Systemic Arterial Embolization for Hemoptysis

Brian Funaki, M.D.¹

Most patients in the United States with life-threatening hemoptysis have chronic pulmonary diseases such as cystic fibrosis; in other parts of the world, tuberculosis is more common. In either case, bleeding sites are typically perfused by one or several bronchial arteries. Patients face significant mortality from asphyxiation when massive hemoptysis is untreated; embolization is appropriate in anyone with severe hemoptysis and is commonly life-saving. It should not be restricted to patients with severe hemoptysis only; it may also be appropriate for some patients with mild hemoptysis and coexistent severe respiratory compromise.

PREPROCEDURE

Cross-sectional imaging studies should be reviewed prior to interventional management, particularly in those patients with chronic pulmonary diseases. Imaging studies may be helpful to plan embolization; for example, arterial perfusion from nonbronchial systemic collateral vessels may be visible on computed tomographic angiography (CTA) studies and should be suspected when pleural involvement is demonstrated. If CTA has been performed, bronchial arteries may be visible. In some cases, CT will identify other sources of bleeding such as bleeding from pulmonary arteries and change management altogether.

In our hospital, most patients undergo bronchoscopy prior to embolization, which often identifies the side of bleeding. Therapeutic maneuvers performed during this procedure may arrest bleeding in select patients. In patients with tumors such as bronchial adenomas or aspergillomas, surgery remains the definitive therapy and may be more appropriate than embolization in patients who are good surgical candidates. Nonetheless, if patients are having massive hemoptysis, embolization may be performed prior to surgery to stabilize patients. Coagu-

lopathies should be corrected prior to embolization; patients with cystic fibrosis malabsorb fat containing vitamins predisposing coagulopathy.

PROCEDURE

Airway Management

In patients with severe bleeding, airway management is critical. In general, the affected side should remain dependent to avoid spilling blood into the unaffected lung. It may be prudent to have sedation done by an anesthesiologist. One important caveat to general inhalational anesthesia should be recognized: intermittent positive pressure ventilation is rarely necessary and should be avoided whenever possible in patients with cystic fibrosis as this can induce massive bleeding. It is also important to take proper airborne precautions for any patients with suspected tuberculosis.

Access

As a rule of thumb, the ipsilateral common femoral artery is punctured and a 5-French vascular sheath is inserted. Guiding sheaths are sometimes helpful, but only in a minority of patients. I usually perform an aortic arch injection, which may or may not show bronchial arteries. This study will often show nonbronchial collateral arterial supply from subclavian or internal mammary arteries when present.

Bronchial Artery Catheterization

CONVENTIONAL CATHETERIZATION TECHNIQUE

I begin searching for bronchial arteries at the level of the left mainstem bronchus (~T5–6 level) with a short

¹Section of Vascular and Interventional Radiology, University of Chicago Medical Center, Chicago, Illinois.

Address for correspondence and reprint requests: Brian Funaki, M.D., Section of Vascular and Interventional Radiology, University of Chicago Medical Center, 5840 S. Maryland Avenue, MC 2026, Chicago, IL 60637 (e-mail: bfunaki@radiology.bsd.uchicago.edu).

Image-Guided Tumor Ablation; Guest Editor, Ron C. Gaba, M.D.

Semin Intervent Radiol 2010;27:314–319. Copyright © 2010 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel: +1(212) 584-4662.

DOI: <http://dx.doi.org/10.1055/s-0030-1261790>.

ISSN 0739-9529.

Figure 1 Systemic arterial sources of hemoptysis.

C-shaped catheter such as a Cobra or RC-1 (Cook, Indianapolis, IN). Occasionally a short recursive catheter (e.g., visceral selective 1; Cook, Bloomington, IN) may be helpful for difficult catheterizations. There are three possible sources of hemoptysis that are targets of embolization: bronchial arteries, anomalous bronchial arteries, and nonbronchial systemic collateral arteries (Fig. 1).

Given the variability in bronchial arterial anatomy, two types of arteries are commonly engaged in “blind” catheterization of branches off the thoracic

aorta: bronchial arteries and intercostal arteries. Differentiation is generally straightforward as bronchial arteries follow the course of the bronchi and intercostal arteries follow the course of the ribs. Two common variants should be recognized; on the right side, most patients have an intercostal–bronchial trunk (Fig. 2A). Less commonly, a common trunk may bifurcate and perfuse both right and left bronchi (Fig. 2B). In patients with pleural disease, both bronchial and intercostal arteries (as well as other systemic collateral

Figure 2 Variations in bronchial arteries. (A) Angiogram demonstrates common right intercostal–bronchial trunk, which is the most commonly found variation for perfusion to the right bronchi. (B) Digital subtraction angiogram shows common bronchial trunk with hypertrophy of both right and left bronchial arteries.

arteries) may perfuse bleeding foci and ultimately require embolization.

ANOMALOUS BRONCHIAL ARTERIES

Anomalous or aberrant bronchial arteries arise outside the T5–6 level and extend along the course of major bronchi. They may originate from a variety of arteries including brachiocephalic, subclavian, internal thoracic, thyrocervical trunk, inferior phrenic and pericardiophrenic arteries. I typically search for these arteries only in cases of refractory bleeding, when demonstrated on CTA, or when I am unable to identify orthotopic bronchial arteries.

SYSTEMIC NONBRONCHIAL COLLATERAL ARTERIES

Systemic nonbronchial collateral arteries are the most likely source of perfusion in patients with recurrent bleeding occurring several months after a successful embolization and should always be considered in these patients. I also routinely perform a subclavian arteriogram to look for collateral perfusion on the ipsilateral

side of bleeding as part of my initial evaluation of any patient with hemoptysis. Patients with pleural or chest wall disease should be suspected of having systemic nonbronchial collateral supply to bleeding sites.

