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Original Article

Role of Interventional Radiology in the Management of Massive Hemoptysis

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Abstract
Massive hemoptysis is one of the emergencies in respiratory system, representing hemorrhage of the bronchial or pulmonary vascular system into the respiratory tract. Massive hemoptysis is a life-threatening condition due to high risk of asphyxia it may induce. Bronchial artery embolization (BAE) is an interventional radiology procedure dedicated in the emergency management of massive hemoptysis. BAE is known for its great success rate and low risk of complications. Proper catheterization technique, recognition of bronchial artery variant anatomy and appropriate selection of embolic material agent proves essential in determining the success of this procedure. As a minimally invasive procedure, BAE is highly recommended to be used in cases of massive hemoptysis. ***(J Respirol Indones 2021; 41(4): 300–7)***
Keywords: *hemoptysis; bronchial artery embolization; angiography; interventional radiology; emergency*

Peran Radiologi Intervensi pada Tata Laksana Hemoptisis Masif

Abstrak
Hemoptisis masif adalah salah satu kegawatdaruratan dalam sistem pernapasan yakni terjadinya perdarahan sistem vaskular bronkial atau pulmoner yang mengisi saluran pernapasan. Hemoptisis masif merupakan kondisi yang mengancam jiwa karena terdapat risiko tinggi untuk terjadinya asfiksia. Bronchial artery embolization *(BAE) atau embolisasi arteri bronkial merupakan sebuah prosedur radiologi intervensi yang ditujukan untuk menjadi tata laksana kegawatdaruratan pada kasus hemoptisis masif. BAE diketahui memiliki angka keberhasilan yang tinggi dan risiko komplikasi yang rendah. Teknik kateterisasi yang tepat, pengenalan varian anatomi arteri bronkial dan pemilihan agen bahan emboli yang tepat berperan penting dalam menentukan keberhasilan prosedur ini. Sebagai sebuah prosedur yang minimal invasif, BAE sangat direkomendasikan dalam kasus-kasus hemoptisis masif.* ***(J Respirol Indones 2021; 41(4): 300–7)***
Kata kunci: *hemoptisis; embolisasi arteri bronkial; angiografi; radiologi intervensi; gawat darurat*

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INTRODUCTION

Hemoptysis or coughing up blood is the expectoration of blood due to bleeding in the airways under the larynx or bleeding that comes out through the lower respiratory tract of the larynx.[1] Massive hemoptysis can be life-threatening, with a mortality rate of more than 50% without adequate bleeding control.[2–5] Ninety percent of the source of massive hemoptysis comes from the bronchial circulation and 5% from the pulmonary circulation. Another small proportion originates from the aorta (aortobronchial fistula, ruptured aortic aneurysm, or systemic arterial circulation to the lungs).[1–3]

Hemoptysis occurs in 30% of patients with lung carcinoma, with 10% of them experiencing massive bleeding.[2–7] The severity of hemoptysis depends on several factors, such as history of disease, coagulation, and hemorrhagic shock.[4]

Bronchial Artery Embolization (BAE) is a diagnostic and therapeutic procedure in interventional radiology that has an important role in cases of massive hemoptysis. Aortography and angiography of the bronchial arteries have good diagnostic value in identifying the source of bleeding. On the other hand, embolization as a minimally invasive therapeutic procedure has high effectiveness in terminating the bleeding.[2,3] The following description introduces and explores the roles of interventional radiology in the form of BAE on massive hemoptysis cases.

DISCUSSION

BAE was first reported as a treatment option for massive and life-threatening hemoptysis by Remy, et al. in 1973.[2,6] Compared to invasive surgery, BAE is a minimally invasive procedure that is relatively safer and has higher effectiveness plus lower risk of complications because BAE does not impair pulmonary function. Patients with massive hemoptysis generally have a poor pulmonary function. Therefore, they had a high risk for anesthesia and surgery with a mortality rate of about 7.1–18.2% and increasing to 40% in emergency surgery.[2]

Indication

BAE procedures can be performed in hemoptysis cases with various etiologies. Pathological processes that indicate BAE include:[1,5,6]

