Endovascular Treatment of Massive Hemoptysis by Bronchial Artery Embolization: Short-Term and Long-Term Follow-Up Over a 15-Year Period

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OBJECTIVE: To present our experience of using arterial embolization for the endovascular treatment of massive hemoptysis along with the results of follow-up over a 15-year period.

PATIENTS AND METHODS: A total of 401 patients with hemoptysis were referred to the minimally invasive surgery unit of the Hospital Universitario Lozano Blesa de Zaragoza between April 1989 and September 2004 for diagnosis and possible endovascular treatment. Of those patients, 314 met criteria for massive hemoptysis and treatment was attempted using embolization in 287 (91.4%). The most common cause of hemoptysis was bronchiectasis (n=99, 31.5%), followed by lesions due to tuberculosis (n=57, 18.1%) and chronic bronchitis (n=47, 14.9%).

RESULTS: Angiography of the bronchial arteries provided evidence to account for the hemoptysis in 287 patients (91.4%). The affected arteries were satisfactorily embolized in 281 (97.9%). Endovascular treatment was clinically successful in 256 of those patients (91.1%). Embolization had to be repeated during the hospital stay in 19 patients (6.7%) and was effective in 52.6% of those cases. The 6 patients in whom embolization was not satisfactory underwent thoracotomy. The mean follow-up in 201 patients (71.5%) was 2372.5 days (range, 61-5475 days). Eighty patients (28.4%) were lost to follow-up for various reasons and at different points. Recurrence of hemoptysis occurred on 1 or more occasions in 45 patients (22.3%) but only 21 (10.4%) required repeat embolization. Minor complications that did not require treatment were observed in 88 patients (28.0%).

CONCLUSIONS: Embolization of bronchial arteries is a nonsurgical treatment that is safe and effective in patients with massive hemoptysis.

Key words: *Bronchial artery embolization. Hemoptysis. Bronchial artery.*

Tratamiento endovascular mediante embolización arterial bronquial en la hemoptisis masiva. Seguimiento a corto y largo plazo durante 15 años

OBJETIVO: Presentar nuestra experiencia en el tratamiento endovascular de la hemoptisis masiva mediante embolización arterial y su seguimiento a lo largo de 15 años.

PACIENTES Y MÉTODOS: Desde abril de 1989 hasta septiembre de 2004 se remitió a la Unidad de Cirugía Mínimamente Invasiva del Hospital Universitario Lozano Blesa de Zaragoza a 401 pacientes por hemoptisis para diagnóstico y posible tratamiento endovascular. De ellos, 314 cumplían criterios de hemoptisis masiva y se intentó tratar mediante embolización a 287 (91,4%). La principal causa de hemoptisis observada fueron las bronquiectasias (n = 99; 31,5%), seguidas de lesiones de tuberculosis (n = 57; 18,1%) y bronquitis crónica (n = 47; 14,9%).

RESULTADOS: La angiografía bronquial reveló alteraciones arteriales que justificaban la hemoptisis en 287 pacientes (91,4%). Se pudo embolizar las arterias patológicas de forma satisfactoria en 281 (97,9%). El tratamiento endovascular tuvo éxito clínico en 256 (91,1%). En 19 pacientes (6,7%) se requirió durante su ingreso otra embolización, que fue eficaz en el 52,6%. En los 6 restantes se realizó toracotomía. El seguimiento medio, en 201 pacientes (71,5%), fue de 2.372,5 días (rango: 61-5.475 días). Se perdieron para el estudio 80 pacientes (28,4%) por diversas causas y en distintos momentos del seguimiento. El 22,3% (n = 45) presentó hemoptisis recidivante en una o más ocasiones, pero tan sólo 21 pacientes (10,4%) requirieron una nueva embolización. Se constataron 88 (28,0%) complicaciones menores que no precisaron otras medidas terapéuticas.

CONCLUSIONES: La embolización de arterias bronquiales es un tratamiento no quirúrgico seguro y efectivo en los pacientes que presentan hemoptisis masiva.

