondelinger, "Imaging guided thoracic interventions," *European Respiratory Journal*, vol. 17, no. 3, pp. 507–528, 2001.

[24] G. M. Brinson, P. G. Noone, M. A. Mauro et al., "Bronchial artery embolization for the treatment of hemoptysis in patients with cystic fibrosis," *American Journal of Respiratory and Critical Care Medicine*, vol. 157, no. 6, pp. 1951–1958, 1998.

[25] C. Witt, B. Schmidt, A. Geisler et al., "Value of bronchial artery embolisation with platinum coils in tumorous pulmonary bleeding," *European Journal of Cancer*, vol. 36, no. 15, pp. 1949–1954, 2000.

[26] Y. Matsuo, T. Okada, M. Yamaguchi et al., "Coil embolization of bronchial artery aneurysm with high flow bronchial artery-pulmonary artery fistula," *World Journal of Cardiovascular Diseases*, vol. 3, pp. 14–17, 2013.

[27] B. Üstünsöz, U. Bozlar, F. Örs, S. Gürkök, A. Balkan, and T. Ilıca, "Bronchial artery embolization: experience with 10 cases," *Diagnostic and Interventional Radiology*, vol. 12, pp. 43–46, 2006.

[28] M. M. Slattery, A. N. Keeling, and M. J. Lee, "Outcome and complications of bronchial artery embolisation for life-threatening haemoptysis," *Irish Journal of Medical Science*, vol. 178, no. 2, pp. 155–159, 2009.

[29] N. Tanaka, K. Yamakado, S. Murashima et al., "Superselective bronchial artery embolization for hemoptysis with a coaxial microcatheter system," *Journal of Vascular and Interventional Radiology*, vol. 8, no. 1, pp. 65–70, 1997.