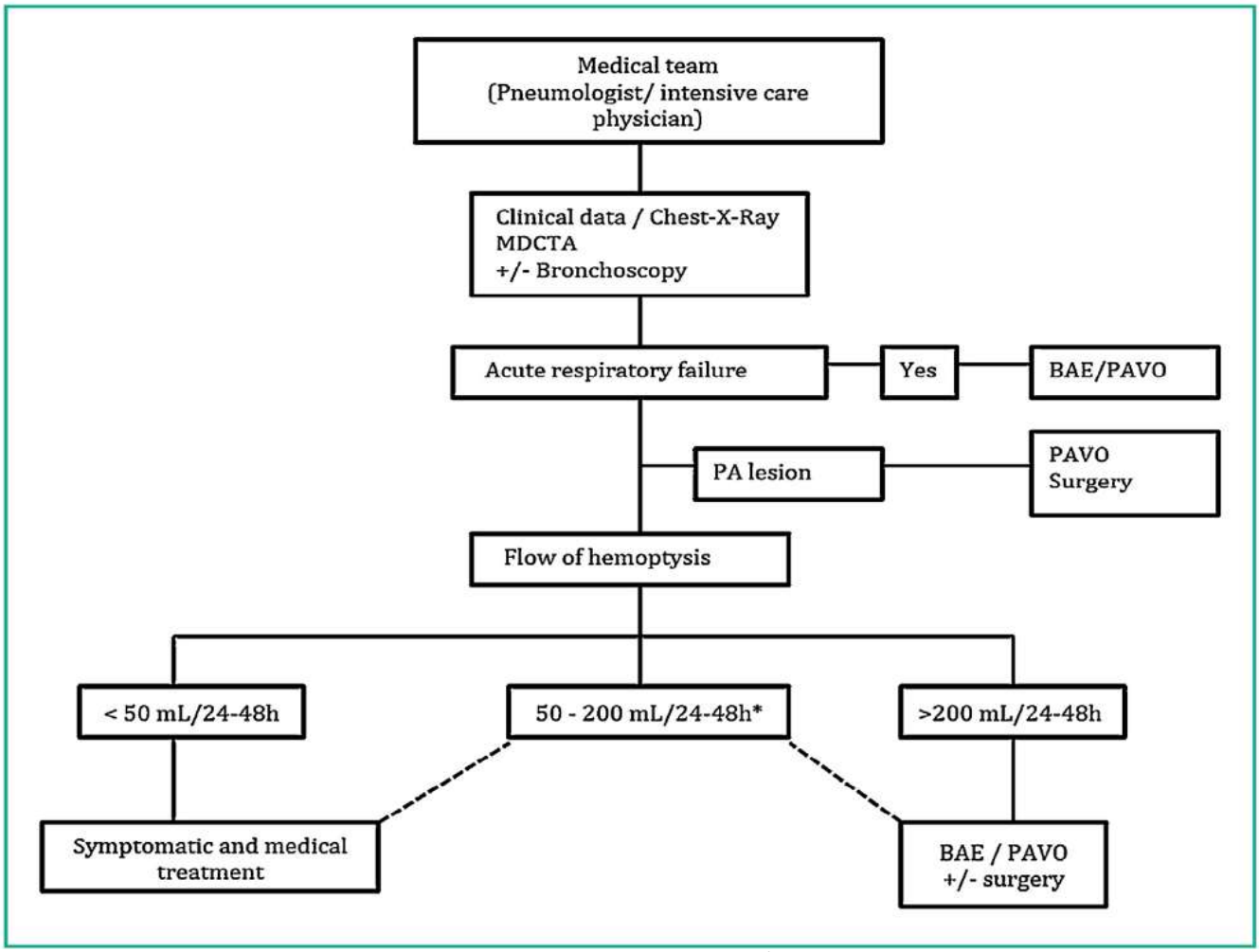
- Life-threatening hemoptysis, i.e., bleeding 300 mL in 24 hours, bleeding 100 mL per day for at least 3 days, or minor bleeding with hemodynamic instability.
- Diffuse interstitial lung disease and chronic granulomatous disease.
- Diseases that can trigger hemoptysis, i.e., cystic fibrosis, tuberculosis, bronchiectasis, interstitial pulmonary fibrosis, fungal infections (e.g., aspergillosis), ruptured bronchial artery aneurysm, arteriovenous fistula, neoplasm, Bechet disease, cryptogenic.