Palabras clave: *Embolización bronquial. Hemoptisis. Arteria bronquial.*

Introduction

Massive hemoptysis, also known as life-threatening hemoptysis, is a serious, critical condition that necessitates urgent assessment and treatment of the patient. Despite advances in the treatment of massive hemoptysis, it continues to represent a high-risk condition. According to published data, in any given year 28% of pulmonologists witness a case of death due to massive hemoptysis.[1] Conservative medical treatment of patients with expectoration of 300 to 600 mL of blood per day is associated with mortality in 50% to 100% of the patients affected,[2] with asphyxia rather than hemorrhage commonly being the cause of death.[3] While surgical treatment of massive hemoptysis is associated with mortality rates of between 7.1% and

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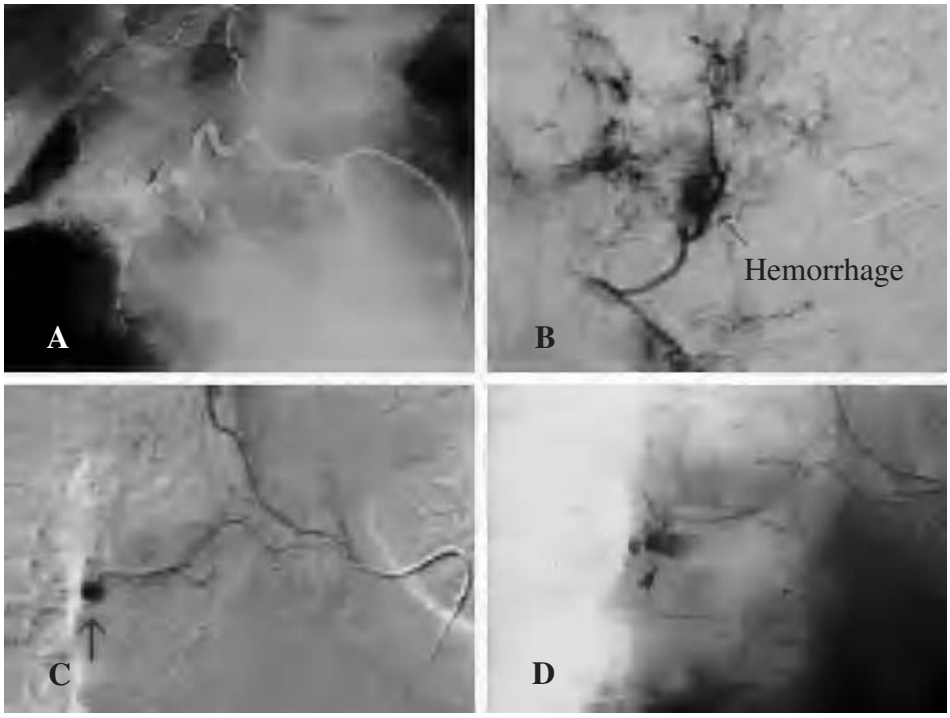

Figure 1. Angiographic patterns: direct signs. A) Aneurysm of the pulmonary artery in a patient with tuberculosis; Rasmussen aneurysm (arrow). B) Clear extravasation (arrow) in a patient with chronic bronchitis and hemoptysis, 300 mL in 24 hours. C) Local extravasation in the right bronchial artery (arrow). D) Major hemorrhage (same patient as panel C).

18.2%, the rate can reach up to 40% when surgery is performed urgently.[4]

Since embolization of the bronchial artery was first described by Remy et al[5] in 1973, it has become the main option for the treatment of massive hemoptysis, either at first presentation or in the case of recurrence. Various studies have demonstrated its effectiveness, safety, and usefulness.[6-14] However, surgery nevertheless plays an important role in the treatment of massive hemoptysis caused by certain diseases, such as pulmonary hydatidosis, bronchial adenoma, and aspergilloma that is refractory to other treatments.[15] In such cases, prior urgent bronchial artery embolization facilitates surgical treatment and improves results, since it allows scheduled rather than urgent surgery to be undertaken.[4] Surgery also represents the treatment of choice when bronchial artery embolization fails repeatedly or is insufficient to control massive, life-threatening hemorrhage.[16]

Currently, when embolization of the bronchial artery fails, the use of endoscopically implanted thrombin preparations has been proposed on the basis of its high success rate.[17]

Here, we present our experience of using arterial embolization for the endovascular treatment of massive hemoptysis along with the results of follow-up over a 15-year period.