Bronchial Angiography

Once the bronchial arteries are catheterized, digital subtraction angiography is performed with a hand injection of low osmolar or isoosmolar contrast to better define anatomy (Fig. 3). Abnormal bronchial arteries are typically enlarged and tortuous. Active extravasation is atypical and embolization is performed irrespective of this finding. Arterial supply to the spinal cord should be scrutinized. In particular, although rare, the anterior spinal artery of Adamkiewicz may arise or be supplied from spinal arteries that also supply bronchi. The artery of Adamkiewicz that supplies the anterior spinal cord typically arises from a spinal artery ~T9–12, below the level of orthotopic bronchial arteries.

Figure 3 Routine bronchial embolization. (A) Chest radiograph shows extensive parenchymal disease in patient with hemoptysis and cystic fibrosis. (B) Coronal reformatted chest computed tomography scan shows right bronchial artery originating from aorta. (C) Digital subtraction bronchial angiogram shows perfusion to diseased lung. (D) Digital subtraction bronchial angiogram after embolization shows complete stasis in the affected artery.

Embolization

Currently, I perform all embolizations through a microcatheter such as a Renegade Hi-Flo (Boston Scientific, Natick, MA) or Progreat (Terumo, Miami, FL), which is positioned with its tip distal into the affected bronchial artery. Microcatheters obviate spasm associated with 5 French catheters and enable a more selective, controlled embolization. Most commonly, I use polyvinyl alcohol particles either 350 to 500 μm or 700 to 900 μm in diameter and embolize to complete stasis (Fig. 4). It is important to dilute particles sufficiently so that clumping does not occur and lead to a false early endpoint. As a rule of thumb, coils should not be used routinely because most patients with bronchial hemorrhage have chronic pulmonary diseases and may require future intervention. Coils may prevent recatheterization of the bronchial artery and preclude repeated embolization.

Many investigators currently use particles for embolization irrespective of findings on angiography. I use particles in most patients, but also perform coil embolization in select instances. For example, if a bronchial artery to pulmonary vein fistula is visualized on angiography, I prefer to use microcoils placed as far distally as

possible rather than risk systemic embolization of particles. For nonbronchial systemic arterial embolization, I tend to use coils simply because it may be difficult to visualize small perforating branches that could perfuse vital structures such as the spinal cord. In my opinion, other embolics such as alcohol or glue have no significant role in bronchial embolization and particulate agents smaller than 300 μm should not be employed due to the unfavorable risk profile associated with their use.

DISCUSSION

Embolization for hemoptysis has become a common first-line therapy for severe pulmonary hemorrhage. Although systemic arteries (bronchial or nonbronchial collaterals) are typically the culprit, occasionally, bleeding from the pulmonary arteries may be encountered and this possibility should not be overlooked. In this regard, preprocedural cross-sectional imaging can be exceedingly helpful to exclude unusual bleeding etiologies and should always be reviewed prior to therapy.

In my experience, there is no accepted algorithm for bronchial arteriography and embolization. Some of

Figure 4 Utility of descending thoracic aortogram. Bronchoscopy could not delineate where bleeding originated due to extensive hemorrhage. (A) Descending thoracic aortogram shows abnormal bronchial arterial supply to left upper lobe. (B) Digital subtraction angiogram showing abnormal left bronchial artery. (C) Digital subtraction angiogram after embolization shows complete stasis in the affected bronchial artery.

my partners simply “seek and destroy” the bronchial arteries and then wait to see if bleeding is arrested before searching for other contributors to hemorrhage. I believe that this is a perfectly acceptable approach, although I more often attempt to tailor my procedure to the patient and usually base therapy on review of available cross-sectional imaging studies. In patients who have not been previously embolized, I perform a thoracic aortogram, an ipsilateral subclavian arteriogram, and a bronchial angiogram. I concentrate my efforts on catheterizing and embolizing bronchial arteries unless noninvasive imag-

ing shows pleural or chest wall involvement, or the subclavian angiogram shows contribution from systemic collaterals (Fig. 5). In this latter situation, I embolize both bronchial arteries and systemic collaterals. As noted above, I rarely search for aberrant bronchial arteries except in cases of refractory bleeding, when I am unable to identify orthotopic bronchial arteries or if I visualize these anomalous arteries on CT angiograms obtained prior to therapy.

Particles are used preferentially for embolization, but I believe that coil embolization is useful in some

Figure 5 Utility of arch aortogram. Hemoptysis originating in the left lung in a patient who had undergone left bronchial embolization one year earlier. (A) Aortic arch angiogram shows extensive nonbronchial collateral supply to the left upper lobe from the subclavian artery. (B) Left subclavian angiogram showing extensive collateral supply to left upper lobe. (C) Lateral thoracic angiogram during embolization showing partial occlusion of collaterals. These were embolized to stasis.

circumstances. If a bronchial artery to pulmonary vein fistula is identified, I use coils rather than particles to obviate risk of systemic embolization. This is controversial and some authors advocate use of large particles irrespective of what is visualized on bronchial angiography. In my anecdotal experience, I've seen at least one stroke when this latter approach was used. Second, if distal catheterization cannot be secured, I may elect to place coils rather than risk nontarget embolization with particles, particularly in aberrant bronchial arteries or nonbronchial systemic arteries. It is much easier to retrieve a misplaced coil than deal with the consequences of nontarget embolization of particles.

In summary, embolization for severe hemoptysis is a valuable first-line therapy that should be offered to any patient with severe hemoptysis.

SUGGESTED READINGS

- Sidhu M, Wieseler K, Burdick TR, Shaw DWW. Bronchial artery embolization for hemoptysis. *Semin Intervent Radiol* 2008;25:310–318
- 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):1395–1409