Contraindications

As a life-saving emergency procedure, BAE has no absolute contraindications. Relative contraindications to BAE include general angiographic contraindications, namely impaired coagulopathy, the presence of the major radiculo medullary artery of the target artery (e.g., the target artery also supplies the spinal cord), and congenital pulmonary artery stenosis (CPAS). In patients with CPAS, pulmonary parenchymal perfusion relies almost entirely on the bronchial artery system, so the BAE procedures carry a higher risk. All of these relative contraindications do not prevent BAE from being performed. Careful preparation and planning are required before BAE can be completed in patients with these contraindications.[2,5]

Pre-Procedure Preparation

The management of massive hemoptysis should focus on airway patency to prevent aspiration of blood, which could lead to asphyxia. The patient's respiratory and hemodynamic status are evaluated and optimized as possible. In emergency cases, transfusion of fresh-frozen plasma or platelets can be performed intra-procedurally to optimize blood coagulation function.[4–6]



Note: BAE= Bronchial Artery Embolization; PAVO= Pulmonary Artery Vaso-Occlusion.[1]

Figure 1. Algorithm for the management of life-threatening hemoptysis.

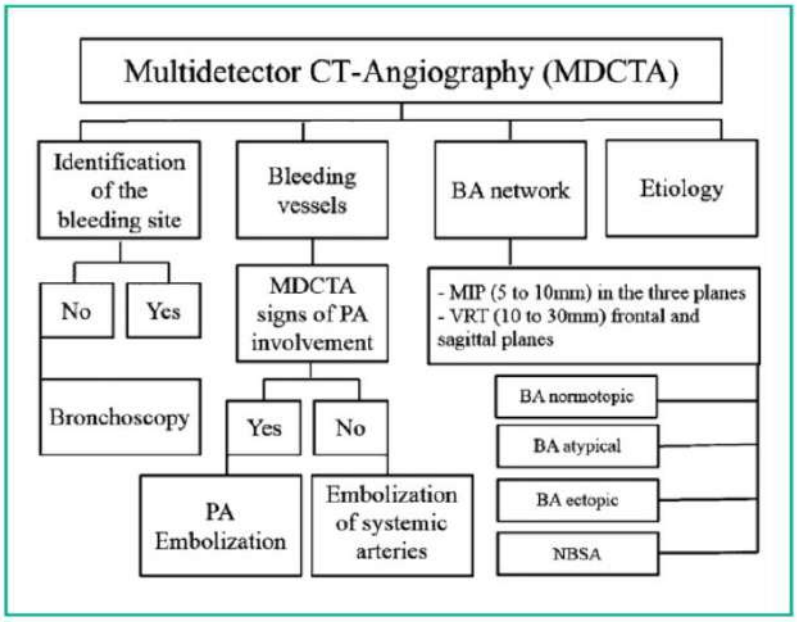
The considerations for endotracheal intubation are evaluated based on the patient's condition. Moderate sedation is generally adequate to stabilize the patient's condition and position during the procedure.[4–6]

Preprocedural diagnostic imaging includes chest radiography to identify the etiology of hemoptysis and to estimate the site of bleeding. Computed tomography (CT) or CT angiography (CTA) is performed when the patient's condition is permitted to evaluate the size and extent of the lung lesion, as well as to identify the source of bleeding (Figure 2 and 3). Bronchoscopy can help localize the site of bleeding. However, in the case of massive bleeding, blood in the bronchial tree can obscure the visual field and make it difficult to identify the source of bleeding.[5,6]

Catheterization Technique

Arterial access through the common femoral artery is carried out using a 5F femoral introducer sheath. In younger patients, the 4F size can be applied. As a first step, descending thoracic aortography is performed to evaluate the location and anatomic variant of the bronchial arteries that branch directly from the aorta. In addition, aortography can also assess structural abnormalities of the bronchial arteries and identify non-bronchial circulation.[2,5]

The commonly used angiographic catheter for selective bronchial artery catheterization is the cobra type catheter. Other types of angiographic catheters such as Simmons-1, headhunter, and Yashiro can also be utilized as alternatives to bronchial arteries catheterization.