Patients and Methods

A descriptive, retrospective study was undertaken in a single reference hospital with a catchment population of more than 500 000. A total of 401 patients with hemoptysis were referred to the minimally invasive surgery unit of our hospital between April 1989 and September 2004 for diagnosis and possible endovascular treatment. Of those, 267 (66.6%) were men and 134 (33.4%) were women; the mean age was 53.8 years (range, 12-84 years). Criteria for massive hemoptysis were met by 314 patients. Of those, 287 were treated by embolization. Criteria for treatment were as follows: agreement and signing of an informed consent form, expectoration of more than 300 mL of blood in 24 hours or more than 100 mL per day over the course of at least 3 consecutive days, irrespective of the clinical severity of the patient's condition. Contraindications were not considered in the study. Patients were referred to the minimally invasive surgery unit by various departments and intensive care units, both within our hospital and from other referring hospitals.

Biochemical and coagulation analysis, and chest radiography were performed in all patients prior to endovascular treatment. A computed tomography (CT) scan of the thorax was performed prior to the procedure in 78 patients and fiberoptic bronchoscopy was undertaken for diagnostic purposes in 252 patients (80.2%). The findings were used for diagnosis of etiology and possible identification of the site of hemorrhage. The most common cause of hemoptysis was bronchiectasis (n=99, 31.5%), followed by acute tuberculosis or scar tissue caused by tuberculosis (n=57, 18.1%), and chronic bronchitis (n=47, 14.9%). Other causes are shown in Table 1. Diagnosis and endovascular treatment was performed in all cases under aseptic conditions in the treatment room of our hospital with provision of adequate monitoring and life support equipment. Orotracheal intubation was required during the endovascular procedure in 37 patients (11.7%) and 114 (36.3%) received transfusions of concentrates or fresh plasma before, during, or after the procedure.

Diagnostic angiography was performed through the femoral artery, preferably on the right side. In all cases, an angiogram of the thoracic aorta was obtained with a pigtail catheter situated in the aortic arch. The aortogram directly

