Feasibility of Computed Tomography Angiography as an Essential Prerequisite Tool in Cases of Massive Hemoptysis Requiring Embolization in a Tuberculosis Prevalent South Indian Population: Case Series

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ABSTRACT

Aims: The objective of this study is to assess the cases of massive hemoptysis suited for bronchial artery embolization (BAE). The useful role of computed tomography angiography (CTA) in assessing the arteries responsible for the hemoptysis, prior to endovascular imaging and intervention is assessed. **Materials and Methods:** CTA was performed with a 16 slice multi-detector row computed tomography scanner on all cases of massive hemoptysis provisionally posted for BAE (12 cases) in a 9 month period. **Results:** Out of the 12 patients, 10 were completely symptom free after 6 months (83% success rate). Out of the 12 cases, 1 was judged as suboptimal detection on the CTA as compared with the conventional angiography. In 11 cases, CTA appropriately demonstrated the hypertrophied bronchials, which were confirmed on conventional angiography and subsequently embolized (sensitivity 92%). All the 11 cases, which demonstrated the bronchial arterial (BA) and non-bronchial arterial feeders were also detected on conventional angiography (specificity 92%). **Conclusions:** CTA is helpful in identifying the precise origin of the BAs from the aorta, which enhances the success of the procedure and clinical results. We recommend CTA before conventional angiography and attempting BAE.

Key words: Bronchial artery; embolization; CT angiography

Introduction

Multi-detector computed tomography (MDCT) angiography is a relatively new imaging technique that allows delineation of abnormal bronchial arteries (BAs) and non-bronchial arteries using reformatted images in multiple projections, which can be used to guide therapeutic arterial embolization procedures.

The availability of MDCT in developing countries has dramatically changed the algorithms and flow charts in the approach and management of many emergency events.

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Massive hemoptysis is a respiratory emergency. The BA supply and to a lesser extent the non-bronchial systemic arterial supply are responsible for the majority of cases of massive hemoptysis, but uncommon causes of massive hemoptysis should be considered to avoid misdiagnosis and delayed treatment.[1] Bronchial artery embolization (BAE) is now considered to be the most effective procedure f or the management of massive and recurrent hemoptysis, either as a first-line therapy or as an adjunct to elective surgery. It has proven to be safe technique in the operative hands of experienced personnel with knowledge of BA anatomy and the potential complications of the procedure.[2]

BAE is recommended as a minimally invasive therapy for hemoptysis, in the event where conservative treatment has not succeeded.[3] BAE is a treatment, which can reduce the need for acute thoracic surgery.

Various studies have concluded that transcatheter BAE is an effective and safe procedure for patients suffering from clinically important hemoptysis.[4]

Hemoptysis is common in the Indian population due to local endemicity of tuberculosis. The aim of this study is to determine the feasibility of performing computed tomography angiography (CTA) in massive hemoptysis. The study also emphasizes the role of good three dimensional (3D) reformatting and rendering of images to search for the BA and non-bronchial arteries as the culprit for hemoptysis.

Materials and Methods

The 12 consecutive patients in a 9 month period, referred to our institution for endovascular treatment of hemoptysis underwent multi-detector row helical CTA as part of the pre-therapeutic evaluation, which also included physical examination, chest radiography and fiberoptic bronchoscopy. Cases where there were contraindications like renal insufficiency, contrast reaction and significant morbidity were not accepted. More than 300 ml of hemoptysis per day was considered to be significant and embolization attempted. CTA was performed on a 16 slice computed tomography (CT) scanner (Brightspeed CT, General Electric Company, Milwaukee, USA). The CT parameters were kV 120 and mA 340, slice collimation 0.625 mm and rotation time of 0.5 s. Patients received 100 ml of non-ionic iodinated contrast at the rate of 3.5 ml/s. Appropriate consent was taken before the CT procedure for general contrast related events and for study participation.

The images were reconstructed on the scanner and 3D renderings were performed on a dedicated workstation (General Electric company Advantage© Windows version 4.5). Dedicated multiplanar reformats, maximum intensity projections and volume rendered images were created. The reconstruction algorithms and processes were performed by the radiologist.

CT interpretation and reporting focused on the evaluation of BAs ipsilateral to the side of bleeding. The report recorded the following information (a) site of the ostium of the BA (or arteries), which was considered as orthotopic when the artery was originating from the descending aorta between the levels of the T5 and T6 vertebrae or ectopic when identified at a level of the descending aorta other than the expected origin (b) the location and course of the vessel was studied in relation to the wall of the descending aorta (i.e. posterior, medial, anterior, or lateral) and its position relative to the tracheal carina; (c) the BA diameter (d) the total number of BAs per side. The Radiologist analyzed the transverse CT scans and 3D images (maximum intensity projections, reformats and volume rendered images).