Note: MDCTA= Multidetector CT-angiography; MIP= Maximum Intensity Projection; VRT= Volume Rendering Technique; PA= Pulmonary Artery; BA= Bronchial Artery; NBSA= Non-Bronchial Systemic Artery.[1]

Figure 2. Utilization of CTA in identifying the etiology and localizing the source of bleeding.

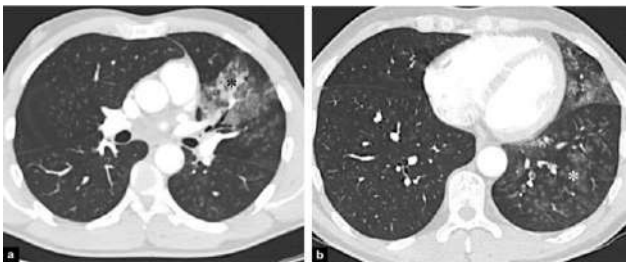


Figure 3. (a) Axial CT shows focal alveolar changes (stars) surrounded by a ground-glass opacity in the linguistic lobe suggesting hemorrhage in that region. (b) Axial CT at the level of the lung bases depicts a nodular ground-glass opacity (star) in the inferior lobe of the left lung, indicating an extension of hemoptysis to the inferior lobe.[1]

Furthermore, super-selective catheterization is carried out using a microcatheter on the branch of the bronchial arteries which are identified as the source of bleeding. The tip of the catheter is positioned as stable as possible at the mouth of the bronchial artery to prevent non-target arterial branch catheterization. Superselective angiography with manual contrast injection will be performed once more post-catheterization to confirm catheter position and to localize the bleeding source.[1,2]

Bronchial Artery Anatomy Variants

The bronchial circulation has four variants of the branching pattern of the bronchial arteries, (Figure 4):

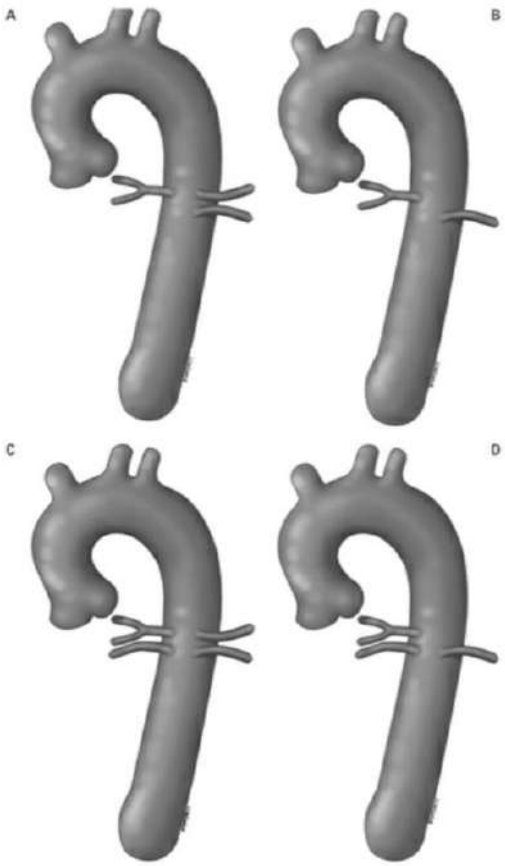


Figure 4. Illustration of four variants of the bronchial arterial supply. (a) Two bronchial arteries on the left and one on the right that manifests as an ICBT. (b) One on the left and one ICBT on the right. (c) Two on the left and two on the right (one ICBT and one bronchial artery). (d) One on the left and two on the right (one ICBT and one bronchial artery). ICBT: intercostobrachial trunk.[2]

- Two separate branches on the left and one on the right as the intercostobrachial trunk (ICBT) in 40% of individuals.
- One branch on the left and one ICBT on the right in 21% of individuals.
- Two separate branches on the left and two separate branches on the right (one ICBT and one bronchial artery) in 20% of individuals.
- One branch on the left and two separate branches on the right (one ICBT and one bronchial artery) in 9.7% of individuals.