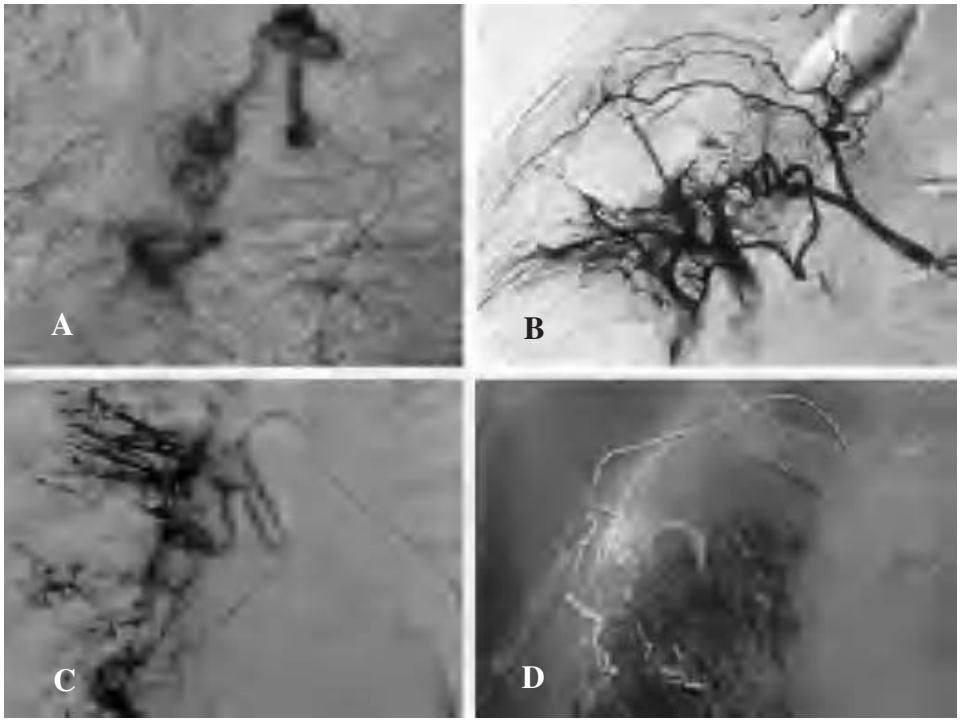

Figure 2. Angiographic patterns: indirect signs. A) Selective angiogram of a large caliber bronchial artery with visible tortuosity in a patient with bronchiectasis. B) Selective angiogram of the right intercostobronchial artery. A shunt can be seen between the bronchial and pulmonary arteries. C) Selective angiogram of the right bronchial artery showing vessels with a speckled appearance and small vascular tufts. D) Lateral thoracic artery with hypertrophic branches that penetrate the pulmonary parenchyma.

revealed diseased vessels in 79 patients (25.1%). According to the protocol applied in the unit, the bronchial arteries of each hemithorax, the intercostal arteries (particularly in diseased areas), the internal mammary arteries, and the lateral thoracic arteries were examined selectively. If the examination was negative, pulmonary angiography was performed. An artery was considered diseased when direct signs such as extravasation and aneurysm (Figure 1) or indirect signs such as irregularity, venous beading, increased caliber, vascular tufts, and arterioarterial or arteriovenous fistulae (Figure 2) were observed. In all cases, attempts were made to identify the medullary arteries.

Once the diseased artery was identified, it was safely catheterized using a guidewire in order to perform occlusion using various embolizing agents. The following configurations of the 5-French catheter were most commonly used: Cobra I and II, Simon I, Michaelson, and Hock. When the position of the catheter was unstable or the caliber of the vessel too small, a straight coaxial 2 to 3-French microcatheter was used in an effort to prevent spasm, rupture of the artery, and reflux of occlusion material (Figure 3).

The embolizing agents used were always permanent: either particles of polyvinyl alcohol with a diameter of 250 to 500 µm or trisacryl gelatin microspheres (Embospheres; BioSphere Medical Inc, Rockland, MA, USA) of a similar diameter (Figure 4). Whenever safe and feasible, the diseased artery was closed proximally with platinum microcoils adapted to the caliber of the vessel. The diseased artery was

TABLE 1
Causes of Massive Hemoptysis in 314 Patients

	Number	%
Bronchiectasis	99	31.52
Acute or residual tuberculosis	57	18.15
Chronic bronchitis	47	14.96
Suppurative processes	23	7.32
Lung carcinoma	12	3.82
Aspergillosis	9	2.86
Other cancers (pulmonary sarcoma, oncocytoma, metastasis)	8	2.54
Cystic fibrosis	8	2.54
Chronic pleural inflammation	6	1.91
Hydatid cyst	6	1.91
Pulmonary fibrosis (idiopathic)	5	1.59
Pneumoconiosis	4	1.27
Malformation of the pulmonary vasculature	4	1.27
Behçet's disease	3	0.95
Lung biopsy	3	0.95
Tracheal intubation	3	0.95
Ruptured aortic aneurysm	2	0.63
Bronchopulmonary sequestration	2	0.63
Rasmussen's aneurysm	1	0.31
Swan-Ganz catheter manipulation	1	0.31
Aortobronchial fistula following radiotherapy	1	0.31
Surgical revascularization of the left coronary artery	1	0.31
Unknown	9	3.7

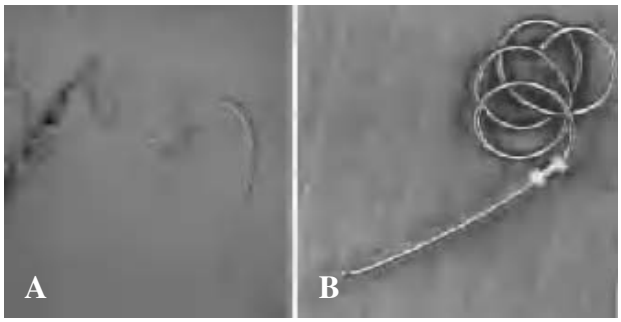

Figure 3. Superselective microcatheterization. A) Selective angiogram showing catheterization with a 2 mm microcatheter inserted coaxially through a 5-French catheter. B) Illustration of the microcatheter and the larger caliber guide catheter.