The radiologist always systematically searched for collateral with a hair pin bend coursing toward the midline (to rule out the common supply to the spinal cord), whenever the intercostobronchial trunk was expected to be the source of bronchial bleeding. The radiologist also looked for any abnormal enlargement of one or several of the branches of the subclavian and axillary arteries, particularly the internal mammary artery and its branches, the intercostal arteries and the inferior phrenic arteries.

The radiologist also looked for the rare incidence of intrapulmonary aneurysms, arterio-venous shunts and aspergilloma within tubercular consolidations, which has been demonstrated as a cause of recurrence of hemoptysis after BAE.

The same radiologist who interpreted the CT scans also performed the angiography. In all patients, conventional angiography was performed with a digital substraction angiography with a transfemoral approach and the seldinger technique. 6F sheath and 5F catheters were used to perform selective angiograms. Various types of angiographic catheters were used to selectively inject the hypertrophied BAs. Gelfoam and polyvinyl alcohol particles (500-710 microns) were used to perform the embolization.

Some of the representative cases are displayed in the Figures 1-11.

Results

In all patients, both the site of the origin of the BA and its hilar path were precisely identified. No anterior spinal artery was seen arising from the right intercostobronchial trunk. This was double-checked to prevent any inadvertent occurrence of paraparesis subsequent to the procedure.

The origin of BAs was accurately depicted on axial CT scans, the mediastinal and hilar course of BAs was more confidently analyzed on 3D images, especially in cases of enlarged and tortuous vessels. Three-dimensional images were superior to transverse CT scans in the depiction of the ectopic origin of BAs, which enabled the interventional radiologists to perform successful embolization after direct catheter placement into the origins of these vessels. A pig-tail thoracic aortography was avoided in all cases. The reconstructed images provided an exquisite road-map to the interventional radiologists to plan the procedure and to select the catheters in advance. All the angiographies were compared retrospectively to the reconstructed images to compare the depiction of the arteries. The radiologists assessed whether there was adequate or suboptimal depiction of the vessels on the reconstructed images. CTA identified the precise origin(s) of BAs and some aneurysms and feeders not identified by conventional angiography.

Out of the 12 patients [Table 1], 10 were completely symptom free even after 6 months (83% success rate). Two patients had a recurrence of hemoptysis within 1 month period. One patient had no BA hypertrophy on the CT

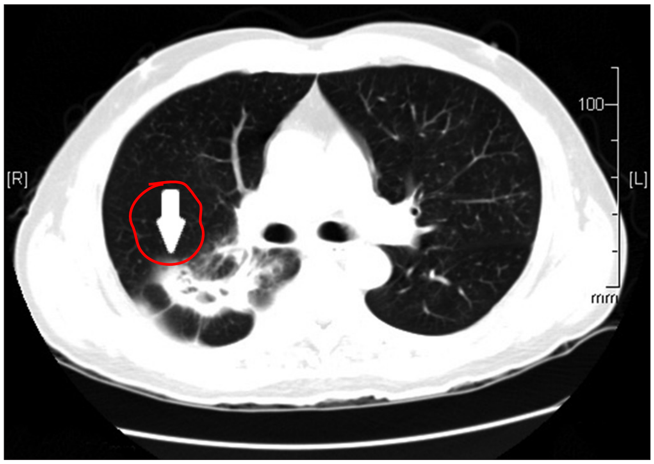

Figure 1: Computed tomography chest lung parenchymal window shows parenchymal consolidation in the right lung related to hemoptysis (white arrow)

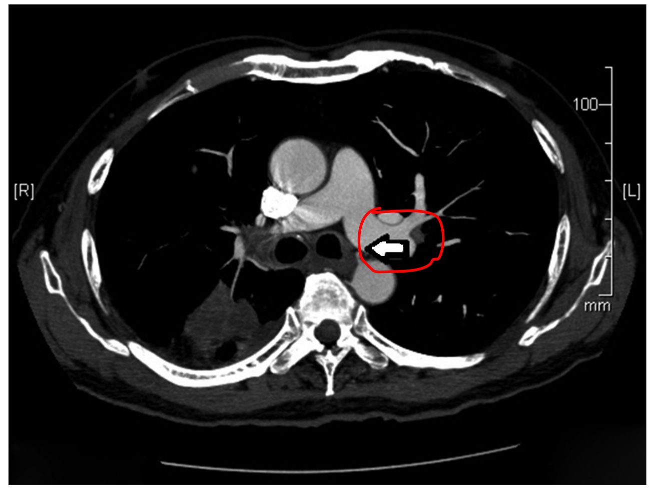

Figure 2: Axial image of case 1 of Figure 1 demonstrating the bronchial artery origin (white arrow)