Identification of the bronchial artery variant is an essential step in preparing for the BAE procedure. These anatomic variants can be identified on CTA or thoracic aortogram (Figure 5).[1,2]

Figure 5. Thoracic aortographic features of massive hemoptysis. (a) Thoracic aortography shows hypertrophy of two bronchial arteries (solid arrows) and one intercostal artery (open arrows) supplying a hypervascular lesion in the superior lobe of the right lung. (b) Selective angiography of the superior bronchial artery. (c) Selective angiography of the inferior bronchial artery showing bronchopulmonary shunting. (d) Selective angiography of the intercostal arteries shows bronchopulmonary shunting.[2]

In general, there is one right bronchial artery originating from the intercostal arteries, the ICBT, located on the posterolateral aspect of thoracic aorta. The right and left bronchial arteries generally emerge from the anterolateral aspect of the aorta. The bronchial arteries supply the trachea and extrapulmonary as well as intrapulmonary respiratory tract, bronchovascular bundles, nervous system, regional lymph nodes, visceral pleura, esophagus, and aortic vasa vasorum. In one-third of cases, one bronchial artery may be located ectopically from the caudal aspect of aortic arch. Other variations of the bronchial arteries may originate from the costocervical trunk, thyrocervical trunk, and the internal mammary artery.[2–4,7]

Angiographic Findings

Angiographic findings in massive hemoptysis may include contrast extravasation, pseudoaneurysm/aneurysm, or abnormal vascularity, e.g., hypertrophy of tortuous bronchial arteries, neovascularization, or shunting of pulmonary arteries or veins. Contrast extravasation is a specific finding in bronchial hemorrhage but only visualized in 3.6–10.7% of cases.[2,4,6]

Normal diameter of the bronchial artery in adults is 1.5 mm at the proximal estuary and 0.5 mm in the distal segment near the bronchopulmonary insertion. The hypertrophied (>2.0 mm) bronchial arteries are visualized as contrast-enhanced nodular or tubular structures in the mediastinal region and around the central airways on chest CT or thoracic CTA with intravenous contrast. Bronchial artery hypertrophy has a predilection for the retro-esophageal, retrotracheal, retrobronchial, posterior walls of the main bronchi, and the aortopulmonary window.[2,4]

Non-bronchial circulation may originate from the intercostal, thoracic, inferior phrenic, thyrocervical, vertebral, axillary, subclavian, and internal mammary arteries. The coaxial microcatheter system (Renegade, Progreat) can reach the target bronchial arteries more easily, minimizing the risk of vasospasm, avoiding non-targeted embolization of the spinal cord arteries, and reducing the risk of reflux of embolic material into the spinal branches of the aorta. Non-bronchial systemic collateralization should be assessed and monitored. Hemoptysis that rapidly recurs post-BAE often indicates the contribution of the systemic vascular system to the source of bleeding.[2,6]