Figure 4. Different types of embolizing agents. A) Polyvinyl alcohol particles of varying diameter. B) Different sized coils. C) Microspheres. D) Gelatin sponge.

occluded at its proximal end in 180 out of 287 patients (62.7%). The criterion used for embolization was that all diseased arteries observed by angiography should be closed.

Technical success was defined as complete closure of the diseased artery or arteries implicated in the hemorrhage without complications and technical failure as the inability to safely catheterize and embolize the diseased artery. Clinical success was defined as cessation of hemoptysis for at least 30 days following the procedure and clinical failure as the persistence of hemoptysis despite occlusion of the presumptive diseased artery. Finally, recurrence was defined as the appearance of a new hemorrhage of 50 mL or more in 24 hours, or a lower volume for various days consecutively, within 30 days of the procedure.

Following the procedure, patients were sent back to the referring department and follow-up appointments were arranged for 1 month, 3 months, 6 months, and 12 months later, followed by annual follow-up appointments. Follow-up consisted primarily of clinical assessment and a chest radiograph was performed at 6 months and 1 year. When necessary for complete examination, fiberoptic bronchoscopy was performed. A CT scan was carried out in patients in whom no scan had been done prior to the procedure.

TABLE 2
Arterial Territories Identified as Diseased

Arterial Territory Examinated	Direct Signs		Indirect Signs		Total	
	Number	%	Number	%	Number	%
Bronchial	31	10.6	245	84.1	276	94.8
Mammary	7	2.4	23	7.9	30	10.3
Lateral thoracic	4	1.3	18	6.1	22	7.5
Thoracoacromial	3	4.4	11	3.7	14	4.8
Thoracodorsal	2	2.1	11	3.7	13	4.4
Intercostal	2	2.1	9	3.0	11	3.7
Pulmonary	5	1.7	1	0.3	6	2.0
Right phrenic	2	2.1	4	1.3	6	2.0
Coronary	0	–	1	0.3	1	0.3
Others	2	2.1	2	2.1	4	1.3

Results

The chest radiograph performed on admission was classified as normal or had nonspecific findings in 63 patients (20.0%); in 14 of those patients CT revealed abnormalities. In the remaining patients, either chest radiography or CT revealed lesions associated with the cause of hemoptysis. Fiberoptic bronchoscopy was performed prior to angiography in 252 patients (80.2%) but, despite revealing diffuse bronchial hemorrhage, only provided information on the site of the hemorrhage in 143 (56.7%).

Angiography of the bronchial arteries revealed abnormalities that would account for hemoptysis in 287 patients (91.4%). Of those, 58 (20.2%) presented direct signs of hemorrhage (extravasation and/or aneurysm). The remainder only showed indirect signs that were more or less intense. The main diseased arteries observed are shown in Table 2.

The affected arteries were satisfactorily embolized in 281 patients (97.9%). In 4 of the remaining 6 cases, despite various attempts, it was impossible to successfully catheterize the diseased artery (2 left bronchial arteries and 2 right intercostobronchial arteries). In the other 2 patients, a medullary artery also arose from the affected bronchial artery and, consequently, embolization was

TABLE 3
Results Obtained in 314 Patients With Massive Hemoptysis

	Reference	Number	%	Observations
Arteriography	314			
No angiographic evidence of pathology	314	287	91.4	
No abnormalities found	314	27	8.6	
Technical success	287	281	97.9	
Technical failure	287	6	2.0	Technically impossible, 4 Presence of medullary branches, 2 (3 treated surgically and 3 self-limited)
Clinical success	281	256	91.1	
Clinical failure	281	25	8.9	
Repeat arterial embolization	25	19	76	Clinical success, 10 Surgery, 6 Died, 3
Surgery	25	6	24	