Figure 3: Coronal reformat image of the computed tomography angiography of case 1 demonstrating the course of the hypertrophied right bronchial artery Figure 3: Coronal reformat image of the computed tomography angiography of case 1 demonstrating the course of the hypertrophied right bronchial artery

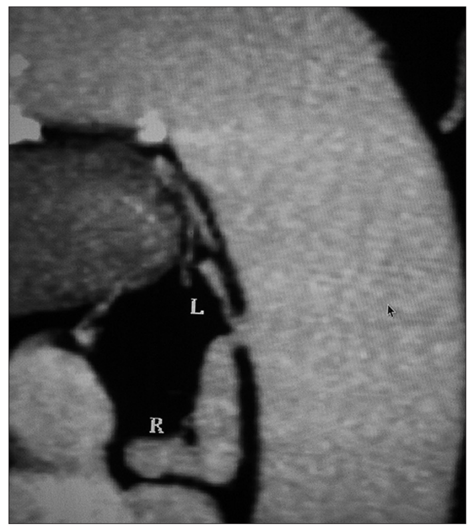

Figure 4: Computed tomography angiography of case 1 shows reformatted sagittal image showing common origin of the right and left bronchial arteries

Figure 5: Volume rendered image of the same case as case 1 showing hypertrophied bronchials having a common origin

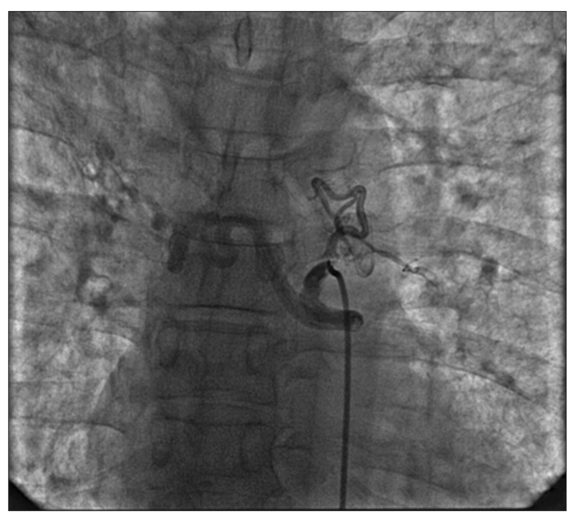

Figure 6: Digital angiography image of the same case as case 1 showing the same hypertrophied bronchial arteries which were embolized

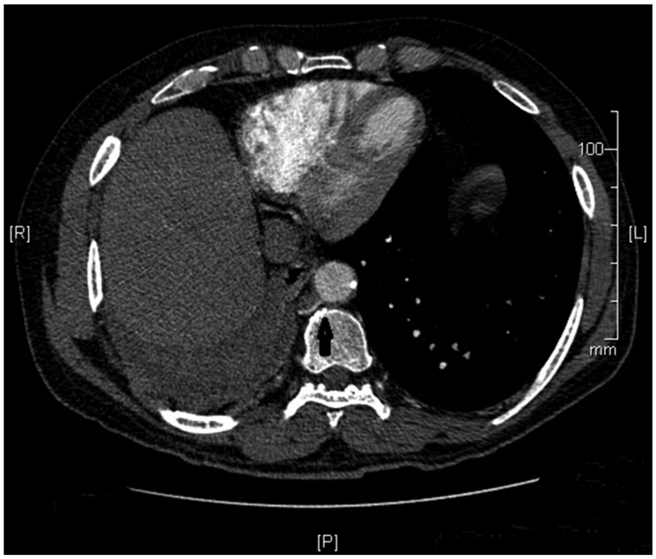

Figure 7: Axial computed tomography contrast raw image of case 2 showing hypertrophied vessel (black solid arrow) arising from the aorta

Figure 8: Digital angiography image of case 2 showing hypertrophied vessel which was embolized

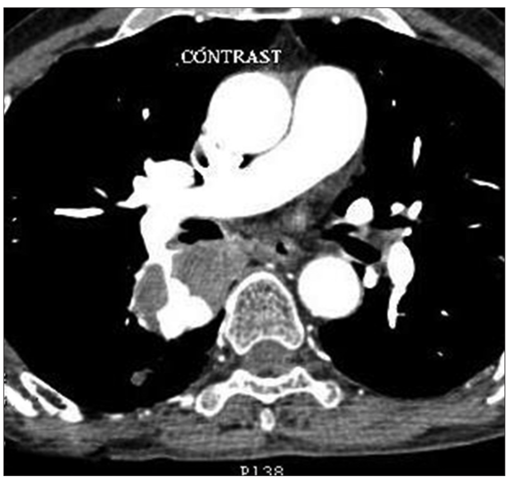

Figure 9: Computed tomography angiography axial image showing intrapulmonary artery aneurysm as the cause for hemoptysis