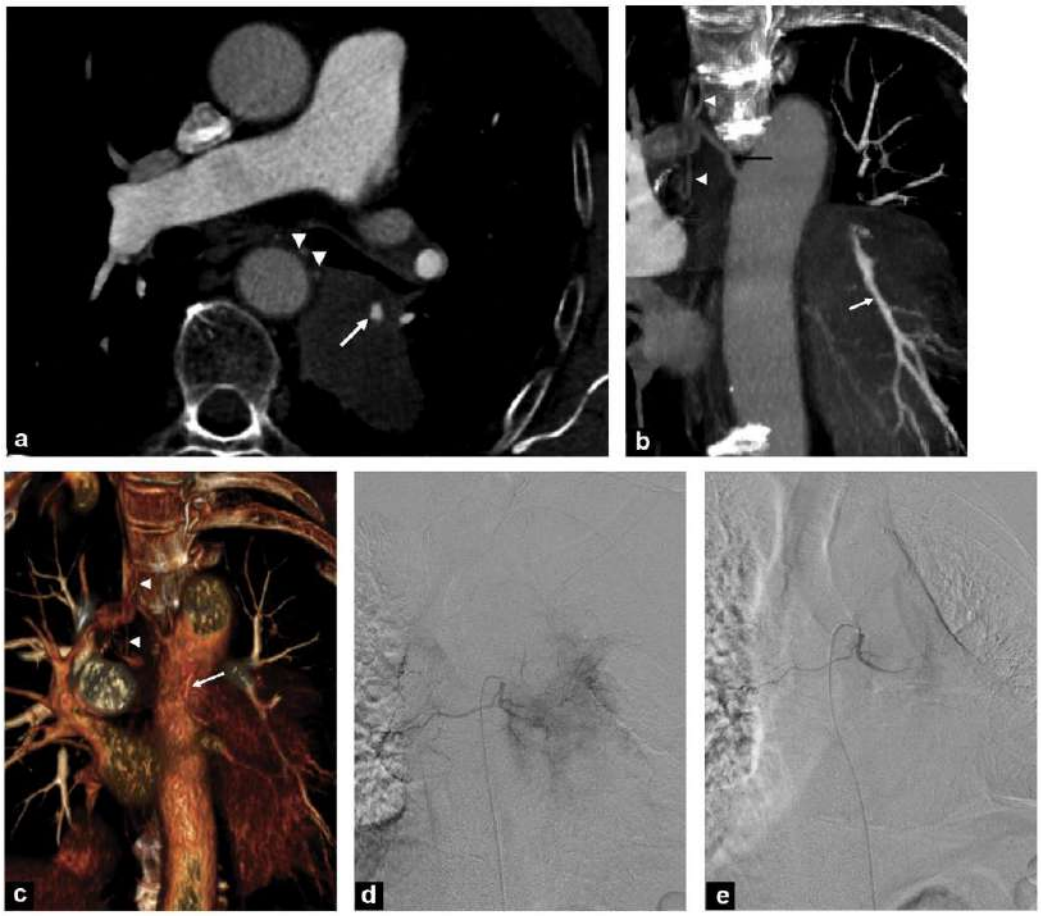


Figure 6. Non-small cell lung carcinoma in the lower lobe of the left lung with hemoptysis of 40 mL/day for several weeks, which is getting larger. (a) Axial CT shows stenosis of the left pulmonary artery (arrows) by tumor and left bronchial artery hypertrophy (arrowheads). (b) The coronal reconstruction shows a mass at the left hilum surrounding the pulmonary artery (white arrow) and hypertrophy of the IBCT (black arrow) providing collateral to the right bronchial artery (arrowhead). (c) VR reconstruction (volume rendering) showing IBCT branching into the right bronchial artery (arrowheads) and the proximal opening of the common right-left bronchial trunk (CRLBT; arrows), providing vascularization to the left lung and right inferior bronchial artery. (d) CRLBT angiography shows hypervascularization at the left hilum without systemic-pulmonary shunting. (e) Postembolization CRLBT angiography using non-resorbable particles with a diameter of 250 umm showed significantly reduced tumor vascularity.[1]

Selection of Embolic Agent

Several choices of embolic agents can be used in BAE. The use of embolic agents that can pass through the bronchopulmonary anastomoses should be avoided (minimum diameter 325 µm). Embolic agents that cause distal occlusion of peripheral branches supplying the bronchi, esophagus, or vasa vasorum of the pulmonary artery and aorta, should also be avoided to prevent complications such as necrosis of the vascular wall.[1,3,5]

An absorbable gelatin sponge is the most commonly used embolic agent because it is inexpensive, easy to use, and has a controlled particle size. The disadvantages are that it decomposes spontaneously, resulting in recanalization and repeated bleeding and also its non-radiopaque nature under X-rays. Polyvinyl alcohol particles, non-resorbable embolic agents with particle diameters of 350–500 µm, and microspheres are alternative embolic agents that can be used.[1,2,8]

Liquid embolic agents (isobutyl-2 cyanoacrylate, absolute ethanol) can not be used as they are able to cross the bronchopulmonary anastomoses, resulting in non-pulmonary embolization target, moreover, it has a serious risk of complications, such as non-target tissue necrosis. Platinum coils are not used in BAE because their relatively large size which means that these embolic agents can only occlude proximal blood vessels. If hemoptysis recurs, the presence of platinum coils

actually closes the bronchial artery access and prevents embolization.[2,5]