TABLE 4
Follow-Up of 314 Patients With Massive Hemoptysis

	Reference	Number	%	Observations
No diseased arteries	314	27	8.5	None underwent surgery None died while in hospital 16 (59.2%) presented new, small hemoptysis sites that were treated medically
Follow-up	281	201	71.5	
Lost to follow-up	281	80	28.4	Surgery due to technical failure, 12 Dead, 3 Scheduled surgery, 8 Died during follow-up for other reasons, 13 Did not return after initial treatment, 16 Contact lost over the course of the study, 28
Recurrence	201	45	22.3	Embolization required, 21 Nonsignificant hemoptysis, 24

ruled out. In the 4 cases in which embolization was technically impossible, manipulation of the artery with the catheter caused arterial spasm or thrombosis, which resulted in control of the hemorrhage. In the remaining 2 patients, a wait-and-see attitude was taken while medical treatment was provided. Surgery was performed in 3 patients with diagnosed bronchiectasis (2 cases of medullary artery involvement and 1 case of technical failure). In the remaining 3 patients (2 diagnosed with chronic bronchitis and 1 with bronchiectasis) the hemoptysis ceased spontaneously. In subsequent examinations 2 of those patients presented hemoptic sputum that did not require invasive treatment.

Of the 281 patients in whom technical success was achieved, immediate clinical success was obtained with endovascular treatment in 256 (91.1%). In 25 cases (8.9%), arterial embolization failed to achieve clinical success. Of those, embolization had to be repeated during the hospital stay in 19 patients (76%) and was effective in 10 of them (52.6%). Of the 9 patients in whom repeat embolization was ineffective, 3 died as a consequence of massive hemoptysis (1 had aspergillosis and 2 had tuberculous cavities), despite medical treatment. The remaining 6 patients underwent surgery. The other 6 patients in whom arterial embolization did not achieve clinical success received surgical treatment directly (Table 3).

TABLE 5
Main Complications Observed and Treatment Provided

Complications	Number	%	Treatment
Immediate	60	20.9	
Inguinal hematoma	45	15.6	None
Intimal dissection of the aorta	6	2.0	None
Coil migration	4	1.3	Endovascular retrieval
Chest pain	3	1.0	Analgesia
Dysphagia	2	0.6	None
Late	28	9.7	
Chest pain	26	9.0	None/analgesia
Segmental dysesthesia	2	0.6	None
Total	88	30.6	

The mean follow-up in 201 patients (71.5%) was 2372.5 days (range, 61-5475 days). A total of 80 patients (28.4%) were lost to follow-up for various reasons and at different points (Table 4). Recurrence of hemoptysis occurred on 1 or more occasions in 45 patients (22.3%) but only 21 of them (10.4%) required repeat embolization. Once hemoptysis was controlled, the underlying disease was treated by scheduled surgery in 8 patients. No case of recurring massive hemoptysis was found. In 88 patients (28.0% of the total population), minor complications were observed that did not require further treatment (Figure 5 and Table 5).