Figure 10: Volume rendered image of the intrapulmonary artery aneurysm as in Figure 9

Figure 11: Plain axial computed tomography after percutaneous glue injection into the intrapulmonary artery aneurysm as in Figure 9

Table 1: Patients characteristics and causes of hemoptysis

Gender male/female	8/12	4/12
Hemoptysis-related deaths	Nil	
Causes of hemoptysis	Bronchiectasis	3
	Tuberculosis	8
	Aspergilloma	1
	Primary lung cancer	0

angiogram and did not show any hypertrophied BAs on the conventional angiogram too. On the CTA, there was evidence of intrapulmonary aneurysm, which was treated with percutaneous glue injection.

Out of the 12 cases, 1 was judged as suboptimal detection on the CTA as compared with the conventional angiography. In the rest 11 cases, CTA appropriately demonstrated the hypertrophied bronchials, which were confirmed on the conventional angiography and subsequently embolized (sensitivity 92%). All the 11 cases [Table 2], which demonstrated the BA and non-bronchial arterial feeders, were also detected on the conventional angiography (specificity 92%).

Discussion

CTA can play a crucial role in assessing the cause and origin of the hemoptysis and directing the interventional radiologist prior to treatment. The MDCT angio provides a good platform to plan the procedure. Failure to assess the imaging appropriately prior to endovascular treatment may result in early recurrent massive hemoptysis or patient death.[1] Prior to embolization, the interventional radiologist needs to be aware of the side of the BA bleeding and the most likely source of bleeding has to be identified to determine, which vessel(s) is to be occluded. Since the bronchial circulation is the most frequent source of hemoptysis, embolization of BAs is usually the favored therapeutic option to stop the bleeding.

The study conducted by Mori *et al*.[3] in which 41 patients were studied, classified the visualized BAs into groups based on their BAE and bleeding statuses. They concluded that the diameters of BAs responsible for bleeding and receiving BAE were apparently larger in each measured segment than those that were not ($P < 0.05$). They concluded that evaluation of BAs on MDCT could be useful for identifying the anatomical characteristics of bleeding-related BAs and determining whether BAE is indicated or whether conservative treatment is sufficient. This study is comparable as it proved that hypertrophied BAs were the cause of hemoptysis and was adequately depicted at the CTA [Figures 3 and 4]. Though we did not measure the diameter of the BAs we found that identifying all the hypertrophied vessels led to adequate embolization and good results.

The multiplanar reformats and maximum intensity projections accurately depicted the origins of the bronchials and hypertrophied intercostals [Figure 5]. These 3D images were found to be superior to axial images in depicting the ectopic origin of the BAs, which enabled the interventional radiologists to perform successful embolization after direct catheterization of the ectopic vessel in every case.[5]

Table 2: Summary of bronchial artery findings on multi-detector computed tomography angiography

Height of ostium	Right	Left
Th5	5	3
Th6	3	3
Ectopic	1	1
Bleeding site		
Upper lobe	4	4
Middle lobe	2	
Lower lobe	0	0
Adequate depiction	7	4
Suboptimal depiction	1	0

CT also demonstrated nonbronchial systemic artery collaterals and systemicto- pulmonary venous shunts.[6]

Another advantage of multi–detector row helical CT is the ability of identification of bronchial arteries not only of orthotopic origin but also of ectopic origin.[7] CT also demonstrated presence of aspergillosis which have been documented causes of recurrence of haemoptysis after embolization.[8,9]

One of the patients in our series had no BA hypertrophy on the CT angiogram and did not show any hypertrophied BAs on the conventional angiogram too. On the CTA, there was evidence of intrapulmonary aneurysm [Figures 9 and 10] which was treated with percutaneous glue injection [Figure 11]. CTA also depicted hypertrophied intercostals and feeders from the subclavian artery which assisted in complete embolization.

Multi-detector row helical CTA can provide a precise road map for the interventional radiologist in performing an endovascular treatment for hemoptysis. The availability of this information before the patient arrives in the angiographic suite is expected to help reduce the examination time and radiation dose by facilitating attempts at direct selective catheterization of the arteries to be occluded. A preliminary thoracic pig-tail catheter aortography can be completely avoided thereby reducing time and cost.

Pulmonary tuberculosis is prevalent in India.[10,11] Inappropriate medication and treatment has resulted in incomplete treatment of the disease. Residual disease and cavitation present with recurrent hemoptysis warranting urgent attention.

Since there is complete screening of the vascular anatomy on the CTA and adequate depiction of the hypertrophied vessels, the failure rate of the procedure tremendously falls. This approach is highly recommended.

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