Postprocedure Treatment

Post-procedure, treatment in an intensive care unit for patients with life-threatening hemoptysis is carried out with the length of treatment depends on the patient's hemodynamic status and complications rate. Routine post-angiography care includes regular monitoring of vital signs, inspection of access sites, pain control, antiemetic therapy if needed, and neurological consultation if the patient shows signs and symptoms of anxiety.[1,5]

Success Indicator

BAE success is defined as successful catheterization of the target artery as the source of bleeding and the successful delivery of embolic agents until extravasation of contrast is no longer visualized. BAE success can be achieved in 90% of cases. The clinical success of BAE can be judged on the basis of:[1,2,6,8]

- Massive hemoptysis can be controlled post-BAE;
- The recurrence rate varies depending on the etiology and chronicity of the disease;
- Rapid re-occurrence of hemoptysis post-BAE indicates the involvement of non-bronchial systemic arterial supply;
- Long-term relapse is generally due to vessel collateralization, recanalization of embolized vessels and disease progression.

Complications

Common complications of angiography include complications at the site of arterial access, such as hematoma, pseudoaneurysm, occlusion, and contrast-related complications. Postembolization syndrome, namely fever, leukocytosis and pleuritic chest pain should be treated with supportive management.[1,2,5,8] Specific post-BAE complications are:[2,5]

- Spinal cord ischemia as a serious complication which occurs in 1.4–6.5% of cases due to non-target embolization of the anterior spinal artery.
- Dysphagia which occurs in 0.7–18.2% of cases due to esophageal necrosis by embolization of the esophageal branches, usually resolves spontaneously.
- Other rare complications include pulmonary infarction, transient cortical blindness, aortic and bronchial necrosis, bronchoesophageal fistula and non-target organ embolization (e.g., mesenteric artery embolization resulting in ischemic colitis).

CONCLUSIONS

Massive hemoptysis is an emergency in respiratory system with high mortality rate. Both bronchial and non-bronchial arterial system embolization is a safe and effective non-surgical treatment in patients with massive hemoptysis. Knowledge of the anatomical variations of the bronchial arteries and an understanding of the pathophysiology of massive hemoptysis are required before doing BAE. The choice of the embolic agent also plays an essential role in determining the success of BAE. Indicators of success can be assessed clinically and radiologically. Patients undergoing BAE procedures are at risk for several complications, but pre-procedure preparation and vigilance, as well as selective arterial catheterization techniques, can reduce the risk of these complications.

REFERENCES

1. Khalil A, Fedida B, Parrot A, Haddad S, Fartoukh M, Carette M-F. Severe hemoptysis: From diagnosis to embolization. Diagn Interv Imaging. 2015;96(7–8):775–88.
2. Yoon W, Kim JK, Kim YH, Chung TW, Kang HK. Bronchial and nonbronchial systemic artery embolization for life-threatening hemoptysis: a comprehensive review. Radiographics. 2002;22(6):1395–409.
3. Rasmin M. Hemoptisis. J Respirologi Indones. 2009;29(2).
4. Revel-Mouroz P, Mokrane FZ, Collot S, Chabbert V, Rousseau H, Meyrignac O, et al.

Hemostastic embolization in oncology. Diagn Interv Imaging. 2015;96(7–8):807–21.

5. Masuda E, Sista AK, Pua BB, Madoff DC. Palliative procedures in lung cancer. Semin Intervent Radiol. 2013;30(2):199–205.
6. Mehta AS, Ahmed O, Jilani D, Zangan S, Lorenz J, Funaki B, et al. Bronchial artery embolization for malignant hemoptysis: a single institutional experience. J Thorac Dis. 2015;7(8):1406–13.
7. Standring S. Gray's Anatomy - The Anatomical Basis of Clinical Practice. 41st ed. Elsevier; 2015. 953–969 p.
8. Lorenz JM, Navuluri R. Embolization of Chest Neoplasms: The Next Frontier in Interventional Oncology? Semin Intervent Radiol. 2019;36(3):176–82.