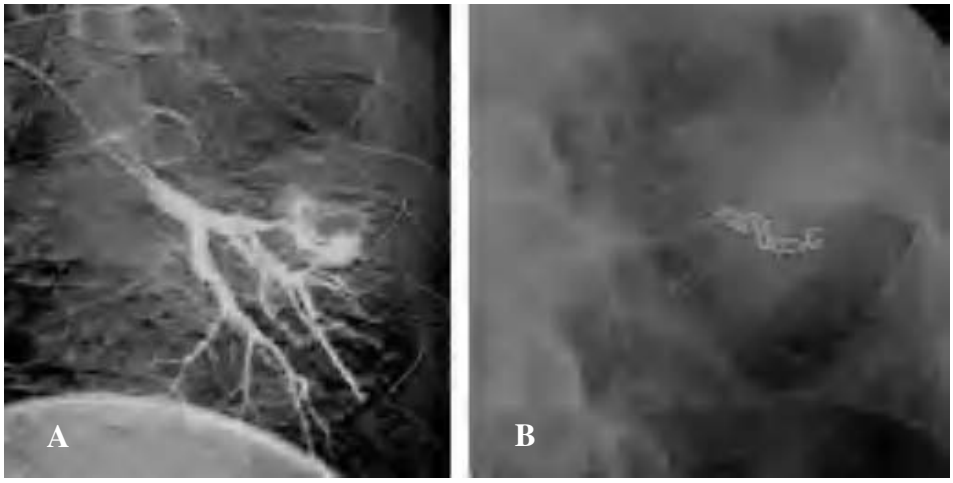

Figure 5. Pulmonary arteriography. A) Iatrogenic rupture of the pulmonary artery causing pulmonary hematoma. B) Result of embolization using coils.

No complications relating to embolization of a medullary artery were observed. Perioperative mortality at 30 days was 1.7%: 3 patients as a consequence of uncontrolled hemoptysis, 1 due to infection during thoracotomy, and 1 due to unknown causes.

Discussion

There is no consensus regarding the amount of blood that corresponds to the concept of "massive" hemoptysis. Although massive hemoptysis has been defined as the expectoration of between 100 and 1000 mL of blood within a 24-hour period, the most widely used criterion is the production of between 300 and 600 mL of blood per day.[2-4,15] However, the definition also depends on the ability to maintain an open airway, such that situations can be considered life threatening with a lesser amount of blood in patients with limited pulmonary reserve. A more practical definition of massive hemoptysis would be a quantity of blood sufficient to cause a situation that threatens the life of the patient and in which interventional treatment is necessary.[15,18] In our study, although all patients presented substantial hemorrhage of more than 300 mL in 24 hours or more than 100 mL per day over the course of 3 consecutive days, not all presented hemodynamic and respiratory instability requiring intubation and treatment in the intensive care unit.[19]

Although there may be multiple causes of hemoptysis, bronchiectasis and tuberculosis and their sequelae, alongside cancer, chronic inflammatory diseases, and cystic fibrosis represent the main causes of bleeding.[2,3,15,20]

The source of massive hemoptysis is usually located in the bronchial arteries (90% of cases). In 5% of patients it is located in the pulmonary arteries[21] and in the remaining 5% it is located in the aorta (aortobronchial fistulae or rupture of aortic aneurysms) or the systemic arterial circulation (branches serving the lungs).[22-24] In this study, the bronchial arteries were the source of the hemoptysis in 94% of patients, while the pulmonary arteries were involved in only 2% of cases. The remaining cases were accounted for by various systemic sources of hemorrhage.

Diagnostic examination in massive hemoptysis should focus on etiology and identification of the site of bleeding. Such examination commonly involves chest radiography, fiberoptic bronchoscopy, and chest CT.[15,18] Despite the fact that chest radiography is a standard procedure and is always available, it rarely provides clear information on the site of bleeding.[18] In this study, 80% of the chest radiographs performed revealed abnormalities and helped in the diagnosis and/or localization of the hemorrhage.

Various studies have reported that fiberoptic bronchoscopy can help to locate the site of the hemorrhage (the diseased side) in between 49% and 92.9% of cases.[18,20] In our patients, bronchoscopy provided information that helped to guide the angiographic identification of the source in 57% of the patients in whom it was performed. Since our hospital does not have facilities for bronchoscopy outside of normal working hours, that procedure was only performed prior to angiography in 80% of patients.

Knowledge of the anatomy of the bronchial arteries is crucial for their localization and examination. The bronchial arteries exhibit various anatomic variations, both in terms of their origin and their various branches.[25] It is essential to try to identify and prevent injection of contrast agent into the dorsal or ventral radicular arteries, mainly the artery of Adamkiewicz, or major anterior radicular artery. Table 2 shows the bronchial and nonbronchial arteries identified in our patient group.

Although direct signs—aneurysm and extravasation—are the most reliable and specific angiographic indicators of bronchial artery involvement, they are also the least common.[20] Extravasation of contrast agent is observed in only 3.6% to 10.7% of cases.[12,16] In our study, the presence of aneurysms, microaneurysms, and extravasation of contrast agent were considered direct signs and were observed in 20.2% of patients.

There are various types of embolizing agents, which can be divided into absorbable and nonabsorbable. Long-term and short-term results can depend upon the embolizing agent as well as the technique used and, of course, the etiology. To our knowledge there have been no comparative studies of different embolizing agents according to the technique used. Currently, distal embolization is recommended using nonabsorbable particles (polyvinyl alcohol or trisacryl gelatin microspheres) and proximal embolization using coils or metal spirals is not advised on the basis that it prevents future catheterization of the artery if a new hemorrhage occurs.[20,26] In our group, whenever possible we perform distal closure with polyvinyl alcohol particles (250-500 μm in diameter) and proximal closure with microcoils, our opinion being that if the occlusion is complete and meticulous then there is little or no likelihood of the vessel bleeding again in the future. Recurrence would be due to reperfusion and bleeding from other vessels. In this study, we encountered no records of difficulties in examining or treating patients with recurrence as a result of having occluded the artery proximally. Other arteries or collateral circulation were implicated in the hemorrhage.

In our opinion, when evaluating results it is important to take into account a number of variables, such as etiology, inclusion criteria, the embolizing agent used, and the length of follow-up. Mossi et al[27] analyzed predictors of failed arterial embolization in a retrospective study of 64 patients treated for hemoptysis and concluded that tuberculosis, aspergillosis, and systemic pulmonary shunt are associated with a high risk of recurrence.

Few studies have involved long-term follow-up. In a study of 37 patients with a follow-up of 96 months, Bustamente et al[28] obtained an immediate clinical success rate of 92%, with a rate of recurrence of 37.5%. In a 6-year follow-up study of 134 patients in whom only distal embolization was performed with nonabsorbable particles, Yu-Tang et al[29] obtained a clinical success rate of 81.6% and a requirement for repeat embolization in 18.4%. Although they did not report the rate of recurrence of hemoptysis in their article, we might assume that it was higher than that. The rate of recurrence following arterial embolization for the treatment of hemoptysis reported in the literature without specifying severity is around 20% to 30%.[30,31] In our study, initial clinical success after embolization was achieved in 91.1%, a rate that rose to 94.6% following repeat embolization. However, it is worth noting that the initial clinical success rate of arterial embolization for all patients with massive hemoptysis was only 81.5%, since no arterial lesions were found in 27 patients and 6 could not be embolized. The rate of recurrence (22%) was adjusted to the percentage of patients in whom complete follow-up was performed (n=201). Although a noticeably large number of patients were lost to follow-up, this loss may be explained by the extended follow-up period, the geographic dispersion of the population (various hospitals and cities), and the loss due to surgery and death of 23 patients.

The most common complication is chest pain, which has a prevalence of between 24% and 91%.[12,20] It is usually transient and is related to ischemia caused by the embolization. As in other studies, in our experience this pain subsided spontaneously. Another lesser complication occurring during the procedure is the subintimal dissection of the aorta or a bronchial artery; this occurs with a prevalence of 1% to 6%.[8-10,14] The patients in whom this complication was observed did not present persistent damage to the wall of the aorta or any significant repercussions. The most severe complication associated with embolization is spinal ischemia caused by accidental occlusion of spinal arteries. The prevalence of spinal ischemia following embolization of bronchial arteries is between 1.4% and 6.5%.[12,13] In our study, we did not observe any severe complication due to embolization of spinal arteries.

In conclusion, embolization of the bronchial arteries is a safe, effective, minimally invasive, nonsurgical procedure. Surgery must be resorted to in some patients due to their underlying disease or failure of percutaneous treatment. Knowledge of the anatomy of the bronchial artery and good angiographic diagnosis are essential for successful embolization of the bronchial artery. In a small percentage of patients the pulmonary artery may be responsible for the hemorrhage, meaning that pulmonary artery disease should be considered as a possible cause of hemorrhage in patients with recurrent hemoptysis. In our experience, proximal embolization improves results, leads to fewer recurrences, and does not present problems should repeat embolization be necessary.

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